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Preface

In March 1986, a Canadian colloquium with an international flavor was convened to discuss the impact of information technology on community health. It was sponsored by the School of Health Information Science at the University of Victoria and the British Columbia Ministry of Health. Notable speakers were Salah Mandil, the Director of Information Systems Service at the World Health Organization, and Stan Dubas, the Deputy Minister of Health for British Columbia. This small, successful gathering was the predecessor of the Information Technology in Community Health (ITCH) conferences that followed in 1987, 1988, 1990, 1992, 1994, 1996, 1998 and 2000.

In 2007, after a brief hiatus, the conference was held again but this time it had expanded its scope. It was known as Information Technology and Communications in Health (ITCH) 2007; with the same acronym but with a different meaning as demanded by its international appeal and wider choice of subject areas. The conference in 2007 was an unmatched success and now, as 2009 approaches, we prepare for an even more eventful convention, which encourages experts to demonstrate and share their experiences and knowledge. The theme for the ITCH 2009 conference is “Revolutionizing Health Care with Informatics: From Research to Practice.”

The Organizing Committee feels honoured to promote this event and, thereby, to contribute to the advancement of informatics in health and health care. Many people have volunteered their time and financial sponsorship; we sincerely thank them. We wish, however, to give specific recognition to those who are serving on the Steering Committee and the Scientific Program Committee.

James G. McDaniel, Editor
School of Health Information Science
University of Victoria,
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December 15, 2008

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Section 1

Decision Support, Artificial Intelligence and Modelling
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A Morphological Approach for the Fovea Location in Color Fundus Images

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Abstract. This paper presents a novel method for the detection of the fovea center in color fundus images. The method was evaluated using a set of 89 images from the DIARETDB1 project, which contains images presenting normal and pathological situations. Using the Mean Absolute Distance (MAD) as a metric, we report 7.37±8.89 (mean ± standard deviation) detection performance for the fovea center which represents an improvement in comparison to other state-of-the-art methods in the literature.

Keywords. fovea detection, mathematical morphology, color fundus image

Introduction

There are few papers that address the fovea location issue. Sinthanayothin et al [1], use an artificial image of the fovea for to find the fovea’s place in real retinal images. They consider the position of maximum correlation coefficient between a synthetic image (template) and the retinal image as the fovea’s place. Li et al [2], use a modified active shape model and the Hough Transform on the main vessels arcade, to fit a parabola which has its center in the optic disk. Then, candidate regions for the fovea are defined at 2 DD (DD=Disk Diameter) away from this optic disk center, but along the main axis of this parabola. Tobin et al [3] also use a geometric model (also parabolic) of the vasculature tree to identify the fovea anatomy. As in the previously described paper, Tobin et al explore the geometric relationship between the optic nerve and the main vessels arcades to find the fovea locus. Besides, Goldbaum et al [4] use a constant distance (i.e. 4.5 mm) away from the optic disk to find the fovea center. In this way, we can classify all these methods of the literature for the fovea localization, in three categories: 1) those that use the variability of the gray values of the image to find the fovea, 2) those that explore the vessels (main vessels arcade or the fovea avascularity) and 3) those that use fixed parameters to identify the fovea region.

Our approach explores the low intensity values of the fovea region on the green channel of the color retinal images. We use morphological operators on the green channel of the original color retinal image. Moreover, other anatomical information is used to select the fovea center position. Later, we compare our method with the
approach used in Sinthanayothin et al and discuss the advantages and drawbacks of both methods.

1. Materials and Methods

1.1. Materials

Our proposed method was tested on a public database of retinal images called DIARETDB1 [5], which consists of 89 color fundus images of size 1500 x 1152 captured using a 50 degree field-of-view digital fundus camera. This database contains normal images (without diabetic lesions) and images with diabetic non-proliferative signs. Also, the images show great variability in terms of quality, i.e., illumination problems. In order to save computation time, we resized the images to 640 x 480 pixels.

1.2. Our Proposed Method

Our proposed method needs two parameters in order to find the fovea. These parameters are the diameter and the optic disk center point, which where found in this work using an approach based in the method proposed by Walter et al [6]. Basically, their method has two steps: the first step is the optic disk locus detection and the second is the identification of its boundaries. Figure 1 (a), illustrates the output of Walter et al for an image of the DIARETDB1 database. Thus, having an acceptable optic disk boundary, its diameter and its center point can be calculated as shown in Figure 1 (a), where the disk diameter (DD) is equal to 68.9143 pixels.

First, we select only a region of interest (ROI) of the segmented image shown in Figure 1 (a). This ROI has a size of 160 x 160 pixels and its center point is located at 2.6 DD pixels away from the optic disk center point. It is important to notice that the ROI center point is aligned to the optic disk center point, or in other words, they are on the same image row as illustrated in Figure 1 (b). We consider that the fovea center is inside of this ROI and in this way only this ROI will be used to detect it. This is a robust approach because there is an anatomical relationship between the fovea and the optic disk, i.e., the fovea can be located at a minimum distance of twice the optic disk diameter [1,2,4]. Then, in order to detect the fovea center on this ROI image, we use morphological image processing techniques.

If we consider two input images where $f$ is a marker image and $g$ is the mask image, and where $\delta$ denotes a morphological dilation and $\epsilon$ represents the elementary morphological erosion, we can denote the geodesic dilatation (with $f \preceq g$) and the geodesic erosion (with $f \succeq g$) by Eqs. (1) and (2), respectively.

\[
\delta_g^{(n)}(f) = \delta_g^{(1)}[\delta_g^{(n-1)}(f)], \quad \text{where} \quad \delta_g^{(1)}(f) = \delta_g^{(1)}(f) \Lambda g
\]  

(1)

\[
\epsilon_g^{(n)}(f) = \epsilon_g^{(1)}[\epsilon_g^{(n-1)}(f)], \quad \text{where} \quad \epsilon_g^{(1)}(f) = \epsilon_g^{(1)}(f) \lor g
\]  

(2)

where $n$ represents successive geodesic dilations or erosions of $f$ with respect to $g$ and $\Lambda$ and $\lor$ are point-wise operators for minimum and maximum. If the geodesic dilation
or erosion is performed successive times until stability, it results in the morphological reconstruction by dilation and the reconstruction by erosion transformations respectively. Eqs. (3) and (4) illustrate these transformations.

\[ R_g (f) = \delta_g^{(i)} , \text{ where } \delta_g^{(i)}(f) = \delta_g^{(i+1)}(f) \]  

(3)

\[ R_g^* (f) = \varepsilon_g^{(i)} , \text{ where } \varepsilon_g^{(i)}(f) = \varepsilon_g^{(i+1)}(f) \]  

(4)

In addition, from the reconstruction by dilation, we can define the regional minimum of an image, \( f \). The regional minimum, RMIN, is a grayscale image where the regions \( \text{RMIN} \leq f \) is delimited. If a pixel value of \( f \), namely \( f(x,y) \), is smaller or equal to its neighboring pixels, it is kept at its original value otherwise it is assigned to zero. In other words, each pixel of \( f \) surrounded by pixels brighter than itself is a regional minimum. The RMIN image can be found according to Eq. (5).

\[ \text{RMIN}(f) = R_f^* (f + 1) - f , \]  

(5)

Next, applying the regional minima and the geodesic morphological reconstruction by dilation on the green channel, \( f_g \), of the original ROI image, we remove the bright areas that are potentially associated with all diabetic lesions. The regional minima of \( f_g \) are computed and then a reconstruction by dilation of \( f_g \) is performed using the previously calculated regional minima as a marker image. The central idea is to identify the foreground and background of the \( f_g \) image. We assume as foreground the brighter structures, e.g., exudates, and as background all the remaining structures, for example, vessels and hemorrhage. Eq. (6) shows this process:

\[ f_{g1} = R_{f_g} (\text{RMIN}(f_g) ) , \]  

(6)

where the new image, \( f_{g1} \), contains no signs of bright lesions, i.e., exudates. Figure 1 (b) is illustrates the green channel of the original ROI image that contains a diabetic lesion (indicated by the white arrow). Figure 1 (c) depicts the resultant image, \( f_{g1} \), where there are no signs of diabetic lesions. However, in the \( f_{g1} \) image, there are still many other undesirable features like little dark dots, which can be a natural pigment of the eye or even a microhemorrhage, and thin vessels (capillaries). Thus, in order to remove these features and to achieve homogeneous areas we use the \( \nu \)-minima filter [7,8] on the \( f_{g1} \) image. The \( \nu \)-minima filter removes all connected components, i.e., the image basins, which have a volume below \( \nu \). Basically, the volume of each level component of an input signal (image) is defined according to the area attribute for each level component in this image. The area of a determined level component plus all the connected areas above it results in the volume of this level component [9]. The algorithm and the mathematical formalization of this filter are beyond the scope of this paper because they are extensive. However, the entire volume graph computed for all level components can be found in [7,8,9]. Then, the \( \nu \)-minima
filter removes all basins in which volume is lower than \( v \). We use a constant value for \( v \), i.e., 1000, and the resultant image, \( f_{g2} \), is shown in Figure 1 (d).

![Image](image.png)

**Figure 1.** Steps for fovea location using our approach: (a) Optic disk center point and diameter detected through the method proposed by Walter et al. (b) Original ROI image. (c) \( fg1 \) image without signs of bright lesions. (d) \( fg2 \) image without small basins. (e) Fovea candidate regions (\( fg3 \) image). (f) Only candidate regions below the optic disk center point remain. (g) Selected region for the fovea.

In order to identify only the fovea region candidates, we perform the RMIN operator on the \( fg2 \) image as shown by Eq. (7).

\[
fg3 = R_{g2} \left( RMIN \left( fg2 \right) \right),
\]

(7)

The image \( fg3 \) is a binary image where the foreground figure depicts all possible fovea regions as illustrated in Figure 1 (e). Thus, we have to apply some criteria to exclude all non-fovea regions. First, all regions above the ROI center are removed because anatomically the fovea center is always below the optic disk center [10], which is aligned with the ROI center as shown in Figure 1 (a). Figure 1 (f) illustrates the resulting image of this previous process. Finally, the centroid of the remaining region of darkest intensity is chosen as the fovea center position. Figure (1) (g) shows the final candidate region chosen as the fovea region. Finally, the centroid point of this final candidate region is selected as the fovea center point.

2. Experimental Results

We tested our approach and the method proposed by Sinthanayothin et al on the 89 images in the DIARETDB1 database. We used the Mean Absolute Distance (MAD) [11] to measure the accuracy of both methods. The method described by Sinthanayothin et al uses a 40 x 40 intensity template image and a real intensity image to obtain the candidate regions for the fovea. This template is an artificial gray-scale image that mimics a real fovea region and is obtained using a Gaussian distribution with a fixed standard deviation [1]. The real intensity image refers to the intensity-hue-saturation color model obtained from the original color fundus image. Then, only the
darkest region located in an acceptable distance away from the optic disk, i.e., 2.5 DD, is selected. Finally the centroid of this region is selected as the fovea center point.

Our method and that of Sinthanayothin et al depend on acceptable optic disk boundary identification. Nevertheless, the approach of Walter et al used in this research to segment the optic disk, failed for some images. Consequently, we compared the two methods using only those 51 images where the optic disk segmentation was considered acceptable. We used the Mean Absolute Distance (MAD) to analyse our results and to validate our technique. For each image, the MAD was calculated for each method - the fovea center was manually labelled by an experienced ophthalmologist and also identified automatically.

The fovea center is identified as a white point on the original green channel image, which means that the pixel representing the fovea center locus is assigned a maximum grayscale value of 255. Then the MAD, based on the Euclidean distance, is used to estimate the average discrepancy between the points identified by the manual and automatic methods. A MAD value of zero indicates that the manually identified fovea center point and the automatically identified center point are in the exact locus or the same pixel. For example, the MAD obtained for the image 2 was 3.1622 pixels using our approach and 89.0449 pixels using that of Sinthanayothin et al. Therefore, for this second image we achieved better segmentation because we were nearer to the ground truth fovea center.

**Figure 2.** Comparative results between our approach and the approach of Sinthanayothin et al: (a) The Mean Absolute Distance (MAD) between these two approaches. The MAD of the solid and dotted lines was calculated using the ground truth images as reference. (b) The MAD histogram of our method. (c) MAD histogram of the Sinthanayothin et al method showing dispersion greater than our method.

Our approach gives a database average MAD of $7.37 \pm 8.89$ (mean ± standard deviation) and that of Sinthanayothin et al, $81.61 \pm 87.09$. Figure 2 (a) shows the MAD values for each image achieved with our method. It is easy to observe that our method
in general has lower MAD values than that of Sinthanayothin et al; in fact, the MAD for image 8 approaches zero. Figures 2 (b) and (c) show respectively the MAD histograms resulting from our method and that of Sinthanayothin et al.

3. Conclusions

We have presented a new method to locate the fovea center point. The performance of the proposed method is more robust than that described in the literature because lesions, i.e. exudates and microhemorrhages, surrounding the fovea region are eliminated. Our method is not negatively influenced by these lesions and the probability of finding false positive points is minor. Our method explores a new anatomic feature that eliminates candidate regions above the optical disk to find the best region of the fovea center point. However, it tends to fail in the presence of large hemorrhages because these may be darker than the fovea region as well as being located below the optic disk center.

References

Integrating Evidence-Based Interventions into Client Care Plans

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Abstract. Within the mental health care system, there is an opportunity to improve patient safety and the overall quality of care by integrating clinical practice guidelines with the care planning process through the use of information technology. Electronic assessment tools such as the Resident Assessment Inventory – Mental Health (RAI-MH) are widely used to identify the health care needs and outcomes of clients. In this knowledge translation initiative, an electronic care planning tool was enhanced to include evidence-based clinical interventions from schizophrenia guidelines. This paper describes the development of a mental health decision support prototype, a field test by clinicians, and user experiences with the application.

Keywords. evidence-based practice, human computer interaction, health information technology, knowledge translation

Introduction

Health care professionals are called upon to create client care plans based on their assessment of clients’ needs and their familiarity with appropriate interventions. This requires, among other resources, understanding of current best practices. The uptake of evidence into clinical practice is a complex area, one that formed the basis for the PARIHS conceptual framework, “Promoting Action on Research Implementation in Health Services”[1]. Doran and Sidani [2] used the PARIHS framework as a basis and created an intervention framework for outcomes-focused knowledge translation that links the theory about evidence-based practice, outcomes research, and quality improvement. In the Doran and Sidani framework, the choice of interventions is directly linked to the uptake of evidence in point of care planning. In turn this is related to the sources and quality of available evidence, patient preferences, the case context, and facilitation or coaching by advanced practice colleagues. They hypothesize that direct access to evidence-based resources at the point of care will increase nurses’ utilization of interventions that are consistent with evidence-based resources and will ultimately result in improved patient outcomes [2]. In the current study, multidisciplinary health care team members were presented with electronic care plans,
client-specific practice guidelines and evidence about various treatments for clients who are living with schizophrenia.

The concept of actively involving clinicians in the implementation of clinical guidelines and of integrating guidelines into the decision making process are consistent with evidence-based recommendations of many researchers [3,4]. When research evidence and decision support are integrated at the time and place of decision-making, interventions are more likely to be successful [5] ultimately resulting in improved client outcomes.

1. Purpose

The purpose of this study was to evaluate the usability and effectiveness of a knowledge translation prototype system aimed at enhancing communication between health care professionals and improving patient-centred, evidence-based inpatient care for individuals diagnosed with schizophrenia. This paper focuses on the process of creating a knowledge-based system to enhance the quality of care plans, and the use of the system by multi-disciplinary health care teams during care planning meetings.

2. Setting

The study was conducted on inpatient units at a tertiary care mental health facility in Ontario. The participating units were part of the schizophrenia program. A total of 87 health care professionals (70 nurses, four psychiatrists, and 13 other health care professionals such as social workers and therapists) participated in the study.

3. Method

Research staff reviewed the literature and identified approximately ten international clinical guidelines for the treatment of schizophrenia, the majority of which were developed by psychiatric associations. We utilized Gaebel’s [6] systematic review of the guidelines which used the AGREE tool (Appraisal of Guidelines Research and Evaluation) [7], a structured set of criteria developed by an international collaboration of researchers and policy makers from Europe, UK, Canada, Australia and New Zealand. The AGREE tool consists of 23 items in six domains, each representing different dimensions of quality. The six domains are scope and purpose, stakeholder involvement in guideline development, rigour of development, clarity and presentation, applicability, and editorial independence. Gaebel’s review was augmented by including a more recent version of one of the guidelines.

An expert panel of 15 local mental health clinicians and decision-support specialists met to review published schizophrenia guidelines. It was agreed that the initial focus would exclude pharmacological guidelines due to their complexity and the short timeframe for the project. Rather than simply relying on the quality of the guidelines in order to decide among multiple resources, the expert panel included additional facility-specific criteria and customized the decision-support system to make it more appropriate for the institution at which the project was taking place. Guidelines
that had the potential to be triggered by RAI-MH client-specific outcomes assessment data were rated by the expert panel, based on factors such as the relevance and prevalence of the issue at their organization, the feasibility of implementing the guideline within a relatively short time frame using existing resources, interdisciplinary acceptability, and consistency with corporate values. Panelists agreed that one criterion was critical: any guideline selected must be client-centred, a core organizational value. Following the rating of various guidelines, group discussion ensued in an enthusiastic and supportive environment until consensus was reached. Based on the results, it was agreed that the project would initially focus on three clusters of guidelines: family support, social skills and substance abuse screening. The selected guidelines and their respective RAI-MH triggers were submitted to a clinical expert who was not a member of the Expert Panel for review, and approval, prior to proceeding with modifications to the electronic care plan application. The expert panel had to consider where, in the development of the care plan, the guidelines should be presented to users. It was important to have clear communication between the clinical experts at the hospital and the technical experts at both the hospital and the developer’s organizations.

Following an iterative process of reviewing mockups and soliciting feedback from clinicians, the application’s database structure was modified to link the RAI’s Mental Health Assessment Protocols and the guidelines that had been chosen by the panel. The care plan’s “front end” was modified to enable health care professionals to both enter plans as free text, as was their custom, or selecting guidelines from drop-down lists that were triggered by specified RAI-MH data. Both the RAI-MH database and the guidelines database were integral components of the knowledge-based system that can assist in decision-making by making clinicians aware client-appropriate. In short, the system brought clinical expertise to the point of decision-making. In addition to selecting a programmed intervention, users also had the option of make their care plan client-specific by adding details in a free text, comments box. For example, for a guideline about a family intervention, the staff could add a customized note such as, “C’s mother brings in lunch for the client every Thursday,” or “Social Worker will contact C’s brother to assess family’s learning needs.” Involving non-clinical stakeholders, who could potentially influence care plan implementation, was perceived as valuable and was consistent with the user-centric process recommended by DiCenso [3]. After the prototype was developed, it was tested both by the developer and by the hospital’s information technology department prior to holding training workshops and roll-out. Fifty-five health care professionals (nurses, therapists, social workers, psychiatrists) attended the workshops, facilitated by the research team, and learned about the decision-support enhancement, after which a four-month field test was conducted.

Collaborative care planning: In each of the two units participating in the trial, each psychiatrist meets with a multi-disciplinary health care team (nurses, social workers, pharmacists, therapists, and out-patient or community representatives as required) on a scheduled basis to discuss and plan client care. On one unit, the client is invited to the final part of the meeting when this is feasible so that (s)he can have input into the treatment goals and plans for his/her own care. Research staff, working in pairs, observed six team meetings, collecting data using a structured observation tool to record how the care plans were developed at the group level and how often guidelines were integrated into care plans. Immediately following each meeting, they compared data, discussed discrepancies and resolved any differences in the coding of their observations.
Table 1. Integration of Guidelines Into Care Plans During Multi-Disciplinary Team Meetings

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Skills discussed</td>
<td>38/58 (65.5%)</td>
</tr>
<tr>
<td>Social Skills guidelines triggered</td>
<td>4/38 (10.5%)</td>
</tr>
<tr>
<td>Social Skills guideline(s) included in care plan</td>
<td>4/4 (100%)</td>
</tr>
<tr>
<td>Family discussed</td>
<td>29/58 (50%)</td>
</tr>
<tr>
<td>Family guidelines triggered</td>
<td>4/29 (13.8%)</td>
</tr>
<tr>
<td>Family guideline(s) included in care plan</td>
<td>4/4 (100%)</td>
</tr>
<tr>
<td>Substance Abuse discussed</td>
<td>10/58 (17.2%)</td>
</tr>
<tr>
<td>Substance Abuse guideline triggered</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Substance Abuse guideline included in care plan</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

4. Results

Demographic Characteristics. Of the staff who provided demographic data, 74% were nurses, 82% worked full time, and 72% were female. They had an average of 12 years experience working at the organization and 6 years on the specific unit.

Each multidisciplinary care planning meeting was led by a psychiatrist, while a health care professional updated the electronic care plan which was displayed using a computer and an LCD projector so that it was visible to all of the team members. During the 6 meetings that were observed, a total of 58 clients were discussed and their care plans were updated (minimum 1 client/meeting, maximum 17 clients/meeting; mean 9.7, median 11.5). The number of health professionals present at the team meetings varied from a minimum of 8 to a maximum of 14, with a mean of 11.7. One client attended part of a meeting during which the client goals and plans were discussed. During five meetings, the care plans were updated, primarily recording decisions that were made by the team in response to team-identified issues. During one meeting, the psychiatrist-leader suggested that the team consult the guidelines and actively sought out appropriate interventions. Table 1 presents data about how often these guidelines were triggered, selected, and integrated into care plans during the six team meetings that were observed.

5. Discussion

One factor that influenced the relatively low rate of guidelines being used at the care planning meetings related to the fact that a priority focus was often medications or post-discharge housing, areas for which guidelines were not available in the electronic care plans. Our observations indicate that the guidelines would be most helpful to users when the client’s initial care plan is being completed or when a staff member decides that a new intervention is needed. They were rarely used if a staff member was simply updating a note about an intervention that was already in the care plan. The presentation of the guidelines as a drop-down menu is triggered when a health care team member intends, by placing the mouse cursor in the intervention selection area, to add an intervention. If team members are simply updating or adding a comment regarding an existing intervention, as was often the case at team meetings, then the system does not alert them that alternate interventions could be considered. The research team continues to work with the software developer and the site’s leadership...
team to explore options for future revisions to the electronic care plan. Design implications include adding flags or additional visual cues within the care plan to alert users when clinical guidelines are available about an issue rather than simply presenting best practices after a user intentionally chooses to address an issue.

It will also be important to review the guidelines usage data in care plans of newly-admitted clients on units where the guidelines are available, especially on units with long lengths of stay. The rate of adoption should be reviewed periodically since four months was a very short time in which to see changes of this nature. Multi-faceted strategies, in addition to enhancing the usability of the care plans, are needed to ensure that staff can consistently use best practices when caring for their clients who are living with schizophrenia.

6. Conclusion

The system has demonstrated that it can simplify the care planning process for mental health professionals and has the potential to improve the quality of client care. Software updates are expected to improve usability and local users are discussing approaches to expand the scope of the interventions.

References


Anemia Analyzer: Algorithm and Reflex Testing in Clinical Practice Leading to Efficiency and Cost Savings

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Abstract. Anemia is a common disease affecting about 3.5 million people in the United States. In present day clinical practice, a clinician makes a diagnosis of anemia based on low hemoglobin levels discovered during a complete blood count (CBC) test. If the etiology of the anemia is not readily apparent, the clinician orders additional testing to discover the cause of the anemia. Which tests are ordered, in what order these tests are run, and how the information gathered from the tests is used is based primarily on the individual physician’s knowledge and expertise. Using this system to determine the cause of anemia is not only labor and resource intensive but it carries a potential for morbidity and an occasional mortality. Utilizing previously published data, we created an algorithmic approach to analyze the cause of anemia in the majority of cases. The algorithm accepts as input three parameters from a CBC test: (1) mean corpuscular volume, (2) red cell distribution width, and (3) reticulocyte count. With these three parameters, the algorithm generates a probable etiology of the anemia. Additionally, the algorithm will automatically order reflex tests needed to confirm the diagnosis. These reflex tests can be modified depending on the policies of the institution using the algorithm, as different institutions may order different tests based on availability and costs. This is a simple algorithm that could be integrated into the CBC test output. When a low hemoglobin level is found, the algorithm suggests the probable etiology and orders reflex tests if they are desired. Such an approach would not only provide cost efficiency and time savings but would also elevate the level of every clinician ordering a CBC to that of an expert hematologist.

Keywords: anemia, reflex testing, diagnostic algorithm

Introduction

Anemia is a manifestation of an illness rather than a specific diagnosis, and as such, it always requires further inquiry as to the etiology. The bedside evaluation of a patient with anemia is neither sensitive nor specific enough to establish the diagnosis, except in the case of obvious bleeding, thus, making laboratory evaluation essential. The World Health Organization criteria for anemia are hemoglobin values of less than 13g/dL for men or 12g/dL for women or hematocrit concentrations of less than 41% for men or 36% for women. Using these criteria, in the United States it is estimated that approximately 3.5 million people are anemic.

Anemia is a common condition encountered by all physicians, regardless of their specialty. Unfortunately, its evaluation is frequently an ad hoc and random ordering of a battery of tests. This not only leads to increased expense but poor management. Expert hematologists are capable of analyzing data from a routine complete blood
count (CBC) to guide them in accurate and efficient use of additional laboratory tests. An algorithmic approach based on the methodology used by an experienced hematologist can guide physicians, who are not specialists in this area, to an accurate, timely, and cost-effective diagnosis.

1. Current Diagnostic Methodology

Evaluation of blood cells has dramatically changed in the past 30 years. Manual microscopy has been replaced by automated flow cytometry and image analysis. Flow cytometry utilizes a high-speed jet of fluid with suspended cells moving in a single file past a sensor. The sensor can measure variables such as impedance, enzyme content, and specific markers. This process can rapidly count large number of cells and the data generated is accurate and reproducible.

The two variables of highest importance in the initial evaluation of anemia are mean corpuscular volume (MCV) and red cell distribution width (RDW). MCV represents the average size or volume of an RBC. The MCV may be low (microcytic), normal (normocytic), or elevated (macrocytic). The variability in the size of red cells if plotted on a graph appears as a bell shaped curve. The ratio of the width of the curve to MCV is reported as RDW. The RDW may be normal or elevated. An elevated RDW represents heterogeneity in red cell size (anisocytosis).

2. Current Approach to Anemia Evaluation

Physicians of all specialties, ranging from psychiatrists to gynecologists, encounter anemia. If anemia is noted on the CBC results, further tests are ordered by the physician depending on their expertise in the field. A usual approach is a battery of tests to exclude iron and B12 deficiency, which account for approximately 40% of the cases. A hematology or gastroenterology consult may also be requested. This is not a systematic or scientific approach and is cost and time inefficient.

3. Proposed Algorithmic Approach

When an anemia is initially detected on a CBC, a reticulocyte should be ordered reflexively. Previously published algorithms exist which can use the reticulocyte count as well as two parameters from the CBC to accurately diagnose the etiology of the anemia in a large proportion of cases (see Figure 1). This proposed diagnosis should be automatically displayed beside the CBC results.

Once the algorithm has generated the probable diagnosis, appropriate confirmatory tests could be ordered manually or by reflex testing if desired. The recommended confirmatory test could be included as an advisory in the report. Each institution may choose its suggested confirmatory test based on individual preferences. Clearly, the reflex testing need not be repeated once the initial diagnosis has been established. In cases where the information is conflicting or the confirmatory test do not clinch the diagnosis, a hematology consultation could be required.
4. Discussion and Conclusion

The availability of automated flow cytometry and computer based analysis of the parameters generated could produce a CBC result with the measured parameters and, as well, an expert analysis of those parameters to arrive at the cause of anemia. Further testing could be guided by this analysis and, for the ease and convenience of the average physician, confirmatory tests could be listed. The reflex testing methodology is already in widespread use and has produced efficiency and cost savings. A similar approach can be applied for such a common condition such as anemia. This approach would not only provide cost efficiency and timesaving but would also elevate the level of every clinician ordering a CBC to that of an expert hematologist. This model needs further validation in a clinical setting. A retrospective analysis could illustrate the time and monetary resources wasted by current practices, and a prospective study, integrating this algorithm into the CBC results, if positive, could change the way we practice medicine.
Process Data: a Means to Measure Operational Performance and Implement Advanced Analytical Models

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Abstract. We present the case of an ambulatory clinic in which an operational review was conducted to identify opportunities for efficiency in appointment scheduling and capacity allocation. We required process data to compare that which was planned to that which actually happened and to develop advanced analytical models. Similar to other health care studies, these data proved to be limited or non-existent. Consequently we had to conduct a time-consuming collection of operational metrics. We make recommendations for the perpetual collection of process data for modeling and simulation.

Keywords. ambulatory care unit, outpatient clinic, process performance data, operational review

Introduction

We examine the case of an outpatient clinic where patient delays and sub-optimal resource utilization led to an operational review. This situation is common across the health care system: a service with variable demand undergoes complex processes under limited resource availability, resulting in operational difficulties, especially during periods of high activity.

Determining an efficient process configuration is a difficult task, mainly due to the presence of variability, but also because of the complex interaction of multiple entities that typically share resources in the process. Therefore, a detailed analysis of the system and decision support tools are required to address these issues effectively.

Advanced analytical methods from the Operations Research (OR) field provide the means to approach this type of problems. OR is the science of developing and applying mathematical models to provide decision-makers with better strategies to plan and operate systems. Techniques from this field are extensively and successfully being used in many industries [1], such as automobile, airlines, forestry, electronics, telecommunications and transportation, and are becoming more common in health care.

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To understand the current state and identify problems, we required detailed data about the processes and resources in the system. In particular, we needed to contrast what was initially planned and what actually happened, and develop metrics to evaluate the performance of the operations. The focus of our study was on achieving a better utilization of resources through changes in the processes, but also on improving the patient experience, an aspect not usually considered in this type of reviews.

To test scenarios with different configurations of the process, we developed a computer simulation model of the outpatient clinic. This type of model is very helpful, but also demands detailed data to accurately replicate the process and performance metrics for comparing scenarios.

Unfortunately, process-related data are usually not collected in the health care sector, hindering the development of advanced quantitative models and evaluation of process changes. During this study, process data proved very limited for our purposes, necessitating time consuming collection of operational performance measures.

Our analysis of the data and the use of our simulation model identified a range of opportunities to improve operations. A complete discussion of the simulation model and the results is available in Santibáñez et al [2].

This paper describes the data needs for this type of study methods, the challenges we faced regarding access to appropriate process data, and recommendations as to what and how data should be collected to support similar advanced analytical studies.

1. Context and Problem

Our study was developed for the Ambulatory Care Unit (ACU) in the Vancouver Centre of the British Columbia Cancer Agency (BCCA), a Province-wide provider of cancer care services for the residents of British Columbia and Yukon, Canada.

The ACU, an outpatient facility, is the primary point of physician-patient interaction. BCCA is an academic teaching and research institution, and in addition to oncologists there are also medical students, residents and fellows participating in the consults. Clinics consist of an oncologist and the group of patients scheduled for the day. During a given day, there are multiple clinics running in the ACU.

At the operational level, clinics are, to some extent, independent to the others in that patients have a pre-scheduled appointment with a specific oncologist. However, clinics share physical space and nursing and clerical staff. Each clinic is assigned one or more examination rooms depending on whether other physicians will be participating in the clinic that day, and the number and type of appointments. These rooms are dedicated to a particular oncologist for a given clinic session.

Part of the complexity in the process comes from the scale of operations. In terms of patient volume, the ACU has an average of 200 patient visits per day (more than 50,000 per year). On a typical day there are between 15 and 25 clinics operating simultaneously, and there are a total of 45 examination rooms for consults.

One of the problems is that at times of peak volume, ACU personnel experienced a limited supply of physicians’ space, clerical support and examination rooms. This led to delays in the clinics’ operation, overcrowding, stress, and an inferior patient experience. The general consensus was that additional rooms, both for examination and physicians, would help alleviate these issues. During busy days, all examination rooms were assigned to clinics, leaving no apparent surplus in physical capacity.
2. Appointment Process and Assessment

ACU appointments can be described by the following steps, as depicted in Figure 1:

a) Patients arrive to the ACU and check-in at the reception. This event is recorded in the booking system, registering the time of arrival of the patient.

b) The patient goes to the waiting room and remains there until called.

c) A nurse or volunteer takes the patient into an available examination room, and fills in basic information such as weight and overall status in the patient record.

d) The patient waits in the room for the physician(s).

e) The physician(s) come into the room, perform the consultation and prepare orders (to be processed by clerical staff at the nursing stations) for diagnostic tests, treatment or future appointments.

f) In the case of multiple consults, the patient waits in the room for the next physician to arrive, subsequent consults take place, and then the patient exits the room and goes back to the waiting area.

g) After the orders are processed, the patient is discharged from the ACU.

Each clinic has the planned activity for the day in the schedule with all the booked appointments. Schedules indicate the start and finish times for each patient appointment, and assume all resources are available. This includes that the patient has arrived, there is an examination room accessible when needed, and the physician is available. If for any reason the patient is not ready, there is no room available, or the physician is busy with another patient, the appointment will not be executed as planned. If schedules are executed as planned, there should not be delays for patients or any other operational problem.

The difficulty is that schedules only provide information about what is planned to happen, not what actually occurred, and therefore cannot be used for performance evaluation. Both the schedules and its execution are required to quantify delays and resource usage, and identify bottlenecks in the process.

Consequently, we needed to analyze the execution of each appointment and determine the availability of resources at any time. This means having, for every appointment, the time of patient arrival, the times patient entered and exited an examination room, the times physicians went in and out of those examination rooms, and the numbers of examination rooms being used at any moment in the day.

Comparing planned versus actual process times allows the determination of whether schedules are being realized as intended, and to identify process bottlenecks and their causes. Unfortunately, the appointment systems contained only booking data (i.e., scheduled activity), with no information on the actual execution of the schedules. No other information source was available to evaluate how schedules were being followed.

3. Data Collection of Process Times

We carried out a data collection study to capture a representative sample of the process times required to perform the evaluation of the schedules. To be the least invasive, we hired graduate students during spring break to observe individual patient appointments in several clinics simultaneously. Time stamps were captured for every stage in the
process described above, including patient arrivals, physician-patient interaction, chart/order processing, turn-around times, and room utilization.

Prior to collecting data for the entire clinic, we piloted different methods. The first one was a MS Excel-based tool on a laptop computer. Using Visual Basic for Applications (VBA), we built a graphical representation of the facility layout and implemented click-and-record counters for each type of event, storing the data in spreadsheet format, ready to be analyzed. The graphical user interface (GUI) displays the individual status of up to 6 examination rooms as time stamp data are entered for each event. This simplifies the data collection by allowing the surveyor to visually keep track of patient/room utilization. However, we encountered several difficulties with this method. First, the battery life of our laptops was less than the duration of a clinic (3 to 4 hours). It was inconvenient to charge the computers while collecting data since power outlets were not available in proximity, and using extension cords will interfere with patient flow and potentially be of risks to patients and staff. Second, it was impractical for surveyors to hold a laptop for the entire observation period, and using chairs and tables proved disturbing in the clinic environment, both for staff and patients.

Our second collection method was based on hand-held devices with a modified version of the MS Excel/VBA application. The much smaller devices, with longer battery life and still a user-friendly, full-color GUI, resulted in an improved experience. Nevertheless, we also encountered challenges. The most significant was to append and/or amend recorded data when necessary, which was slow and difficult to execute.

The third method we tried was a low-tech version of our application: we used the traditional clipboard, a stopwatch, and pen and paper to capture event times. Following the format of our Excel/VBA tool, we created paper-based forms and organized them in stacks representing the location of the rooms being observed by a surveyor. This served as a visual aid to relate events with the forms where they should be recorded. This method allowed for amendments to be easily incorporated, full view of the current status of the system, and surveyor mobility. Its major drawback was that collected data needed to be transcribed into electronic format. After considering all the advantages and disadvantages of the three systems, we selected the last method for the full study.

We also contemplated technologies such as radiofrequency identification (RFID). After some preliminary research we discarded them as viable options for this phase because of higher implementation cost and development time. We believe that automated, non-intrusive methodologies like RFID or similar are preferred solutions for collecting process data on a permanent basis and at a larger scale.
In total, we captured up to 14 process time-stamps for 600 patient appointments during a period of two weeks. With these data we reconstructed the different stages in the process for each patient and determined statistical distributions. We also linked the data to the booking system to append appointment information from the schedule.

The data collection was expensive, and difficult to plan, execute and replicate. For subsequent phases of our study, including implementation and evaluation of process changes, we are designing an electronic system that can operate on a permanent basis with minimum human interaction and provide real-time data.

4. Simulation Modelling, Performance Evaluation and Results

To provide a framework for developing recommendations we built a computer simulation model of the process. This technique allows to effectively account for variability, and has been extensively used to address a broad range of problems in health care settings, such as those described by Jun et al (1999) [3].

Considering the structure of the process, we developed a discrete event simulation model of the entire ACU using the Rockwell Arena (version 11) software. The model encompasses patient flow from arrival to departure from the examination room, seizing limiting resources such as physicians and examination rooms. It incorporates the randomness and variability present in all stages of the process, including patient arrivals, consult durations, and other process times.

To evaluate the performance of each scenario, we defined the following metrics: patient wait time, clinic duration, physician idle time, and resource utilization metrics including waiting room occupancy and examination room utilization.

We used the simulation model to identify limiting resources and on a “What if?” basis, to evaluate the impact of changes in physical configuration, scheduling and resource allocation policies. We found that a combination of strategies in terms of clinic start, appointment duration, and management of unscheduled cases can significantly decrease patient wait times, with almost no deterioration of the other performance metrics. In these scenarios we also observed, as a derived result, a significant decrease in room utilization, indicating that this was not a limiting resource. We tried additional scenarios with a more dynamic room allocation policy and decreased the availability of examination rooms, finding that under these settings a considerable number of the existing rooms can be spared with no significant impact on the patient experience or utilization of other resources. The liberated rooms can be converted into additional physician space, or used to accommodate more clinics.

5. Discussion

5.1. Problem Generalization

The problem faced in this paper can be generalized to many other settings in health care. At the most simplified level, our case represents an outpatient consult that requires a particular resource (physician), and employs other shared resources such as physical space (room), medical equipment and personnel (nursing, specialists and
clerical staff). A natural extension is other ambulatory services in outpatient facilities. These include a range of services along the continuum of care, from primary care clinics to mental health and diagnostics. The methodologies used in our study can be applied to these other cases to streamline the processes and reduce unnecessary waits.

5.2. Health Information Systems and Process Data

Health Information Systems (HIS) contain a wealth of data. However, these data are usually associated to clinical or billing information, with very limited operational value. One of the main challenges in this project was the lack of data in the form required to develop advanced analytical models. Based on our experience in many other health care projects, this is a recurring problem for this sector.

Process-related information has received little attention; it is hardly measured, and even less frequently stored in a database/warehouse. The lack of data prevents the execution of in–depth studies based on advanced analytical methodologies. Furthermore, having no baseline and post-implementation data inhibits the execution of a proper evaluation of the implementation of changes to the processes.

Fortunately, HIS are rapidly evolving. The main focus to date has been on the integration of clinical, imaging, order entry, and other components to implement electronic patient records. We believe an opportunity exists to incorporate operational data to those information systems, which will in turn facilitate the implementation of OR applications that can lead to significant gains in efficiency.

5.3. Recommendations

To support operational performance evaluation and the development of advanced analytical methods, such as those from the Operations Research field, we strongly advise health care organizations to collect process data. These data are related to the temporal realization of the same events that are planned and scheduled in a process, such as start and finish of a consult or appointment duration.

Process data should be collected on a permanent basis and stored in such a way that can be linked to other information systems. Collection of these data is not a simple task and will most likely require additional infrastructure and/or cultural changes to be sustainable, but the benefits of this information are invaluable.

Ideally, the data collection system should be integrated to existing HIS and be readily accessible to allow more informative reports to be developed. This will support both decision makers and operations researchers alike, enabling the development of advanced analytical models to find opportunities for improvement in the processes. Participation of HIS specialists is paramount to the success of these projects.

Acknowledgements

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References


Benefits and Challenges of Health Information Systems for Operations Research: An Illustrative Example to Improve Surgical Scheduling

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Abstract. Operations research (OR) is playing an increasing role in the support of many health care initiatives. However, one of the main challenges facing OR practitioners is the availability and the integrity of operations data. Hospital information systems (HIS) are often designed with a clinical or accounting focus and may lack the data necessary for operational studies. In this paper, we illustrate the data processing methods and data challenges faced by our team during a study of surgical scheduling practices at the Vancouver Island Health Authority. We also provide some general recommendations to improve HIS from an operations perspective. In general, more integration between operations researchers and HIS specialists are required to support ongoing operational improvements in the health care sector.

Keywords. operations research, health information systems, data challenges

Introduction

Operations research (OR), the discipline of applying advanced analytical methods to decision making, is becoming increasingly popular to help better manage the limited resources in health care. The need to reduce wait times and increase access to care has led to an increased presence of OR based initiatives. OR has been around for over 50 years and has been applied to many different industries. Techniques in OR are used to help make better operational decisions based on sound quantitative evidence. Interested readers can refer to a well written book by Hillier and Lieberman [1] for an introduction to OR based techniques. Applications of OR in health care are diverse, ranging from reduction of emergency room congestion, to the location of new health care facilities, to clinical decision making. Pierskalla and Brailer [2] illustrate the breadth of OR applications in health care.

Health information systems (HIS) in hospitals store a wealth of information that, when analyzed in the proper context, can be used to support hospital operations and OR

1 Corresponding author: Vincent S Chow, British Columbia Cancer Agency, 600 West 10th Avenue, Vancouver, BC, Canada, V5Z 4E6; e-mail: vchow@bccancer.bc.ca.
based solutions. Pierskalla and Brailer [2] and many others have identified the importance of HISs and how they play an integral role in supporting these solutions. However, many OR practitioners also mention data availability as a major issue. Challenges include poor data accuracy and consistency, lack of HIS integration across departments, and the lack of the desired data altogether. As a result, considerable amount of time and effort is often required to obtain workable datasets for OR studies.

1. Objectives

The objectives of this paper are:

- to illustrate the important role HISs play in OR related studies,
- to illustrate the challenges faced by OR practitioners when using current HIS for OR studies, and
- to provide recommendations for improvements in HISs to aid future studies.

To achieve these objectives, we will describe an OR study we carried out in collaboration with the Vancouver Island Health Authority’s Surgical Services Department that illustrates the process and subsequent challenges of data processing. While we will be providing some background and context, the intent of this paper is not to recount the study. For more details please see, Chow et al [3]. We will then discuss challenges in extracting and processing data and provide general recommendations aimed at improving HISs for OR related studies.

2. Study Background

The Vancouver Island Health Authority (VIHA) provides health care services to over 750,000 British Columbians. With continuing pressure to deliver more surgical procedures, congestion at VIHA hospital surgical wards has increased. This has lead to ward over-capacity which causes additional stress for hospital staff, more surgical cancellations and prolonged wait times. In 2007, we conducted a study at the Royal Jubilee Hospital (RJH) in Victoria to investigate which factors contributed to ward overcapacity and developed OR solutions to address them. Site visits were made to RJH to observe the surgical program and to gain insights into potential solutions. Interviews with key stakeholders provided a general idea of the issues involved but an in-depth analysis of data within the HIS clearly identified the problem.

3. Methodology

3.1. Identification of Data Needs

Operations research focuses on quantifying what actually happened in a system; not what was scheduled or intended to happen. Understanding actual operations can help identify underlying issues causing the problem. Analyses based solely on qualitative sources such as interviews can lead to erroneous conclusions. Frequently, people tend to remember the rare one-off cases that are not common to typical operations. In this particular study, we focused on analyzing data that could identify factors that lead to
overcapacity in wards. This paper will describe our approach to obtain and process this data, and illustrate the challenges we faced.

In our data analyses, we sought to account for each patient within each surgical ward and determine whether these patients had surgery. In addition, if they were surgical patients, we needed the following patient information:

- Surgical specialty (orthopedics, general, etc.)
- Patient type (day care, inpatient)
- Method of entry to the hospital (elective or emergency surgery)
- Surgery date
- Recovery wards visited, and the order and length of stay within each ward

At the time of the study, VIHA had reports generated from their HIS where data cubes were constructed to allow managers to analyze data across different dimensions. However, data present in these reports were too general for our purposes. Therefore, our team directly used several of the underlying data sources.

3.2. Data Sources

The Admissions Discharge Transfer (ADT) system provides patient tracking information using Health Level 7 (HL7) standards to transmit and exchange information. This system allows the hospital to determine the location of an admitted inpatient within the hospital through the entry of an admission, transfer, or discharge time stamp by a care provider, usually a nurse. In addition to a unique patient ID, the ADT data source also contained a data field named “Inpatient Encounter ID” (EID) which generates a unique number for each unique inpatient visit to the hospital. We obtained a record of all admission, transfer, and discharge records along with its EID number to allow us to reconstruct each patient visit within the surgical wards.

The Operating Room Scheduling Office System (ORSOS) is used for the scheduling and management of surgical procedures. In our study, we used ORSOS as a data source to obtain the surgical procedures performed and for each surgical procedure, we obtained its type, specialty, and date.

The Discharge Abstract Database (DAD) contains demographic, administrative and clinical data for both inpatients and day surgeries. This information is submitted to the Canadian Institute for Health Information (CIHI). The information in this database acts as a data source for verification. This data source also provided information on day surgeries whereas the ADT database only contained inpatient information.

A nightly bed count performed by nurses at each surgical ward was also used. This data source is stored electronically and served as a validation tool for our data cleaning.

3.3. Data Processing

Data processing is often the most time-consuming activity in an OR study and this study was no exception. The ADT data source had consistency issues and contained erroneous transfer entries. Patient characteristics were also stored in other data sources (ORSOS and DAD) for the same patient. To achieve the full breakdown of surgical occupancies, cleaning and linking of these data sources were required.
3.3.1. Data Cleaning

Data cleaning was first performed on the ADT dataset by attempting to reconstruct the ward occupancies using only ADT feeds. This was done by aggregating ADT feeds based on EID to create a unique patient visit record (referred to from now on as an EID record), each describing the path of wards and the associated length of stay a patient stayed. Data on 81035 cases over an 11 month period was analyzed. Approximately 7% of these records had an error. Most errors were ordering errors (6.4%) where a transfer time stamp occurred before an admission time stamp, or a transfer time stamp occurred after a discharge time stamp. In other instances, one patient may have two EID records with overlapping time points, suggesting there is two of the same person at a given time (0.3%). Duplicate records were also present as well (0.3%). The reconstructed ward occupancies were compared with manual head counts performed nightly by ward nurses. Discrepancies were identified and the erroneous records were fixed or removed. A considerable amount of time was spent to achieve a clean ADT dataset. Data cleaning was also necessary for ORSOS but as the data was extracted from a structured database, it was less prone to errors (<0.1%).

3.3.2. Data Linking

The only common field among all data sources was a unique patient identification number. This number does not allow for a unique match since each patient may visit a hospital more than once during a given time period. An EID field did exist in the ORSOS database, but it was not frequently reported. Instead, each record in ORSOS was linked to ADT based on time. If a patient’s ORSOS operation date fell within an ADT visit record, then the records would be linked. However, this criterion did not successfully link all cases. In particular, it may be possible for a patient to have an operation before being formally admitted into a hospital (e.g., emergency cases, hospital transfers, etc.). For such cases, the operation date may precede the admission date. Other minor discrepancies may exist as well and these cases had to be accommodated for by relaxing the matching criteria. The resulting linkage between ORSOS and ADT was then cross verified with DAD records. Any discrepancies were further scrutinized to ensure the linking was accurate. After several iterations of linking the data and validating, a finalized dataset was obtained.

3.4. Use of the Constructed Dataset

The data cleaning and linking took roughly 4 weeks of time for two analysts. Most of this time was spent understanding the types of errors that existed in the data sources and finding solutions to address them. An analysis of the consolidated dataset indicated that a sizable portion of beds occupied were not surgical patients, but medical patients. This meant that the interaction of these two patient groups might contribute to the observed congestion. In addition, the current approach to scheduling the surgery dates of the elective patients was a significant factor in ward overcapacity. While variability exists on a day to day level for unplanned patients, their average occupancies in each day of the week across surgical wards was consistent. Elective surgical patients on the other hand, exhibited a reoccurring pattern of low occupancies on Mondays and high occupancies on Fridays, causing overcapacity issues at the end of the week. This has led our team to develop recommendations to address elective surgical scheduling.
The important findings from the consolidated dataset lead to the development of two operations research based models: the Bed Utilization Simulator (BUS), an MS EXCEL-based simulation model, and a mixed integer program developed in Frontline’s Premium Solver Platform with Xpress Solver plug-in to support surgical scheduling decision making. Both models made extensive use of this consolidated dataset to deliver recommendations for VIHA.

4. Results and Discussion

4.1. Project Results

Results of the project illustrated that VIHA had the potential to significantly reduce instances of patient location to non-ideal wards and surgical cancellations while at the same time increasing the number of surgical cases performed. The BUS model helped quantify the impact of new surgical initiatives, alternative surgical schedules, and varying ward capacities on ward occupancies.

The project has been tested and will be used to inform an upcoming revision of the surgical schedule. Surgical planners recognize that using BUS can assist them in testing new schedules on a what-if basis. VIHA recognizes the value of Operations Research. The Operations Research Department within VIHA is now evaluating the possibility of expanding the tool for use at other sites within the authority.

4.2. Recommendations

The data challenges we described above are common to many OR studies. The principle reason for these challenges is that HISs are not designed with patient flow and system improvement as their main focus. From this and other health care based studies, we can recommend several changes to the existing HISs which would greatly benefit OR based studies. These recommendations are the following:

- Include common identifiers across multiple databases
- Develop methods to minimize data entry errors
- Collect process and demand related time stamps

The presence of a common identifier, such as the EID number in our study, would reduce the effort required to link databases. Integrating other databases such as labs, pharmacy and other departments allows researchers to analyze the full spectrum of care received by a patient. These linkages would enable quicker project turnaround time, and the development of more sophisticated models.

Developing methods to minimize data entry errors is also vital for OR projects. When possible, redundancies and checks should be integrated. Proper time stamp ordering would have greatly reduced data cleaning time in our study.

The availability of accurate time stamps for each action on a patient is crucial for any type of operations based analyses. Common time stamps include transfer and discharge times as described above as well as the beginning and end times of key activities such as operating room and PACU occupancy. These time stamps would allow for the calculation of process times for major steps within the process. Other time stamps which measure the demand for resources, such as the paging of an orderly, or a request for imaging/lab results, are all significant time stamps as well. These times
allow for the analyses of the demand for various resources. All the recorded time stamps should be stored and never overwritten to keep detailed operational information for future OR needs. In general, time stamps are needed in OR studies to help identify bottlenecks within the system.

The application of such changes to current HISs would require extensive planning and may require a revision of current standards. Many health facilities are heading towards a more integrated HIS across departments and the field of OR is one of many fields that would benefit greatly from this integration. The inclusion of key operational data such as that described above would be invaluable to OR studies.

From our experience, a large gap of knowledge still exists between both OR practitioners and HIS specialists. A lack of understanding of both party’s field of work contributes to this gap. This paper aims to present an OR perspective on this topic. We believe that increased integration between both parties is necessary. For operations researchers, increased knowledge learning of HIS is warranted while for HIS specialists, greater exposure to OR would provide a better understanding to OR needs. Having cross functional teams for both HIS and OR projects would be a good first step towards achieving such a partnership.

5. Conclusion

Operations Research is playing an increasing role in many health care sectors. To support these initiatives, HISs with proper capture and storage capabilities are necessary. Many OR practitioners are becoming more adept with HIS through data analyses and likewise, many HIS specialists are also becoming aware of the benefits of keeping detailed operational data. However there are still much more learning and collaboration possible. Through increased collaboration, better operations based solutions can be realized to improve patient care.

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References


Toward Automatic Detection and Prevention of Adverse Drug Events

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Abstract. Adverse Drug Events (ADE) due to medication errors and human factors are a major public health issue. They endanger patient safety and cause considerable extra healthcare costs. The European project PSIP (Patient Safety through Intelligent Procedures in medication) aims to identify and prevent ADE. Data mining of the structured hospital data bases will give a list of observed ADE with frequencies and probabilities, thereby giving a better understanding of potential risks. The main objective of the project is to develop innovative knowledge based on the mining results and to deliver to professionals and patients, in the form of alerts and decision support functions, a contextualized knowledge fitting the local risk parameters.

Keywords. adverse drug event, ADE, data mining, computer-decision support system, CDSS, knowledge elicitation

Introduction

Adverse Drug Events in the Hospital Setting

In the last ten years, Adverse Drug Events (ADEs) have become a major public health issue [1]. Applications in healthcare information and communication technology (ICT) should help to reduce the prevalence of preventable ADE but their efficiency is impeded by the lack of reliable knowledge about ADE and the poor ability of ICT solutions to deliver contextualized knowledge. This is aggravated by poor consideration of causative human factors [2].

In the hospital context, ADEs occur during the course of the Medication Use Process that describes the typical flow of action related to drug therapy [3]. The main steps of the medical use process are the physician diagnosis and prescription, the pharmacist verification and dispensation, and the nurse control and administration. An ADE is “an injury caused by medical management rather than the underlying condition of the patient” [4]. A non-preventable ADE consecutive to a normal use of a drug is usually distinguished from a preventable ADE consecutive to an error. A medication error is characterized as a distance to “what should have been done” in the therapeutic care process [5]. This normative definition may generate some difficulties. Besides the
In order to efficiently prevent ADE, it is mandatory to have a proper knowledge of the ADE. Retrospective analyses methods consist in assessing events such as accidents, incidents or near-misses. The objectives are the identification of the fundamental reasons, facts and causes that fostered the accidents or incidents [8]. These methods are efficient but very time consuming and intrusive. As well, it is sometimes difficult to generalize the results. Therefore, the most common method remains the voluntary report of an ADE by a healthcare professional who completes a structured form and includes a descriptive narrative of the incident.

Unfortunately the rate of incident reporting is extremely low. Declarations of medication accidents/incidents are compulsory but users often hesitate to complete them due to lack of time and, also, possible blame [9].

Another reason, though, could explain the low-level of reporting of Adverse Drug Event: they may be difficult to detect. To differentiate a potential ADE from a “normal” symptom is not so easy. In contrast, it is easy to detect a serious accident in the industrial or transport domain. The technical systems are supposed to function correctly and any disturbance to the nominal functioning can be considered as an incident. The computerization of medical records as well as electronic prescribing and Computerized Physician Order Entry (CPOE) systems has opened interesting opportunities for new methods of ADE detection.

The PSIP Project

The European Patient Safety through Intelligent Procedures in medication project (PSIP) [10] aims to overcome the problem of ADE detection by searching huge repositories of electronic medical records and data in order to detect abnormal cases that present typical ADE features. The objective of the PSIP project is 1) to facilitate the systematic production of epidemiological knowledge on ADE and 2) to ameliorate the entire medication cycle in a hospital environment.

The first sub-objective of PSIP is to innovatively produce knowledge on ADE: Data mining of the structured hospital data bases will provide a list of observed ADEs
with their frequency and probability and patterns of statistical associations to gain a better understanding of potential risks. Data mining, also called Knowledge Discovery in Databases (KDD) or Knowledge Discovery and Data Mining, is the process of automatically searching large volumes of data for patterns using tools such as classification, association rule mining, clustering, etc.

The second sub-objective of the PSIP project is to develop innovative knowledge based on the mining results and to deliver to professionals and patients a contextualized knowledge fitting the local risk parameters in the form of alerts and decision support functions. This knowledge will be implemented in on PSIP platform independent of existing ICT applications. These applications will connect to the platform to access and integrate the knowledge in their local systems. The design and development cycle of the PSIP solution will be human factor oriented and take the complexity of the health care professional’s activity into account.

Traditional approaches to the problem of ADE detection are usually knowledge-oriented. For example the starting point of an ADE report is the knowledge that a potential ADE has occurred. The PSIP project addresses the problem of ADE detection the other way around: it attempts to track potential ADEs back from the manifestation of their outcomes as identified using mining techniques. As such, one of the most important challenges of the project is the validation and interpretation of the data and semantic mining results.

The relevance of the results provided by the data mining is critical for the proper functioning of the project. Indeed, results with a too large a proportion of atypical cases that do not turning out to be actual ADEs would make the development of alerting and decision support functions almost impossible. It is therefore necessary to closely monitor the validation and interpretation of data mining results and to set specific methods for this important knowledge elicitation phase. This requires the participation of experts in charge of 1) assessing the adequacy of the rules for automatic selection of atypical records that may be ADE-related and 2) producing the necessary knowledge to characterize these ADEs and to feed the decision support rules of the PSIP platform.

The human factors specialists participating in the PSIP project will both support and monitor the experts’ activities while assessing the selection rules of potential ADE-related records and characterizing these ADEs. The objective is to understand the experts’ reasoning and the parameters or data they rely on while interpreting or validating the ADE cases. This information should help to iteratively refine the data mining procedures and rules.

1. Methods

1.1. Atypical Medical Records Selection

1.1.1. Data Model

One year of medical record archives are extracted from different French and Danish hospitals repositories and analyzed by data and semantic mining techniques. The atypical records are selected according to the characteristic of a data model specifically designed for extraction and mining purposes, characterized by 72 fields grouped into 7 main categories: 1) administrative information (patient, flows), 2) medical diagnoses,
3) medical procedures, 4) drug prescriptions, 5) biology results, and 6) reports and letters.

1.1.2. Data-mining Rules

Data mining techniques allow eliciting association rules describing the statistical link between several causes or contexts and an effect. Several different effects can be traced. The nature of some effects or the fact that some drugs appear as causes or contexts can often be interpreted as the possibility of an adverse drug event. For example the following descriptors should contribute to the characterization of a stay as abnormal:

- Specific sequences of steps of the stay, like a transfer from a standard medical unit to an intensive care or resuscitation unit in the middle of the stay without any surgical procedure before,
- A duration of the stay longer than the expected duration when considering the patient’s Diagnosis Related Group (DRG),
- Death of the patient while the probability of death of his DRG is low, and
- The fact that the stay crosses different medical specialties, etc.

The data mining process provides several decision rules that can be expressed under the following format:

\{patient older than 75\} AND \{vitamin K antagonist\} AND \{another drug having enzyme inhibition side effect\} \implies higher probability of death.

Each rule is characterized by:

- its support (number of previous stays matching the conditions and having the effect), and
- its confidence (probability of having the effect once the conditions are met).

An important point is that the support and the confidence may vary between two different medical departments and/or different hospitals. The contextualization of the statistical link appears as a very important feature. In each department those rules have to be filtered to make sense and to limit their number. Confidence thresholds have to be carefully tuned to obtain relevant and reliable rules.

As the results of the data mining process can be expressed under the form of rules, and as these rules can be weighed by confidence parameters, it is possible to use these rules as the basic foundation for the Decision Support System aimed at reducing the number of Adverse Drug events. The contextualization of the rules is obtained through the application of different weights to identical rules, or by the identification of specific rules.

1.2. Analysis and Validation with the Expert Group

An expert group, composed of pharmacologists, pharmacists and physicians is asked to review the results obtained by the knowledge rules. They have to characterize two types of stays: 1) stays connected with knowledge rules, 2) stays not connected with knowledge rules. The experts have access to the medical record of the stays in order to infer the presence of Adverse Event, ADE and Preventable ADE. The main objective of this evaluation is to validate the accuracy of the knowledge rules for the detection of ADE. The experts are asked to analyze and interpret the atypical cases selected by data mining in order to a) support the refinement of the data model and data mining rule and
ii) issue usable knowledge to feed the decision support functions of the PSIP platform. Specialists in cognitive ergonomics provide methods to support this knowledge elicitation task, relying on the “think aloud” method to record the experts’ reasoning processes.

2. Results

In the PSIP project, the data mining is in progress but some preliminary results demonstrate the feasibility of the method and its potential to deliver a contextualized knowledge on ADEs. In this section, we present an example of knowledge discovered from the analysis of medical records by means of decision trees methods. These first results have been obtained from the data mining of 2700 records from cardiologic units of the Region H Hospitals (Copenhagen, DK). The results are expressed under the form of association rules. Table 1 gives two rules as examples.

At this stage of the project over 150 rules have been obtained by mining 2 different data bases from Danish and French hospitals. The rules are under validation process, and about 95% of the already reviewed rules have been validated. The experts’ review of the stays attached to the rules is in progress.

Table 1. Examples of association rules obtained from data mining.

<table>
<thead>
<tr>
<th>Rule 1</th>
<th>(Drug: vitamin K antagonist) AND (Drug: Prokinetic) =&gt; Appearance of a too low INR</th>
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<tbody>
<tr>
<td></td>
<td>{Drug: vitamin K antagonist} AND {Drug: Prokinetic} =&gt; Appearance of a too low INR</td>
</tr>
</tbody>
</table>
| Charac-
|     | teristics                                                                 |
|        | Support: 4; Confidence: 67%                                                      |
| Outcomes| This means that 6 stays match the conditions and four of them present the effect (4/6 = 67%) |
|        | Average duration of the stay: 15 days (the ordinary mean duration of stay for this type of patient is 6.5 days) |
|        | Outcomes                                                                 |
|        | Unexpected death 16.67%                                                          |
|        | Average duration of the stay: 15 days (the ordinary mean duration of stay for this type of patient is 6.5 days) |
| Rule 2 | (Drug: vitamin K antagonist) AND (Drug: antibiotic = betalactamin) AND {age < 76 years} => Appearance of a too low INR |
|        | {Drug: Prokinetic} => Appearance of a too low INR                                |
|        | Support: 3; Confidence: 60%                                                      |
|        | This means that five stays match the conditions, three of them present the effect (3/5 = 60%) |
|        | Average duration of the stay: 12.6 days (ordinary mean duration: 6.0 days)        |
|        | Outcomes                                                                 |
|        | Death: 0%                                                                       |
|        | Average duration of the stay: 12.6 days (ordinary mean duration: 6.0 days)        |

3. Discussion and Conclusion

The current identification rate of ADE through reporting systems is too low to support an efficient prevention of these ADEs. Computerized-based screening of electronic medical records is considered an interesting alternative method to identify ADE [11] but current research suffers from low specificity in the identification of ADE and would therefore issue too general, non context-related potential alerts or DSS rules. PSIP is based on the hypothesis that data and semantic mining may allow the identification of a significant proportion of abnormal cases potentially due to ADE, along with the characteristics of their context of occurrence. The preliminary results of the data mining performed on two groups of hospitals from two different countries look promising, as the association rules seem able to catch the context of occurrence of the
identified ADE. However, in order to turn these retrospective data into prospective CDSS functions aiming at preventing those ADEs, it is necessary to:

- properly review and validate the association rules elicited by the data mining procedures,
- review the abnormal stays attached to these rules and validate their ADE status, as compared to a sample of “normal” stays not positively screened by the data mining process, and
- analyze the corresponding work system relying on a Human Factors (HF) approach in order to identify HF potential root causes of the identified ADE. This analysis is necessary to design acceptable and usable alerts or DSS functions aiming at preventing the ADE.

The objectives of the PSIP project are ambitious but the success of such a project would significantly contribute to patient safety by detecting and preventing a significant number of potential ADEs. The chances of the project reaching its objectives will be enhanced by considering human factors and ergonomics.

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References

Modeling Knowledge Resource Selection in Expert Librarian Search

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Abstract. Providing knowledge at the point of care offers the possibility for reducing error and improving patient outcomes. However, the vast majority of the physician’s information needs are not met in a timely fashion. The research presented in this paper characterizes an expert librarian’s search strategies as it pertains to the selection and use of various electronic information resources. The 10 searches conducted by the librarian to address the physician’s information needs varied in terms of complexity and question type. The librarian employed a total of 10 resources and used as many as 7 in a single search. The longer term objective is to model the sequential process in sufficient detail as to be able to contribute to the development of intelligent automated search agents.

Keywords. information seeking, search strategies, knowledge resources, cognition

Introduction

It is well documented that clinicians’ information needs arise continuously for physicians during the course of clinical practice and that unanswered needs have the potential to compromise patient care [1]. However, there is an abundance of high quality electronic information resources in healthcare to address such needs [2]. These range from a database of original articles in Medline to systematic reviews available through the Cochrane Library to summarized texts such as UpToDate, drug reference databases like those furnished by Micromedex Drug and search engines such as Google Scholar. Each resource is best suited to particular kinds of questions contain different kinds of content and support different search strategies (e.g., basic key word to advanced functions). Most clinicians lack the prerequisite knowledge to select the appropriate resources and the skills necessary to execute effective searches. McKibbon and Fridsma investigated whether physician’s use of resources improved their abilities to answer certain clinical questions [3]. Physicians demonstrated a marginal improvement in the number of correct answers. Ironically, some previously correct responses were incorrect after clinicians were given the opportunity to search. This is indicative of the fact that evidence-based resources are unlikely to improve decision making if clinicians lack mastery of the various knowledge resources and may even lead to additional errors. On the other hand, there have been studies demonstrating that...
health librarians possess advanced search skills and a repertoire of search strategies that can be used to address physician’s information needs [1].

The research discussed in this paper is conducted as part of the CIQR (Context-Initiated Question and Response) project [4,5]. Our objective in the CIQR project is to develop intelligent agent technologies that are able to accept a defined information need and autonomously generate complex, adaptive search strategies that will result in a high precision search to retrieve an appropriate answer. Towards that end, we are endeavoring to leverage expert search knowledge of librarians to articulate context-specific search strategies. We employ a hierarchical theoretical framework of information seeking proposed by Hung and colleagues [4]. The framework draws on cognitive models of information seeking [6] and constructs developed by information scientists for characterizing search strategies [7].

Information seeking can be construed as a problem solving activity. Problem solving consists of a search in a problem space, which is constituted by an initial state, a goal and moves that transition the solver from one state to another [8]. The CIQR framework describes four levels ranging from grand strategy at the highest level, which is largely concerned with resource selection to operations at the lowest level, which involve action sequences necessary to execute a query (e.g., select MeSH headings) in an information retrieval system. In this paper, we are focused on grand strategies. Appropriate resource selection is predicated on the type of question (e.g., foreground or background), the expected answer type (e.g., comparative efficacy of two therapies) as well as the purpose of the question (e.g., patient care) [4]. An effective grand strategy maps the demands and elements of a given question to information resource(s) likely to yield maximal value (e.g., the desired answer) with a lower cost (e.g., time saving). Depending on the complexity of the question, a grand strategy may necessitate multiple phases with each phase drawing on a single resource (e.g., Micromedex).

Although electronic knowledge resources are increasingly important in addressing health information needs [2], there is a paucity of studies that address effective resource selection strategies [3]. This paper reports on a formative qualitative study examining an expert health librarian’s search strategies in the context of the CIQR project. Our research program is predicated on the development of 1) elaborated information seeking theoretical framework and 2) novel methodologies for representing search strategies and differentiating the constituent components of the search process. The focus of the research presented in this paper is to model an expert librarian’s strategies as it pertains to the selection and use of various electronic information resources. The specific objectives are to provide a descriptive representation of the search process, expand upon an analytic vocabulary for characterizing the process and explain the variation in search strategy as a function of question type. The longer term objective is to model the sequential process in sufficient detail as to be able to contribute to the development of intelligent automated search agents.

1. Methods

The goal of this research is to develop technologies to help clinicians articulate information needs that arise during clinical practice, and address them in a timely manner that is co-extensive with clinical workflow. One of the objectives of the project is to test the efficacy of mobile devices to capture needs using data and voice input, and transmit them electronically for central processing. We have equipped several
clinicians at varying levels of expertise with digital voice recorders. Each clinician was asked to articulate their information needs at the closest possible proximity to its emergence. Since July 2007, 8 clinicians have participated in this study for 2 week intervals. The questions are transmitted as WAV files to a server, transcribed through an automated speech recognition system (ASR) (Dragon Naturally Speaking) and transmitted to a librarian via the CIQR workbench, a Java tool for managing Medline searches and searches of other data sources by clinicians and librarians. It provides a list of transcribed question as well as the voice files. Since the ASR was only partially successful, the librarian would often have to listen to the voice files to discern the questions. The librarian then conducts a search and returns an answer using the workbench to be received by the clinician.

The searches were captured in Morae™, a multifaceted usability, video capture and video analysis tool. Morae™ provides a video of all screen activity and logs a wide range of events and system interactions including mouse clicks, text entries, web-page changes, and windows dialogue events. This enables us to study the librarian’s information seeking performance in great depth. We have also asked the librarian to think-aloud as she performs the searches. The data for this paper was drawn from the first 10 searches that she performed. The searches address questions provided by three participants including an internist, resident and a final year medical student.

2. Results

The 10 questions (in abbreviated form) and electronic information resources used by the librarian are presented in Table 1. They vary considerably in terms of question type and complexity. The concepts in each question were mapped onto UMLS terms using a semi-automated system and serve as a coarse measure of semantic complexity. The number of UMLS terms range between 3 and 11. Following Ely’s classification scheme [9], 4 questions were diagnostic questions, 4 were etiology and 2 were classified as therapy questions. The duration of the searches ranged between 9 and 53 minutes.

The librarian used a total of 10 different electronic knowledge resources covering the spectrum. For a given question, she used as many as 7 and as few as two sources. Although there are too few questions to draw any firm conclusions, the number of UMLS terms was not strongly associated with the complexity of the search process. The librarian was intimately acquainted with each of the resources and understood their utility as well as their weaknesses. PubMed offers a wide range of affordances such as the MeSH database, limits, and clinical queries in which to expand or restrict the scope of a search. Others are limited to Boolean searches and yet others only provide for keyword searches.

Given the complexity and heterogeneity of the questions, it is difficult to discern recurring search strategies (from beginning to end) as reflected in the precise ordering of sources. However, the sequence of selection of resources appeared to follow a relatively precise logic. For example, PubMed was used initially to define terms such as diplopia and to seed MeSH terms for further searching. UpToDate and Stat!Ref were used in a similar sequence for 7 of the 10 questions. UpToDate provides a succinct summary that could be used to address a question. This in turn seeded concepts and terms that could be used to search Stat!Ref which provided additional documentation.
Table 1. Order of electronic sources employed by librarian in searching.

<table>
<thead>
<tr>
<th>Time</th>
<th>U</th>
<th>Questions</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>38:25</td>
<td>4</td>
<td>Can toxoplasmosis in the setting of HIV AIDS present with diplopia?</td>
<td>PM</td>
<td>MX</td>
<td>UD</td>
<td>SR</td>
<td>PM</td>
</tr>
<tr>
<td>31:30</td>
<td>5</td>
<td>For a patient with stable ventricular tachycardia what’s the indication for lidocaine and for amiodarone?</td>
<td>PM</td>
<td>MX</td>
<td>UD</td>
<td>SR</td>
<td>CR</td>
</tr>
<tr>
<td>27:11</td>
<td>4</td>
<td>Can HIV/AIDS patients with cryptococcal meningitis present without a fever?</td>
<td>UD</td>
<td>SR</td>
<td>GS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27:35</td>
<td>4</td>
<td>What is the incidence of Mongolian spots in newborn infants?</td>
<td>UD</td>
<td>SR</td>
<td>UD</td>
<td>PM</td>
<td></td>
</tr>
<tr>
<td>52:40</td>
<td>11</td>
<td>What diseases cause respiratory insufficiency, pulmonary infiltrates and anemia in young children (age 3 or younger).</td>
<td>UD</td>
<td>SR</td>
<td>PM</td>
<td>SR</td>
<td></td>
</tr>
<tr>
<td>34:20</td>
<td>7</td>
<td>Is there a relationship between phenobarbital exposure and hepatosplenomegaly or increased LFTs in infants.</td>
<td>OV</td>
<td>MX</td>
<td>LC</td>
<td>CP</td>
<td>UD</td>
</tr>
<tr>
<td>40:44</td>
<td>4</td>
<td>What's the differential diagnosis for congenital bilateral absence of thumbs?</td>
<td>SR</td>
<td>PM</td>
<td>UD</td>
<td>GS</td>
<td></td>
</tr>
<tr>
<td>9:18</td>
<td>6</td>
<td>Are there patients with fragile X syndrome who display some of the behavioral characteristics more commonly associated with autism?</td>
<td>UD</td>
<td>PM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42:30</td>
<td>6</td>
<td>Is it peritoneal dialysis or hemodialysis or CVVH better way to treat elevated blood ammonia levels</td>
<td>UD</td>
<td>PM</td>
<td>CR</td>
<td>SR</td>
<td>NG</td>
</tr>
<tr>
<td>14:00</td>
<td>3</td>
<td>Is there a genetic syndrome that links panhypopituitarism and ventricular septal defects?</td>
<td>PM</td>
<td>UD</td>
<td>SR</td>
<td>NG</td>
<td></td>
</tr>
</tbody>
</table>


Figure 1. Representation of librarian grand search strategy for 2 questions. The graphic begins with the first resource and also includes the librarian’s stated goal. The output of the search process is represented as a square leading to the subsequent resource. The net result of the search is cumulative in terms of found references and text material that contains all or part of an answer. Link indicates the duration of search.
The grand strategy search process is illustrated in two graphics in Figure 1. The first case, involving a diagnosis question, was one of considerable complexity involving 11 UMLS concepts. The librarian employed 3 different resources and the search required almost 53 minutes. The search began with UpToDate and she consulted three chapters, noting that one of them, “Infants of mothers with substance abuse”, was particularly relevant. However, the text did not precisely answer the question. Subsequently, she conducted a search in STAT!Ref since this source was known to be particularly strong in pediatrics. It also supports advanced search and UpToDate does not. She selected the pediatric search filter which selects only relevant textbooks such as Rudolph’s Pediatrics. She employed the same search terms “parental exposure” and was able to locate 3 chapters of interest that discussed the problem in great detail. Although there was much in the way of relevant content, it did not specifically answer the question. As a consequence, she felt compelled to search the primary source - journal articles in PubMed. This resource supports more flexible and powerful searches. The librarian conducted extensive searches on the major facets, parental exposure, pulmonary infiltrates, pneumonia and anemia. The mesh terms were used in various combinations to produce 3 articles of high relevance. After completing her PubMed search, the librarian expanded the scope of her search in STAT!Ref. The latter search was fruitless, but she had already generated a satisfactory answer to the question.

The second graphic involved a drug therapy question of moderate complexity (5 UMLS terms) and lasted for 31 minutes. The question proved to be somewhat difficult because it was ill-formed. The use of the term “stable” is not commonly used to modify ventricular tachycardia and this proved to be a source of confusion. The search began in PubMed with the objective of identifying a set of MeSH terms that would provide her with greater precision in conducting her subsequent searches. She proceeded to Micromedex because this is a drug therapy question. She searched on “ventricular tachycardia” to determine the comparative efficacy of two drugs and found evidence to suggest that amiodarone is superior to lidocaine in treating this condition. However, she could find no reference to “stable” ventricular tachycardia. As a consequence, she went to UpToDate in view to find more elaborate information on these drugs in the context of this condition. Interestingly, the same study was referenced in UpToDate, confirming what she found in Micromedex. She subsequently searched STAT!Ref because of the availability of an excellent textbook resource in cardiology (Hurst’s the Heart). The results largely echoed what she had previously found in the other resources. However, she was unable to find a referenced article of interest. This led her to go to the Cochrane library, a source of systematic reviews on a range of topics. Although the review did not expand upon the question, she was able to locate an article of interest and copied the PubMed Unique Identifier (PMID) attached to this particular citation. She subsequently conducted a search in PubMed using the PMID. The librarian then used a pearl-growing strategy to find related articles. These articles served to confirm and expand upon the previous searches in answering the question. She employed the same heuristic on two other occasions to verify or martial additional evidence to answer a particular question.

3. Conclusions

Despite the ever increasing abundance of electronic health information knowledge resources, there is a paucity of research as to how they can be used productively. This
paper provides a descriptive analysis of an experienced health librarian conducting 10 searches. The librarian employed a vast array of resources and sequenced them strategically as to exploit their relative strengths. Each of the resource queries was guided by an explicit goal and would yield output such as exemplary articles, key concepts or text strings that would be further exploited in the subsequent search. The next goal is to derive a set of heuristics that guide decisions pertaining to 1) initial resource selection, 2) sequencing of resources and 3) evaluation of output.

This is a formative exploratory research study and one of the goals was to better understand how we can study and model the process more effectively. The collection and analysis of data for this study is an ongoing process. The study is limited by the fact that it employed only one librarian who searched only 10 questions. Furthermore, the librarian was not limited in terms of the time allocated to the search. The time taken per search exceeded what one may reasonably take if the goal were to provide clinicians with timely answers to their information needs. In addition, the questions may have been unusually complex. One of the problems we have encountered is that clinicians often ask ill-formed or unclear questions. We are working on strategies that structure their queries, for example through the use of templates, in a way to make them more comprehensible and answerable. Our longer term objective in the CIQR project is to develop intelligent agents that are able to process a clinician’s queries and autonomously generate complex, adaptive search strategies that will result in a high precision search to retrieve an appropriate answer. This study represents an effort towards leveraging librarian’s expertise and understanding how to effectively deploy these powerful knowledge resources to answer clinician’s questions in the context of clinical workflow.

Acknowledgements

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References

Analysis of Acuity Trends Using Resource Intensity Weights Via the CIHI Portal

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\textsuperscript{b} Portal Services, Canadian Institute for Health Information (CIHI), ON, Canada

Abstract. One key to revolutionizing health care with informatics is the ability of decision-makers to access and analyze relevant data in a timely and efficient manner. Inspired by the demand for timely access to hospitalization data in Canada, CIHI Portal is an innovative web-based analytical tool which combines leading technology and data for decision support analysis. Hospitals, regional health authorities and ministries of health can use CIHI Portal to access comparable, pan-Canadian healthcare data for health data analysis, collaboration and dissemination. The goal of CIHI Portal is to support health care decision-makers in their local and regional health care planning and to answer service delivery questions.

The Capital Health region in Alberta used Resource Intensity Weights (RIW) to investigate claims that patients within their region were getting sicker over the past few years and that additional resources would be required in the future. Using the CIHI Portal, Capital Health conducted an analysis on historical trends in the average RIWs\textsuperscript{1} and found that although typical patients were not using a greater amount of resources, there was definitely an increase in the amount of resources consumed by atypical patients. Information contained in the analysis influenced budgeting, fund reallocation and health care planning. CIHI Portal has proven to be a reliable tool for data access, information sharing and knowledge exchange. It has enhanced decision support services within the Capital Health region.

Keywords. CIHI Portal, resource intensity weights

Introduction

The purpose of this analysis was to investigate a claim that patients admitted in the Capital Health region were getting sicker and required a greater amount of resources than in previous years. This claim was based on a graph of Average Resource Intensity Weights (ARIWs) over time for Capital Health region and other Alberta health regions. This graph showed an increase in the overall ARIWs over time.

Resource Intensity Weights (RIWs) are values that are assigned to each case and represent resource use compared to the “average case”, where the average case has a value of one. RIWs indicate expected relationships of costs between patient types and provide a relative measure of resource consumption. The RIW value for each case is

\textsuperscript{1}Average Resource Intensity Weight is calculated as the total Resource Intensity Weight (RIW) divided by the total number of inpatient separations.
derived from CIHI’s Case Mix Group (CMG) methodology\(^2\) which aggregates acute care inpatients with similar clinical and resource utilization characteristics. An increase in the ARIW over time within Capital Health was thought to indicate that patients were using an increased amount of resources, on average.

Hospital separations were split for this study into two main types: typical and atypical. Typical cases were those patients who received a course of treatment in a single institution and were discharged. Atypical cases were those patients who exhibited a different pattern of care who were categorized in the following four sub-types: deaths, transfers (from and/or to another acute care hospital), long-stay outliers and sign-outs against medical advice. Each of the four atypical sub-types represents separations where the costs incurred would differ from those of a typical separation with the same condition.

1. Methods

1.1. Data Collection

Total inpatient separations and RIW data were extracted from the Discharge Abstract Database (DAD) via the CIHI Portal for fiscal years 2002/03 through 2006/07. The analysis was broken down by typical and atypical separations for three jurisdictions: Capital Health region, other Alberta health regions, and the rest of Canada. The CIHI Portal was used for much of this analysis given that the most recent CMG and RIW methodology (CMG/Plx and RIW 2005) had been applied to all years of historical DAD data within the Portal in order to facilitate consistency in comparative analysis of CMG and RIW values across locations and fiscal years.

The current practice with many regional and provincial DAD datasets is to apply only the annual CMG and RIW methodology to its corresponding annual year of DAD data and to not re-group historical data with the latest methodology. Unfortunately, this failure to re-group historical data impedes analysis and trending over time as CMG and RIW values become incompatible and incomparable if they do not utilize the same grouping methodology when they were applied. An additional advantage for Capital Health in using the CIHI Portal for this analysis was the ability to include DAD data from the rest of Canada alongside that of Alberta when examining trends in RIW values.

To evaluate the impact of atypical cases over total ARIW values, a comparison was performed between the percent of atypical separations and the percent of the total atypical RIWs. Evaluation of trends in ARIWs over time was achieved by plotting the annual ARIW values by separation type for each jurisdiction. This form of analysis offered insight into how each type of separation had changed individually over time.

\(^2\) Grouping methodologies are de facto standards for grouping hospital patients with similar diagnoses and similar treatment requirements. They help health care facilities predict a patient’s length of stay and resource use, for utilization management and other purposes.
2. Results

From 2002/03 onwards, the total ARIWs increased for all jurisdictions, with the sharpest increase occurring from 2005/06 to 2006/07 for Capital Health and other Alberta health regions, as shown in Figure 1. Although this initially appeared to support the claim that patients were sicker over time, this observation was distorted by the presence of atypical separations which tended to have higher ARIWs. To investigate whether the increases in ARIW were actually due to increases in the level of resource use of average patients, investigations by type of separation were performed.

ARIWs measuring resource consumption of typical separations display a decreasing trend over time for Capital Health while other Alberta regions and the rest of Canada appeared to be remaining steady with little appreciable change noted as shown in Table 1. This difference is likely due to differences in the available level of care in jurisdictions outside Capital Health. Therefore, in 2006/07 typical patients would be expected to consume fewer resources on average than in 2002/03 for Capital Health and the rest of Canada.

Since 2002/03, ARIWs measuring resource consumption of atypical separations have increased for outliers, transfers and sign-outs, with the most substantial increase occurring in Capital Health between 2005/06 and 2006/07 for outliers and transfers. Outliers and transfers also increased in other Alberta health regions and the rest of Canada, but to a lesser degree. ARIWs measuring resource consumption of atypical separations for deaths have increased since 2002/03 for only Capital Health.

![Figure 1. Average RIW for all separations - fiscal 2002/03 to 2006/07.]

3. Discussion

The presence of atypical separations can lead to misleading conclusions in trends of average resource use and level of illness. The separate examination of RIWs associated with typical and atypical separations more accurately identified and described trends in acute hospitalization resource use.
In Capital Health, the overall ARIWs have increased since 2002/03; however, the ARIWs associated with typical separations have actually decreased in spite of annual increases in the volume of typical separations. By contrast, the ARIWs attributable to atypical separations have markedly increased since 2002/03 for Capital Health, with the most notable increase occurring for long-stay outliers and transfers from and/or to another acute care hospital. Similar results were found for the rest of Canada, while other Alberta health regions have experienced a slight increase in ARIWs attributable to typical separations.

The evidence gathered from this analysis did not support the initial claim that patients in Capital Health had been sicker than in previous years. Rather, it showed that typical patients had been consuming a decreasing amount of resources. At the same time, higher ARIWs attributable to atypical separations suggested that these types of patients had been using an increased amount of resources.

4. Conclusion

When faced with increasing patient resource intensity, it is helpful to examine the mix of typical versus atypical separations to see if changes in clinical or management practice can possibly impact this trend. For example, a decrease in ARIWs attributable

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3 Between 2002/03 and 2005/06 total typical separations in Capital Health increased by 11% from 83,955 to 93,324 separations.
Table 1. Average RIWs* by Jurisdiction and Separation Type - Fiscal 2002/03 to 2006/07.

<table>
<thead>
<tr>
<th>Jurisdiction &amp; Separation Type</th>
<th>2002/03</th>
<th>2003/04</th>
<th>2004/05</th>
<th>2005/06</th>
<th>2006/07</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Separations</td>
<td>1.50</td>
<td>1.50</td>
<td>1.48</td>
<td>1.49</td>
<td>1.58</td>
<td>5.1%</td>
</tr>
<tr>
<td>Typical</td>
<td>1.10</td>
<td>1.08</td>
<td>1.04</td>
<td>1.04</td>
<td>1.03</td>
<td>-5.6%</td>
</tr>
<tr>
<td>Atypical</td>
<td>3.19</td>
<td>3.28</td>
<td>3.30</td>
<td>3.39</td>
<td>3.60</td>
<td>13.0%</td>
</tr>
<tr>
<td>Outliers</td>
<td>4.86</td>
<td>5.07</td>
<td>5.09</td>
<td>5.02</td>
<td>5.56</td>
<td>14.5%</td>
</tr>
<tr>
<td>Transfers</td>
<td>2.77</td>
<td>2.77</td>
<td>2.74</td>
<td>2.91</td>
<td>3.11</td>
<td>12.5%</td>
</tr>
<tr>
<td>Sign-Outs</td>
<td>0.82</td>
<td>0.85</td>
<td>0.93</td>
<td>0.86</td>
<td>0.87</td>
<td>6.2%</td>
</tr>
<tr>
<td>Deaths</td>
<td>4.05</td>
<td>4.28</td>
<td>4.31</td>
<td>4.28</td>
<td>4.44</td>
<td>9.7%</td>
</tr>
<tr>
<td>Other Alberta Regions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Separations</td>
<td>1.18</td>
<td>1.18</td>
<td>1.18</td>
<td>1.19</td>
<td>1.24</td>
<td>5.2%</td>
</tr>
<tr>
<td>Typical</td>
<td>0.87</td>
<td>0.87</td>
<td>0.87</td>
<td>0.88</td>
<td>0.88</td>
<td>1.3%</td>
</tr>
<tr>
<td>Atypical</td>
<td>2.80</td>
<td>2.81</td>
<td>2.79</td>
<td>2.80</td>
<td>3.04</td>
<td>8.6%</td>
</tr>
<tr>
<td>Outliers</td>
<td>4.47</td>
<td>4.33</td>
<td>4.29</td>
<td>4.37</td>
<td>4.60</td>
<td>2.9%</td>
</tr>
<tr>
<td>Transfers</td>
<td>2.19</td>
<td>2.26</td>
<td>2.29</td>
<td>2.26</td>
<td>2.64</td>
<td>20.8%</td>
</tr>
<tr>
<td>Sign-Outs</td>
<td>0.57</td>
<td>0.56</td>
<td>0.58</td>
<td>0.59</td>
<td>0.66</td>
<td>15.9%</td>
</tr>
<tr>
<td>Deaths</td>
<td>3.62</td>
<td>3.62</td>
<td>3.50</td>
<td>3.55</td>
<td>3.45</td>
<td>-4.5%</td>
</tr>
<tr>
<td>Rest of Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Separations</td>
<td>1.34</td>
<td>1.31</td>
<td>1.31</td>
<td>1.32</td>
<td>1.35</td>
<td>0.6%</td>
</tr>
<tr>
<td>Typical</td>
<td>1.03</td>
<td>1.01</td>
<td>1.01</td>
<td>1.02</td>
<td>1.02</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Atypical</td>
<td>2.97</td>
<td>2.90</td>
<td>2.87</td>
<td>2.86</td>
<td>3.01</td>
<td>1.2%</td>
</tr>
<tr>
<td>Outliers</td>
<td>4.77</td>
<td>4.57</td>
<td>4.57</td>
<td>4.64</td>
<td>5.04</td>
<td>5.8%</td>
</tr>
<tr>
<td>Transfers</td>
<td>2.12</td>
<td>2.16</td>
<td>2.15</td>
<td>2.15</td>
<td>2.21</td>
<td>3.9%</td>
</tr>
<tr>
<td>Sign-Outs</td>
<td>0.62</td>
<td>0.60</td>
<td>0.62</td>
<td>0.62</td>
<td>0.63</td>
<td>1.4%</td>
</tr>
<tr>
<td>Deaths</td>
<td>3.60</td>
<td>3.42</td>
<td>3.42</td>
<td>3.41</td>
<td>3.47</td>
<td>-3.6%</td>
</tr>
</tbody>
</table>

* Source: CIHI Portal Discharge Abstract Database

to typical patients may suggest a need to examine admission criteria relative to patient resource intensity, to the extent that is possible. An increase in atypical outlier ARIWs is suggestive of a need to examine discharge criteria or possibly other barriers to outplacement.

The results of this analysis were used to inform decision makers about the way costs are distributed among different types of patients and to show how the ARIWs associated with the different types of separations have changed over time. The information contained in this analysis was used to inform budgeting decisions, reallocation of funds, and health care planning within the Capital Health region. Furthermore, use of the CIHI Portal also allowed for the benchmarking of Capital Health against other Alberta health regions and the rest of Canada with ease.
Section 2

Educational Initiatives and Professional Development
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The University of Victoria Interdisciplinary Electronic Health Record Educational Portal

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Abstract. Use of Electronic Health Record (EHR) systems is increasing globally. However, adoption rates of Health Information Systems (HISs) continue to remain poor. To improve adoption rates, there is need to provide greater HIS experience to health professionals and informaticians in health and biomedicine during their undergraduate and graduate education. A recent review of the health professional educational curricula (i.e., medicine, nursing, allied health and health/biomedical informatics) revealed that they provide only limited exposure to EHRs. In response to this educational need, the authors have developed the University of Victoria Interdisciplinary Electronic Health Record Educational Portal (UVicIED-EHR Portal). This unique, web-based portal allows students of the health professions and practicing professionals to access and interact with a set of representative EHR HIS solutions using the web. The portal, which links to several EMRs, EPRs and PHRs, has been used by several health professional educational programs in medicine, nursing and health informatics. It provides practicing health and health/biomedical informatics professionals, for example, managers and directors, with opportunities to access and review EHR systems. The portal has been used successfully in the classroom, laboratory and with distance education to give hands-on experience with a variety of HISs and their components.

Keywords. EHR, EPR, PHR, medical education, nursing education, health informatics education, biomedical informatics education

1. Introduction

The prevalence of the Electronic Health Record (EHR), an electronic repository of an individual's lifetime information about their health status and health care, is increasing globally among healthcare organizations. The EHR has had a significant impact upon the quality and safety of healthcare and is considered the most effective means of improving health care delivery [1-3]. The EHR's ability to reduce medical errors and provide evidence-based decision support to clinicians at the point-of-care is well known [3]. The EHR integrates information from several HISs including electronic medical

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records (EMR), electronic patient records (EPR) and personal health records (PHR). More importantly, the EHR allows health professionals and patients to document, communicate and integrate health information about patients such that it may improve the quality clinician decision-making and patient care.

Many researchers have documented the value of EHRs. For example, research has found that EHRs may improve the safety of healthcare. However, the adoption and appropriation of the technology is subject to significant issues. Less than 25% of physicians use EMRs the United States [4]. In Europe, physician EMR adoption rates are much higher (greater than 95% of primary care physicians in some European countries such as Denmark and Sweden use EMRs) [5].

EPR adoption rates are similarly low. Of US hospitals, 20.8% capture the total patient record on a computer [9] and in Canada 2.4% of hospitals have full EPRs [10]. PHR healthcare policy makers, for example, Canada Health Infoway and the European Union, are just beginning to address the use of HIS in healthcare. U.S. vendors are only now initiating the development and launch of PHRs that may be available on a long term basis (e.g., Google® and Microsoft®). Therefore, in this paper the authors suggest that in order to improve the adoption of the EHR and its components, there is a need for novice health professionals and health/biomedical informaticians to work with these systems in the classroom, laboratory or through distance education prior to graduation.

1.1. Health Professional Education and the EHR

A recent review of the health professional educational curricula (including medicine, nursing, allied health and health informatics) reveals that exposure to EHRs and their components is limited in the classroom setting [11]. Classroom learning in the form of formal lecture, discussion as well as hands-on use, access, and opportunities to work with EHRs and their components is limited. Many health professional students learn about paper patient records in academic settings and they have only limited exposure to HIS during clinical practice. Here, student and novice clinicians must learn about how to use HIS in real-world clinical settings using real patient data. Novice clinicians or health professional students who are new to a healthcare organization, must continue to learn about patient care while at the same time learning how to incorporate HIS into their clinical practice following their organizational training. (If they are not provided with a sufficient opportunity to learn the technology, students may be at risk of learning “bad” habits because they lack understanding of the theoretical underpinnings of the HIS and how the components of the EHR integrate and work together.) Alternatively, the expectations among policy makers and healthcare organizations is for health professionals to be knowledgeable, computer savvy and prepared to use an HIS.

1.2. Health Informatician/Biomedical Informatician Education and the EHR

The issues are much the same for undergraduate and graduate health informatics students. Educational opportunities involving EPRs are limited in the academic setting. Only a few academic undergraduate and graduate programs for health informatics, such as that at the University of Victoria, have been able to incorporate the EHR into their undergraduate and graduate curriculum as a learning tool. This is unlike the opportunities afforded to other disciplines (e.g., business, computer science and engineering) in which students have the opportunity to work with the tools of their profession before entering the work setting.
Additionally, there is wide variability in the design, implementation and evaluation of HIS globally, nationally and locally. Research has found that effectively designed and implemented EHRs (and their components) can achieve those healthcare gains outlined earlier in this paper. Alternatively, if EHRs are poorly designed and implemented such gains may be lost or impaired (with no cost reduction or improvements in patient safety) [3]. There are many documented instances of healthcare organizations who have invested in HIS and have experienced difficulty encouraging health professionals to adopt the technology. As well, in cases where adoption was successful, health professionals have often failed to appropriate many of the useful functions and features that are intended to support patient care [6,8,12]. Therefore, providing undergraduate and graduate health informatics students with opportunities to work with a variety of HISs allows students to gain the necessary design, development, implementation, evaluation and maintenance experience required to ensure HISs are both adoptable and appropriated by health professionals.

2. Methodology and Development of the Portal

In response to this educational need, the authors have participated in the development of the University of Victoria Interdisciplinary Electronic Health Record Portal (UVicIED-EHR Portal). (See Figure 1 which shows the portal’s resource page and a list of working HISs that users can select to interact with directly over the WWW.) This unique, web-based portal was designed to give students in a health profession, practicing professionals and health informaticians access a set of representative EHR HIS solutions remotely[13]. The portal houses several different EMRs, EPRs and PHRs (e.g., Digital Anthrologix\textsuperscript{\textregistered} and Veteran’s Affairs VISTA). A variety of HISs were selected to provide health informaticians and health professional educators opportunities to teach students about HISs using different design metaphors, features and functions. Students are given an opportunity to learn about those aspects of HIS design, such as usability and safety, that influence clinical practice, adoption and appropriation. Students can gain experience with EHRs prior to working in the real-world. The portal provides students with high fidelity simulated HIS system experiences that are representative of the real-world. Educators have the opportunity to teach students how to effectively and efficiently use a HIS in the safety of the classroom and laboratory setting.

3. Experiences to Date

The portal has been used by several health professional educational programs in medicine, nursing and health informatics. The portal also provides practicing health and health informatics professionals with EHR component access and review opportunities. The portal, in conjunction with classroom education, enables users to obtain hands-on experience while in the classroom or laboratory and/or enrolled in distance education.
3.1. Medical School Experiences

3.1.1. University of British Columbia

We have hosted educational EHRs on the portal and been involved in deploying and modifying a system, Digital Anthrologix®, to include features for integrating it into the curricula of a medical program at three sites in British Columbia. This was done in collaboration with the Island Medical Program, Northern Medical Program and the Vancouver based University of British Columbia Medical Program. In a test run of the approach, rather than accessing patient cases on paper, 200 four-year medical students from Vancouver, Victoria and Prince George used an EHR prior to classroom lectures. Students received classroom education about HISs including EMRs, privacy and ethics and the impact of an HIS upon the work done by physicians. Students found this experience extremely valuable, teaching them how such systems could be used and integrated into their medical practice.

![Resource page of EHR educational portal.](image)

Figure 1. Resource page of EHR educational portal.

3.1.2. University of Arizona

In another experience, The University of Arizona College of Medicine – Phoenix in partnership with Arizona State University (COM-P) has been using the portal to provide students exposure to EHRs. The COM-P plans to utilize this functionality with Case Based Instruction as a core IT platform in the deployment of a new IT-centered medical education program.
3.2. Nursing School Experiences

3.2.1. University of Victoria

More recently, the UVicIED-EHR Portal was used to deliver EHR education to 150 fourth-year nursing students at the School of Nursing. Students were asked to complete readings about the use of HISs by nurses. Students were asked to access and explore the EPR in Veteran Affair’s Open VISTA over the WWW from home prior to receiving classroom instruction. Classroom work included lectures and discussion about nursing informatics, health informatics and the use of HIS in healthcare. Classroom discussion activities included opportunities to consider the impact of an HIS upon nursing practice (i.e., examining those parts of an HIS that worked well or less well in nursing practice and why) and the roles that nurses could undertake as change agents.

Students left the experience with a new understanding of EHRs as a means for documenting care. The portal based EHR permitted students to see how medical diagnoses and treatments could be documented by using a simulated record with point-and-click documentation. Students also learned how drop down menus could cue health care providers to aspects of care expected within diagnostic categories. The system used medical and ICD coding. Issues related to nursing and documentation emerged as did the potential need for narrative charting embedded within the EHR. Students new to the EHR reflected on the use of the EHR in clinical practice.

3.3. Experiences for Health and Biomedical Informaticians

The UVicIED-EHR Portal has been used to educate health informaticians at the undergraduate and graduate level in the design, development and evaluation of EHRs. At the undergraduate level, students in health informatics have reviewed and used the portal EHRs as a component of their coursework to develop health informatics competencies. The open source EHRs allow for assignments where students can work on designing, programming and testing new modules and functionalities. Graduate students are designing, developing and evaluating systems. Students now have the opportunity to work with a variety of HISs in the classroom and laboratory setting. We plan to extend the UVicIED-EHR Portal for use in other health professional educational programs such as social work and physiotherapy.

4. Summary

To improve EHR adoption and appropriation rates, there needs to be an opportunity for health professionals and informaticians to work with a variety of EHRs and their components in the classroom, laboratory and distance education. These would be EHRs that have a variety of design metaphors, features and functions. The authors have been participated in the development of a WWW portal that provides access to several different EHRs. The portal has been successfully used by several education programs for professionals in medicine, nursing, and health informatics. The portal also provides professionals, including managers, directors and other IT decision-makers, with an opportunity to access and review EHRs. The portal provides in-classroom, laboratory and hands-on experience for novice health professionals and practicing professionals.
We conclude that such a portal is a promising tool for improving and disseminating education and for encouraging the adoption of EHRs in healthcare.

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References

Abstract. At the University of Technology, Sydney (UTS), Australia, a pilot study was conducted to introduce and integrate mobile point-of-care technologies into the clinical laboratory experiences of students in the Bachelor of Midwifery program. The pilot study was a collaborative project between Intel Healthcare and the Faculty of Nursing Midwifery and Health at UTS and was conducted using Intel’s mobile clinical assistants (MCA). Through role playing, students were exposed to a number of case scenarios drawn from authentic midwifery practice. The MCA was used to gain information such as test results, clinical practice protocols, and best evidence guidelines. The students were expected to discuss the information with the woman. Following the activity, students completed an online survey to identify the impact of the MCA on the role-playing situations. They also participated in a focus group where they could discuss the use of the point-of-care technology in relation to preparation for practice. Results from these evaluations indicated that the students were positive about using the MCA in simulation sessions and they also considered that this technology would be helpful in their practice. It is hoped that the use of such point-of-care technology will be integrated across the Faculty’s pre-registration midwifery and nursing programs to provide students with access to the most recent information technology innovations in health care.

Keywords. mobile clinical assistant, point-of-care technology, midwifery education

Introduction

Point-of-care technologies are increasingly being utilized in the health care sector. It is recognised that midwives and nurses need to have the skills required to use these technologies in their practice. The pilot project was attended within the Faculty of Nursing, Midwifery and Health at the University of Technology, Sydney (UTS), Australia, where students were introduced to Intel’s Mobile Care Assistant (MCA) (Figure 1). In a clinical practice laboratory setting, students used this tablet style computer to participate in authentic midwifery practice scenarios where the MCA provided point-of-care support.

This paper discusses the pilot project aimed at introducing and integrating mobile point-of-care technologies into the undergraduate midwifery curriculum at the (UTS). Currently, UTS conducts the only three-year undergraduate midwifery program, the Bachelor in Midwifery (BMid), in the state of New South Wales. This course commenced in 2005 with an initial cohort of 30 students. At present, the BMid accepts 50 students per year.
1. Background

A perennial dilemma in preparing students to be work-ready is to address the gap between that which they learn at University, and that which is the actuality in the practice environment. This theory-practice gap leads to students feeling that they are not useful participants in the clinical practice environment and that they are therefore not valued as members of the health care team. With the increase in the use of computer and information technology in health care, students will be required to have a level of competence in these areas on graduation [1]. It is essential that students are prepared for this environment while undertaking their undergraduate courses so that they are valued members of the health care team on graduation [2].

Increasingly, hospitals are utilizing new technologies in patient care. For example, point-of-care technology (such as personal digital assistants - PDAs) can be used for information storage, estimation of drug doses and interactions, and finding standard protocols and clinical practice guidelines at the point of care [3]. PDA technology can also operate with wireless connectivity so that health databases can be accessed, images can be sent, and stored data can be transferred. It is suggested [3-5] that the use of these new technologies will improve the safety and quality of patient care. Thompson [6] was particularly enthusiastic about the ability of handheld computers to ‘transform’ nursing practice and claimed that the use of these “…will make nursing practice more efficient, safer, and of a higher quality.” Point-of-care devices can be used as a patient data storage tool and as an information storage tool for practitioners. Farrell [7] reported on the use of PDAs with nursing students and her evaluation indicated that students’ knowledge of pharmacology increased with the use of PDAs during their clinical practice as the PDAs provided point-of-care access to information.

Lewis and Sommers [1] discussed the role of PDAs and claimed that, as point-of-care support, they are valuable tools for nurses. They suggest that nurses can have their PDA with them at the bedside and refer immediately to clinical information. Other literature [7-10] similarly described the advantages of using PDAs at the point-of-care and indicated that these devices are becoming more commonplace in our health care system. Indeed, the literature on this subject is quite extensive and clearly indicates widespread use of PDAs.

It can be argued, then, that it is essential that newly registered midwives be literate and familiar with new information technology uses in practice. At UTS, the Faculty of Nursing, Midwifery and Health have committed to the integration of information technologies in both undergraduate midwifery and nursing courses.

It is important to ensure, when designing learning activities that introduce and integrate new technologies into practice-based curricula, that the learning activities or tasks are authentic. Authentic learning tasks enable the learner to construct meaning in the real world. Authentic learning uses real life situations to anchor the students’ learning [11,12]. McKenzie et al [13] described authentic learning as “…alignment of student learning experiences with the world for which they are being prepared.” The activities that were used in this project were aligned as an authentic representation of the midwifery practice setting. The MCA tablets were loaded with midwifery documentation that is familiar to the students and the students were given a role play that mimicked the midwifery practice setting.
2. Pilot Project

The pilot project was conducted at UTS by the midwifery team in the Faculty of Nursing Midwifery and Health. The midwifery teaching team were successful in gaining a UTS Small Teaching and Learning grant in 2007 and this funding enabled the team to purchase a MCA for the pilot project. Intel Healthcare representatives were involved from the beginning of the project and were able to provide assistance with the use of the technology, preparing the MCA for the scenarios, and in loaning equipment for the pilot day.

Simulated scenarios of midwifery practice were developed so that Bachelor of Midwifery students could use the MCA in the clinical laboratory setting. Three case studies were designed in which the MCA could be used to assist the student in providing information and implementing care for a woman. In order to promote relevance to practice, the case studies were based on authentic experiences that student midwives would commonly encounter in midwifery practice.

As the case studies were developed, appropriate hard copy clinical records were completed. These records were converted to PDF format and uploaded onto the MCA where PDF Annotator was installed. Students could use this program to enter data (documentation) directly into the clinical records stored in the MCA.

To ensure maximum use of the MCA by the student and to demonstrate the possibilities of using the MCA in practice, further information and documents relating to each scenario were loaded onto the MCA. This included evidence-based information leaflets, local clinical practice protocols and relevant clinical forms such as observation and medication charts. Additional clinical information including pregnancy ultrasound reports and blood test results relating to the case studies were also accessible.

Due to the limited nature of the pilot program, some of the usual capabilities of the MCA went unutilized. For example, there was no wireless connectivity at the site where the project took place. Had wireless connectivity been available, students would have been able to access databases for evidence and clinical information such as that about medication. To overcome this, hard copies of relevant medication information were scanned and loaded onto the MCA. As the aim of the project was to evaluate the possible integration of MCA technologies into the midwifery curriculum, it was important to ensure as much information as possible was made available on the MCA.

3. Participants

Prior to the planned day, all students enrolled in the Bachelor in Midwifery program were invited to participate in the pilot project. A random sample of eight of the students who volunteered were asked to attend for the pilot day. All of the students participating in the study had experienced clinical midwifery practice. This was important as the scenarios were developed on authentic midwifery practice situations and the students needed to be able to play both roles: midwife and pregnant woman. The pilot project was conducted outside of teaching time. The students were offered payment for attending the pilot project day.
4. The Pilot Day

Eight students participated in the pilot project. The day began with an overview of the project, which included background information and the rationale for the project. The general introduction and overview was followed by a tutorial on, and a role-play using the MCA. The role-play was enacted by the midwifery lecturers. The MCA was connected to a data projector, which enabled the students to follow the tutorial and the use of the MCA within the role-play. Students were then able to have a practice session to familiarize themselves with the capabilities and use of the MCA. Many questions arose from the practice session. Fortunately, representatives from Intel Healthcare were present to observe the pilot project and were able to answer questions about the MCA functionality and its potential uses prior to the actual scenarios.

Participants were paired and each pair was given one of the three pre-prepared scenarios. One student took on the role of the midwife, the other the role of the pregnant woman (Figure 2). The pairs initially worked through the scenario, then swapped roles, and proceeded to move through all three pre-prepared scenarios. The scenarios were observed by the midwifery lecturers and the representatives from Intel Healthcare.

5. Evaluation

To evaluate the pilot project, we required the students to complete an online questionnaire and participate in a focus group discussion. The primary purpose of the online survey, which used a Likert scale format for some of the questions, was to determine whether or not the students felt comfortable using the device and whether or not they felt it would be useful in midwifery practice.

When asked if they would feel comfortable using the device in practice, all students either strongly agreed or agreed. Only one student felt the device was awkward to manage. In the focus group discussions, students particularly liked the fact that the screen could be rotated to suit both right- and left-handed users. Half of the students felt that the device was an appropriate weight, whereas the others felt it might be too heavy for prolonged hand-held use. One student felt that the device would become uncomfortable due to the heat it generated and felt that a portable stand would be beneficial. All students believed that the device made it much easier to access both the woman’s notes and information for the women. Finally, all students agreed or
strongly agreed that the device was applicable to midwifery practice and felt they could and would use the device if it were available in the practice setting.

There were some short answer questions in the online evaluation. One question asked the students which functions of the device they felt were the most useful in midwifery practice. Students particularly liked that the MCA would allow them to spend more time with the woman and would provide them with information to share with the woman. When asked what they found useful about the MCA, students replied:

“Being able to stay with the woman while providing care and information - having handouts and guidelines available on hand and available to print out or download for the woman as needed - a great time saver for the midwife and the woman.”

“Being able to stay with the woman when providing her care and not run back to the office looking for protocols, medication references, etc. was a great time saver and led to the care being provided more conducive and productive.”

Students also liked the fact that the device was so compact and portable. They were able to see the potential the device has in allowing midwives to care for women in the community or in their own homes.

“It would be useful in all settings, however, I imagine the area which it would make most difference would be in rural/remote settings, in community clinics, and when doing home visits. Being able to access women’s records electronically would reduce the need to carry so much bulk around in such settings.”

Interestingly, students were able to see the potential of the device for duties related to, but not directly involved in, the provision of midwifery care. Some suggestions included using the device as a GPS navigator when conducting home visits; having an alarm function to remind the midwife of appointments, medications due, or results needing to be checked; and using the device as a digital tracker to improve the safety of midwives in the community.

As well as potential benefits of the device, the students were able to identify possible issues. Security was a major concern for the students.

“If you have it open at say Delivery Suite and its open in the room and you go to do something else, anyone can just look as they’re walking in.”

There was concern that the technology, in clinical practice, would be resisted because the students had noticed that many midwives with whom they work lack the ability and willingness to embrace information technologies.

“I would imagine it would be hard to get all the midwives to use something like this because I’ve seen many of them get into difficulty with their PCs so I imagine that would be something you would have to get around.”

Students were also concerned about adding more documentation to the current areas where it is already required. Some students found using on-screen documentation more time consuming than documenting by hand on paper but, in comparison, some students were surprised at how easy it was to document on screen.
“I was pretty impressed with being able to write properly. I usually find that, if my hand touches the screen it doesn’t recognise the pen but for me it was fine … and how fast it was too, I was pretty impressed with that.”

Overwhelmingly, the students felt the device assisted them to provide current and correct information in a way that encouraged the active involvement of the woman. When asked if the device assisted them to provide appropriate care for the woman, all students were positive in their responses.

“Absolutely, I was able to access and share important information with the woman. I was able to involve the woman in her own care and show her any documentation taking place. Accessing information was quick and easy and there was no time wasted on looking for pamphlets or blood test/USS results.”

“It was far more interactive in terms of sharing information with the woman and it can be used by both the midwife and the woman as a tool of learning and support.”

Students also participated in a focus group and this discussion again demonstrated that students were extremely positive about the use of the technology. The students recognised benefits in relation to time, information sharing, and partnership with women.

“It is more inclusive rather than writing notes and the more comfortable you are with it, the less invasive it is on a discussion, because you can actually both do it together and are both involved in it rather than just writing secret notes - it’s a tool that you’re both using in the care rather as a separate person.”

“You’ve got it all there, now if a midwife is with a woman, and she needs a pamphlet she needs to leave the room. Whereas with this, she can say ‘oh I’ve got that for you here, I’ll put that on your memory stick or print it out and you can take it home.’ You don’t have to leave the woman in limbo.”

6. Conclusion

Although the pilot project was small, the evaluation clearly indicates the ease with which the students worked with the MCA. The students appeared to have minimal difficulty operating the device following a very basic tutorial session. The students adapted quickly, felt very comfortable using this device and were thoughtful about the advantages this technology would bring to midwifery practice.

The use of various technologies in healthcare is rapidly expanding. For graduates to be “work ready” upon graduation, these technologies and appropriate training for their use should be integrated into the curricula of all healthcare professionals.

References


Incorporation of Medical Informatics and Information Technology as Core Components of Undergraduate Medical Education – Time for Change!

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Abstract. It is generally accepted that Information Technology (IT) is a highly desirable and a very necessary ingredient of modern health care. Review of available literature reveals a paucity of medical informatics and information technology courses in undergraduate medical curricula and a lack of research to assess the effectiveness of medical informatics in undergraduate medical education. The need for such initiatives is discussed and a pilot project is described that evaluated the effectiveness of education in the use of Electronic Medical Record (EMR) applications. Educational activities, for example, could be medical students conducting virtual medical encounters or interacting with EMR applications. An EMR application, which was used in several related projects, has been adapted to the educational environment: standardized patient records can be created and cloned so that individual students can interact with a “standard” patient and alter the patient’s data.

Keywords. EHR, EMR, medical education, education of health professionals

Introduction

Information Technology (IT) has played a part in health care and the practice of medicine for over thirty years [1,2]. Computers were first used in hospitals in the 1960’s primarily for administrative and fiscal tasks with few clinical applications. Later, systems were used to collate and analyze patient data. In the 1970’s there were discussions about the potential for connecting primary, specialist, and institutional care. Also, medical informaticians began to define goals such as the improvement in clinical decisions and the reduction of medication errors by means of accessible computerized medical data at the point of care. The introduction of computers in physician offices occurred in the 1980’s. Use of web-based resources began in the 1990’s. There have been many recent advances in IT, for example, robust and sophisticated databases, high-speed networks, data interchange protocols for data exchange among disparate systems, open clinical and messaging standards, and distributed software architectures. These changes have enormous potential to improve information access, review, analysis, and sharing to the benefit of patients in their effective treatment.

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Today, it is uniformly accepted among all jurisdictions that IT is not only a highly desirable but indeed a very necessary ingredient of modern health care. The reasons for this are manifold and include the realization among health care professionals, policymakers, managers, and administrators that the current environment encompasses such a plethora and complexity of information that individual providers cannot possibly be expected to assimilate, retain or effectively manage all of the information elements required to provide accepted standards of patient care expected of them. Amongst the various IT solutions and initiatives, numerous software application suites for use by physicians at the point of care have been developed and are variously known as computerized patient records, electronic health records, electronic patient records, and electronic medical records (EMRs), the latter being the preferred terminology in Canada. These applications vary in their sophistication and robustness, but some of the more mature and advanced examples are capable of extensive searching and indexing of chart information, varying levels of clinical decision support functions, computerized physician order entry, alerts and reminders to perform certain tasks, drug allergy and interaction warnings, and presentation of contextual evidence-based information by accessing and intelligently searching medical databases. Despite the widespread agreement that such IT applications have the potential for revolutionizing the delivery of health care by improving the quality of clinical decisions, reducing the incidence of medication errors, and improving health outcomes, there have been very few attempts to introduce such applications, and medical informatics topics in general, as core components of undergraduate medical education. This paper argues for the need for developing formal and robust medical informatics modules in undergraduate medical curricula and focuses on discussion of the need for the evaluation of the effectiveness and potential inclusion of such applications in medical undergraduate courses.

1. Need for the Inclusion of Medical Informatics As a Core Component of Undergraduate Medical Education

Health information technologies are rapidly becoming an increasingly important part of the health care milieu and the potential benefits of IT solutions in health care have been well documented in the past [3-8]. Electronic medical records in particular offer a wealth of benefits. The ability to capture and maintain patients’ histories, examination findings, diagnoses, treatments, allergies, immunizations, and results of investigations makes it possible for health providers to quickly and easily access this potentially lifesaving information at the point of care.

There is a general realization amongst all stakeholders involved in the delivery of health care that the practice of medicine in today’s environment of information overload cannot be effective without the use of technologies that facilitate and enable rapid and efficient access to relevant information. It is also clear that the ability to appropriately interact with the available information is just as important. Despite this realization, widespread adoption and effective use of IT in medicine remains very low and this is especially evident in the United States [9] and in Canada when contrasted with jurisdictions in the European Community, Australia, and New Zealand. One study conducted in the United States and published in 2005 [10] names the U.S. Health Care industry as the world’s “largest, most inefficient information enterprise”. The same study estimates that, over fifteen years, the adoption of interoperable EMR (electronic
medical record) systems could produce cumulative efficiency and safety savings of $142 billion from physician practice EMR systems to $371 billion from hospital systems. Unfortunately, multiple barriers to the widespread adoption of information technologies in health care continue to exist and include technical [11], institutional, cultural, ethical, financial, legal, and social factors [12-14].

The use of these technologies cannot be effective or even possible if their end users do not possess the necessary skills that include knowledge of, and proficiency in, basic computer techniques such as data entry methods, specialized knowledge in the areas of medical information applications and systems, ability to search medical literature, ability to access and search medical databases, and the ability to adapt and to cope with the dramatic differences in workflow processes that are involved. The need for graduating physicians who are equipped with core competencies in medical informatics and information technologies had been recognized a long time ago. Report II of the Medical School Objectives Project developed by The Association of American Medical Colleges in 1998 was entitled: “Contemporary Issues in Medicine: Medical Informatics and Population Health” and included, as part of its guidelines addressing the learning objectives for medical student education, a set of detailed and well formulated recommendations for inclusion of medical informatics agenda as part of the core curricula in medical schools; this was developed by establishing two expert panels – one on medical informatics and one on population health – and by extensive consultation with the American Medical Informatics Association and others with experience and expertise in medical informatics and population health [15].

Ebell and Frame, in a 2001 article entitled “What can technology do to, and for, family medicine” [16], make a lucid and convincing case for the necessity of utilizing IT in general medical practice in order to provide effective care, and specifically mention the use of electronic medical records, decision support systems, and tools for managing medical information. Although they do not specifically address medical education, their arguments obviously apply in that context also. In 2002, Lyman, Cohn, et al [17] reviewed the results of introducing an academic data warehouse into an existing 2nd year medical school course where exercises requiring students to retrieve and interpret information regarding local disease prevalence, practice patterns, and patient characteristics. The majority of the students felt that the exercises complemented the clinical cases around which they were structured. In 2007, McGowan [18] conducted a survey, which explored the extent to which the recommendations of the 1998 Medical School Objectives Project have been incorporated into medical school curricula in the United States and found that, although many of the objectives were stated in the schools' respective curricula and the competencies were being evaluated, very few schools taught and assessed the medical informatics objectives that required interaction with health information. It concluded that more medical informatics concepts need to be included in all undergraduate medical curricula in the United States and found that, although many of the objectives were stated in the schools' respective curricula and the competencies were being evaluated, very few schools taught and assessed the medical informatics objectives that required interaction with health information. It concluded that more medical informatics concepts need to be included in all undergraduate medical curricula in the United States. In 2006, Krause et al [19] confirmed the fact the currently no medical informatics curriculum is required in US medical schools. They endeavoured to assess the self-perceived level of confidence of first and second year medical students in several areas of medical informatics and found that two of the areas that students scored lowest in their perceived abilities were: Use of clinical information systems, and Competency in accessing databases of clinical information.

They concluded that medical students surveyed in their study did not feel confident in their ability to apply medical informatics skills needed to practice effective medicine in the future and reiterated the need for formal medical informatics training in
undergraduate medical school curricula. We reviewed the available published literature dealing with IT in medical education and found that there is a considerable amount of literature with respect to the use of IT as a tool to present or access educational materials of conventional content [20,21], but very little material dedicated to the goal of introducing and teaching the role of medical informatics and IT topics in programs intended for the purpose of acquiring skills as practicing clinicians. In particular, the use of Electronic Medical Records as integral tools for medical students and residents is conspicuously absent in the literature. Keenan et al [22] reported that, in their extensive review of available publications, they found fewer than 50 articles with evidence on their use in medical education. The applications to education that they found included point of care delivery of contextual knowledge, computerized clinical decision support systems, daily management of workflows, and profiling of learner experiences. They concluded that EMRs are powerful patient care tools that are gradually gaining acceptance and will become more prevalent in medical practice and eventually in medical education. The ability of EMRs to automatically present contextual information offers great potential as an educational tool, but data to support their effectiveness in education is not yet available. Similarly, clinical decision support systems have been demonstrated to improve providers performance in patient care, but there is no clear evidence that they improve learning.

In 2007, Huang [23] reported rapid emergence of programs in medical informatics and biomedical informatics, investigated the recommended competencies for health and medical informatics, and outlined a very detailed and comprehensive suggested framework that might be used in the development of modular curricula. Although that study dealt primarily with graduate programs and was not confined to medical education, the proposed framework could be simplified and modified for use in medical undergraduate programs.

Skills in medical informatics and IT should be considered to be core competencies of graduating physicians. As well, these topics should be included as required components of undergraduate medical curricula. It is vital that such initiatives not proceed blindly without scientifically sound and valid assessment. The exact methods as well as the structure and content of the topics taught should be evaluated with respect to their applicability, usefulness, effectiveness and acceptance by students and educators alike.

In 2006, Leung and Johnston [24] observed that the evidence base for most education initiatives, consisted of very low-level evidence and argued that the burden of proof for educational effectiveness should be no less rigorous than that concerning evidence of clinical care. They advocated adoption of a “balanced scorecard approach” in the evaluation of educational interventions that would bring together a comprehensive panel of outcomes under one framework, and the application of rigorous methods to generate such outcomes. They further suggested that the research community agree on and develop a standardized set of benchmarks.

2. A Canadian Pilot Project to Introduce a Custom EMR as a Learning Tool in Undergraduate Medical Training

At the beginning of the 2007 academic year, the School of Health Information Science at the University of Victoria embarked upon several pilot projects to introduce and evaluate a course for medical students involving the use of an electronic medical record
application (EMR) in the context of teaching the workflows and processes involved in clinical encounters between health care providers and patients (see paper in this issue by Borycki et al [25]). The EMR used in several of these projects is a custom application that has been developed by us, a practicing family physician and a graduate student of Health Informatics, in collaboration with a colleague who, in addition to possessing advanced skills in software development, is also a practicing physician pursuing graduate degree in Health Informatics. This custom EMR is a system, which has been developed utilizing the latest Microsoft technologies such as the .NET framework and is capable of all the usual patient encounter, charting, clinical decision support and computerized order entry functions. For the purposes of this project, it has been uniquely modified to the educational environment by incorporating the capability to create multiple clones of a standardized patient created by educators, the ability to track the details of all individual changes made by students, the ability to retain all the individual patient records created by students, and the ability to virtually roll back the changes made to each record. Permissions to view or roll back a patient record or parts of it are based on the user’s role, in this case, educator or student.

3. Conclusion

It seems clear from reviewing the available literature that a vast majority of researchers, policy makers, academicians, and educators support the basic premise that use of IT may result in better patient care and improved outcomes as well as result in more satisfaction for both patients and doctors due to, *inter alia*, the ability to quickly search for and access the information needed to provide a high standard of care. The adoption of IT remains low in the US and Canada and the majority of health care providers lack the skills necessary to practice effective medicine in today’s environment in which there is a rapidly increasing presence and importance health IT. There is a general lack of IT and medical informatics education in undergraduate medical programs internationally and a similar lack of evidence regarding their appropriate use and effectiveness.

There have been significant changes in computer technology and societal attitudes toward technology since EMRs were first introduced three decades ago and today, EMRs offer the potential for revolutionizing the delivery of health care and providing enormous benefits in terms better outcomes as well as monetary savings. The ability of EMRs to automatically present contextual information offers great potential as an educational tool, but data to support their effectiveness in education is not yet available. Similarly, clinical decision support systems have been demonstrated to improve providers’ performance in patient care but there is no clear evidence that they improve learning, and research in the use of EMRs as educational tools is in its infancy. A project to evaluate the use of EMRs in undergraduate medical training has been commenced by the University of Victoria and further reports on the progress and results of this pilot project will follow.

References


The Engineering 4 Health Challenge – An Interdisciplinary and Intercultural Initiative to Foster Student Engagement in B.C. and Improve Health Care for Children in Under-serviced Communities

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Abstract. This paper describes the Engineering 4 Health (E4H) Challenge, an interdisciplinary and intercultural initiative that, on the one hand, seeks to improve health education of children in under-serviced communities and, on the other, seeks to attract students in British Columbia to professions in engineering and health. The E4H Challenge engages high school and university students in BC to cooperatively design and develop health information and communication technology (ICT) to educate children living in under-serviced communities. The E4H Challenge works with the One Laptop Per Child (OLPC) program to integrate applications for health awareness into the school programs of communities in developing countries. Although applications developed by the E4H Challenge use the low-cost, innovative XO laptop (the “$100 laptop” developed by the OLPC Foundation) the software can also be used with other inexpensive hardware.

Keywords. health education, OLPC, student recruitment

Introduction

This paper describes the Engineering 4 Health (E4H) Challenge, an interdisciplinary and intercultural initiative that seeks to improve health of children in under-serviced countries. The E4H Challenge engages high school and University students in British Columbia (BC) to cooperatively design and develop health information and communication technology (ICT) in support of children in under-serviced communities. The E4H Challenge works with the One Laptop Per Child (OLPC) program to ensure that software is accessible and integrated into current school programs of communities in developing countries. Although it uses the low-cost, innovative XO laptop (known as the “$100 laptop” developed by the OLPC Foundation), it does not depend on this particular platform and may use other inexpensive hardware, that is, “netbooks” such as the ASUS eePC.

The long-term objectives of the E4H program are to improve health awareness and health care for youth in BC and, eventually, in under-serviced communities and
developing nations. The OLPC project is an international initiative, which has been undertaken to counter the effects of the growing digital divide between the developed world and the developing nations. The vision of the project is “to create educational opportunities for the world's poorest children by providing each child with a rugged, low-cost, low-power, connected laptop with content and software designed for collaborative, joyful, self-empowered learning [1].”

The OLPC vision is becoming a reality with laptops, to assist in the education of children, which are being deployed in many developing communities around the world. There are many software tools on these laptops but there is a need for health education applications. Initiatives in this direction have just recently started [2].

The University of Victoria (UVic) has taken an interest in the OLPC and has had several engineering activities based on the OLPC platform, including a course dedicated to the development of software tools. Students have been very positive about and engaged in these courses, building on existing tools, developing new software, and contributing to the OLPC global community.

The E4H Challenge engages students and helps raise awareness of professional studies related to health care, engineering and health informatics. BC has a shortfall of students entering these disciplines. This is of great concern as the Province faces an increasing demand for health services and experiences a transition to an Information and Communication Technology (ICT) enabled infrastructure for health care delivery.

1. The E4H Challenge Design

The E4H Challenge is designed to encompass five main education and development phases, arranged in an iterative cycle, as depicted in Figure 1. A full iteration takes twelve months so that the Challenge can be held as an annual event in collaboration with developing communities, high schools and universities.

1.1. Phase I - Community Education and Requirements Elicitation

This phase is used to identify one or several under-serviced target communities in developing countries. Even a national target such as a first nations community could be chosen. Ideally, members of these communities or, if they are unavailable, individuals with intimate knowledge about these communities, help to identify the software requirements. These community stakeholders also help to evaluate the designs throughout the next three phases. Community stakeholders are selected based on the availability of committed educators and engaged health care providers, student participation, and the existence of a health curriculum that can be leveraged in the project. Clinical and engineering faculty in BC support the community partners in their education and requirements elicitation efforts. These professionals provide much of the technical infrastructure needed to ensure that the community partners are engaged throughout the E4H Challenge.
1.2. Phase II - High School Education and Conceptual Design Contest

Phase II involves students and educators in BC secondary schools. Student-led teams of three to five students work with a teacher-facilitator. The program develops conceptual designs for health applications based on the needs defined by the partner community. A workshop, which is organized by interdisciplinary university faculty, is held to give the students basic knowledge about the clinical and engineering context of the Challenge. The workshop guides students through a focused design session to learn experientially about software design and health care needs. Facilitators work with the students throughout the workshop to develop ideas and describe them in a storyboard format (see Figure 2). High school students have an opportunity to work hands-on with university students, clinicians and faculty as facilitators in the Conceptual Design Contest. Secondary school educators are encouraged to use the project theme in their science curricula. The winning team is selected by a panel consisting of university faculty, community participants, and students in health care and engineering. The best teams are awarded with small prizes and their designs are carried forward to the next phase.

1.3. Phase III - University Prototyping Challenge

The object of phase III is to refine the paper designs and construct the first prototypes for the best ideas. Teams in this phase are composed of interdisciplinary university students. Ideally, some representatives from the high-school student teams in Phase II participate. The Prototyping Challenge is held during the week of “reading break” as an extra-curriculum activity at UVic. Students are encouraged to interact with the global OLPC development effort to share ideas. Each team creates a prototype and a poster presentation, which is entered into a competition for the best prototype. This year, the ITCH 2009 poster session program includes submissions by E4H student teams. Winning teams are awarded prizes and the teams are given the opportunity to use their prototype in phase IV.
1.4. Phase IV - University Design and Construction Project Course

This phase spans a full, four-month, academic term. Interdisciplinary groups of three to five university students participate. Each group is mentored by clinical and engineering faculty with experience in health care software design and development. The objective of this phase is to construct a working ICT application that runs on the OLPC laptop and that builds on the work from the previous phases, enhances the prototype, confirms the scope, and iteratively develops the software. Several lectures on clinical and engineering topics pertinent to the ICT applications are given by the faculty during the first week of this phase. The groups must achieve three major milestones: an initial construction plan, a midterm report with poster presentation, and a final report and demonstration. Throughout the phase, the community partners are invited to participate online through forums, chat and audio and video conferencing. An award is given for the best result.
A participating student can receive course credit in the university curriculum. The project can be the mandatory “capstone” project for engineering students. It can be a project or special topics course for students in the UVic School of Health Information Science.

1.5. Phase V - Community Partner Testing and Iterative Improvement,

This testing phase provides iterative feedback based on real world experience. Software is deployed on the students’ laptops in the target community. The observations made by the community partner during testing leads to project enhancements once the competition has ended. This phase also produces more refined requirements for the next iteration of the E4H Challenge.

All information is released through open content and open source licenses so that the knowledge is freely shared.

2. Summary

The Engineering 4 Health Challenge was established this year. To date, we have successfully completed two high school Conceptual Design Challenges (Phase II). Students were able to engage successfully in the Design Challenge and develop storyboards that successfully describe software and its use for health education and promotion. The University Prototyping Challenge (Phase III) is scheduled for this winter.

Work is underway to establish this event as an annual program at the University of Victoria.

Acknowledgements

The E4H Challenge has been supported by many UVic student volunteers, including Melisa Yestrau, Steven Lonergan, Sandra Irwin, Scott Miller, and Pamela Schmitt. The authors would like to thank them for their great contributions. Thanks also to Derek Church from the UVic Software Engineering program for organizing the Challenge.

References

An Innovative Learning Experience for Entry to eHealth Careers

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Abstract. We describe an innovative educational program that provides an easily-accessible introduction to Applied Health Informatics (AHI) in an effort to attract new trainees to this discipline. We call this program the AHI Bootcamp. It includes an intense, interactive, but brief on-site program, with the majority of its content delivered in approximately 80 hours of on-line presentations. The AHI Bootcamp introduces individuals, who have a broad spectrum of backgrounds but little or no knowledge of Health Informatics (HI), to the nature, concepts, methods, tools and applications of HI to address information-based challenges in health maintenance and health care delivery. AHI is the discipline that is concerned with the planning, procurement, deployment, implementation, management, effective use, and evaluation of informatics solutions in the health space. This program targets the high profile areas of AHI, orienting participants to the pursuit of broader and deeper explorations in the field.

Keywords. health informatics education, applied health informatics, introduction to health informatics

Introduction

There is growing awareness in Canada as well as elsewhere that we are facing a human resources crisis related to introducing and effectively using information and communications technology (ICT) and advanced informatics methods (often referred to as “ehealth” capabilities) as the basis for innovation of the processes and products of our health maintenance and care delivery systems. Even incumbent personnel in information systems (IS) departments lack key informatics-related competencies, impairing their ability to be fully-effective agents in embedding enabling technologies in their organizations and achieving productive adoption. [1]. Further, experience is clearly demonstrating that technology and technical skills, on their own, are inadequate to address the real needs of the health system and to derive advantage from ehealth capabilities. This is especially true in areas such as information management and the complementary factors of technology, including process re-engineering, management of change, adoption management, role and organizational restructuring, and so forth.

Estimates of the gap between the number of needed qualified professionals and the number available indicate a deficit of thousands of ehealth professionals. Unfortunately, the ability of the health system to access competent professionals is limited by the production of the education system. There are already a number of educational programs in Canada [2,3] at the certificate and diploma (e.g., at various community colleges), baccalaureate (e.g., Conestoga College, the University of
Victoria, and Dalhousie University), masters (e.g., at the University of Victoria, McMaster University, Dalhousie University, University of Sherbrooke, York University and the University of Toronto) and at the Ph.D. and post-doctoral levels [4]. Thankfully, many new programs are emerging throughout the country. However, current programs produce a total of at most about 150 graduates per year. Thus, even with new programs coming on line, it will be many years before production catches up with demand. Meanwhile most programs face significant challenges recruiting students, as Health Informatics is not a career widely-recognized by career counselors, students or parents [5].

To address this human resources gap, there are only a few possibilities. These include opening more programs and increasing the awareness of AHI so as to increase the number and quality of applicants to the programs. Some good might also be derived from giving those already in the health system a greater knowledge of HI so that they at least know what they need to apply and pursue in terms of additional education. We recognized, based on this thinking, the need for an innovative solution.

In 2003, in discussions that led to the AMIA 10 X 10 program [6] in the United States, we defined a program designed to attract people into Applied Health Informatics. We decided to focus our efforts on raising awareness of potential careers in this discipline, on stimulating interest in part-time or full-time studies under one of the existing programs and on encouraging a self-directed life-long learning process that could take advantage of the resources of existing programs. We also decided that whatever we offered should provide enough basic knowledge to give students at least basic competencies.

The result was that the Waterloo Institute for Health Informatics Research (WIHIR) developed and deployed the Applied Health Informatics Bootcamp. The Bootcamp raises awareness of AHI, provides a basic level of knowledge for those in information services, inter-departmental liaison and other incumbent roles, and introduces the possibility of a career in AHI.

1. Bootcamp Development Methodology

Our definition of AHI competencies [7] determined the content of the Bootcamp. In particular, we identified the needed knowledge and attitude competencies that could be introduced in a relatively brief program. Approximately 80 to 90 sessions of duration between one-half and one hour were developed and delivered by about 40 teachers from Canada and the U.S. An organizing committee designed and oversees the Bootcamp offerings and reviews student evaluations of both content and teaching.

To ensure the quality of content, all teachers are provided with content and presentation guidelines, and presentations must be available for review prior to the sessions. Bootcamp teachers have brought in expertise in various aspects of Health Informatics from academia, the health system and industry. They have included both academics and senior professional experts. We select teachers based on their expertise, experience in the field and ability to present.
2. Bootcamp Learning Objectives

In terms of learning objectives, the program strives to enable its graduates to be able: 1) to understand the current landscape of the practice of AHI, 2) to better determine and define their own areas of interest, 3) to undertake advanced explorations into their areas of interest, 4) to launch a systematic process of broadening and deepening their knowledge and skills, and 5) to access other HI information resources and training opportunities.

3. Program Participants

We have geared the Bootcamp to be valuable to a wide cross-section of participants, including IS/IT professionals in health system organizations, physicians and other clinicians interested in becoming involved in AHI, community college and high school teachers, managers and staff in government agencies, health sector product and service vendors, and anyone who might be considering a change of career. Everything that is needed to fully participate in the Bootcamp is included, but a basic level of computer literacy is expected. We are in the process of adding a major online component to improve computer, software and applications literacy to address a request from a national organization whose members are deficient in this area.

4. Bootcamp Content

The Bootcamp introduces all key AHI knowledge areas identified in Pointing the Way [7]. Most of the content is delivered on-line (see Table 1), and is reviewed during the on-site session. We add new topics, such as regional ehealth strategies and local projects, and redo or refresh others at each occurrence of the Bootcamp. As we have moved forward, though, the on-site component is increasingly dedicated to current issues and interactive sessions with participants.

Each Bootcamp presentation is required to address the following: the motivation for including the topic and its importance, the delivery of assigned content, the definitions of key concepts, the identification of and contact information for key experts, personal reflections and insights, and resources for further learning. Each presentation is required to have an interactive component, such as a case study, an exercise, and/or a question-and-answer period.

<table>
<thead>
<tr>
<th>Table 1. Online bootcamp topics.</th>
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<tbody>
<tr>
<td>1. The Structure of the Healthcare System and Its ICT: National to Institutional</td>
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<td>2. Health, Healthcare, and their Challenges for Health Informatics</td>
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<td>4. Patient Safety</td>
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<td>5. Human/Social Aspects of Health Information Systems 1 + 2</td>
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<td>6. Applying Health Informatics 1 + 2</td>
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<td>7. Systems Support for Public and Population Health</td>
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<td>8. Major Healthcare Applications 1: Information Systems</td>
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<td>9. Health Communications Systems and Telehealth</td>
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<tr>
<td>10. Managing Risk in the Digital Enterprise</td>
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</tbody>
</table>
11. The Health User Interface and Interactive Systems
12. Quality Assessment and Improvement Support
13. The Critical Nature of Health Informatics Relative to the Quality of Care
14. Systems in Community and Home Healthcare
15. Workflow Representation and Evaluation
16. Health Informatics Education
17. Major Healthcare Applications 2: Digital Imaging and PACS
18. The Future and Persistent Issues in Health Informatics
19. Key Personal Skills for Applied Health Informatics
20. “Intelligent” Health Systems
21. Procurement
22. Mental Health Informatics
23. Nursing and Information Systems
24. Introduction to Bioinformatics and Translational Bioinformatics
25. Information Systems and IS HR
26. Physicians Office Systems
27. Industry-Institutional Partnerships
28. Project Management
29. Informatics-Enabled Community and Home Care
30. The Health Informatics Professional
31. Networks
32. Canada Health Infoway and the Federal E-Health Strategy
33. Completing the Bootcamp: Accessing Online Resources and Discussions
34. Continuing Education and Maintenance of Competency
35. Critical View of E-Health
36. Nature and Components of the Bootcamp Program
37. Health Informatics: A Bootcamp Perspective
38. A Critical Perspective on eHealth Strategies
39. eHealth Infrastructure
40. Physician eHealth Strategy and Implementation
41. Sharing Patient Information within Primary Care Network Teams
42. Standards and Best Practices
43. Privacy, Ethics & the Law
44. Translational Bioinformatics
45. Telehealth Strategy and Progress 1 + 2
46. Evaluation in Health Informatics
47. EHR Video
48. Regional and Provincial ePharmacy and eLaboratory
49. Overview of Health Informatics
50. Health Information Management
51. Managing eHealth Risks and Opportunities
52. Intelligent Health Systems
53. User Interaction and the Human-Computer Interface
54. The Dark Side of Health Informatics - Insights from the Social Sciences
55. Digital Imaging, Image Processing, and Management
56. Mathematical Computing in Health
57. The Health Informatics Infrastructure
58. You, Your Competencies and Being a Health Informatician
59. Evaluation: Is IT Worth it?
60. Data Mining
61. Mobile Virtual Communities in Health
62. Healthcare 2015: Win-win or Lose-lose
63. Strategic Planning for Information Systems
64. HI Professionalism
65. Collaborative Learning
66. Knowledge Translation and Its Application to Chronic Disease Management
67. Clinical Results Communication: Synoptic Reporting
68. Chronic Disease Management
69. Health Informatics Core Competencies
70. Communities of Practice: Application in Healthcare
5. Bootcamp Format

The Bootcamp is delivered in two parts, the on-site sessions and the online sessions. In developing the program, we committed to the migration of as much content as possible from on-site to online availability.

The first Bootcamp occurrence included 5 days of on-site presentations, with the second and third occurrences being of 4 and 3-day durations, respectively. The on-site part of the Bootcamp is now typically about two-days in duration, supplemented by about 80 hours of online material derived from previous sessions. Other on-site formats are possible, including one suitable for videoconferencing (two half-day videoconference sessions preceded by and followed by online sessions). We have also offered a Bootcamp with an added third day that allowed teams of students to participate in projects and to present and have their work reviewed by Bootcamp teachers.

Online material is password-protected and is available to both past and future students. Video resolution options allow access by students with either high or low-speed connections. On a monthly basis, we convene web-conference question and answer sessions in which any student may participate. These sessions are supported by a weblog that enables students to ask questions at any time. As a result of our efforts to move more content online, we have been able to reduce the fee students pay to approximately CAD 11.00 per hour of instruction.

In addition to the above, we also provide students with access to an online system that explains HI competencies and enables them to self-assess their competencies versus those required for a variety of AHI roles [8].

6. Program Attendance and Evaluation

Over 400 individuals will have participated in the 7 occurrences of the program up to the end of 2008: Waterloo (3) and Toronto (2) in Ontario, Edmonton in Alberta (1), and Halifax in Nova Scotia (1).

We have used pre and post-tests to assess learning in two of the sessions. This is currently in the process of being revised with the assistance of an e-learning expert.

An evaluation has been performed of each offering of the program. Students are asked to assess program content, teaching quality, handouts, facilities and other aspects of the program. These evaluations reveal a high-degree of satisfaction with the Bootcamp, with ratings averaging 4.3 out of 5.0 (range: 4.1 to 4.5). Our experience with the Bootcamp indicates that it was much-needed, that it has initiated individuals into a life-long learning process and that it has stimulated them to interact with the members of the HI community.

7. Accreditation

The Bootcamp is an accredited program of the University of Waterloo, Department of Continuing Education. Also, Continuing Medical Education credits have been available for most occurrences. Accreditation by nurse and technologists’ associations is
currently being pursued. In addition this program is being prepared for accreditation as an AMIA 10 x 10 program.

Acknowledgements

The Bootcamp program is made possible by co-hosts, partners and other supporters. These have included: members of the Waterloo Institute for Health Informatics Research (http://hi.uwaterloo.ca/hi/Members.htm), McMaster University (D. Koff, A. McKibbon), Sunnybrook and Women’s College Health Sciences Centre (S. Marafioti), the University of Alberta (N. Shaw), the Northern Alberta Institute of Technology (R. Stumbur), York University (N. Cercone, R. Irving and S. Dinca), Dalhousie University (G. Paterson, D. Zitner, M. Shepherd), the Ontario Telehealth Network (E. Brown), the Smart Systems for Health Agency (M. Connolly and B. Seaton), Healthcare Information Management and Communications Canada (S. Huesing), Agfa Healthcare (E. Akyuz), McKesson (R. Dunn), Borden Ladner Gervais (M. Fecenko), Cisco (S. Lawrence), Capital Health Edmonton, VON Canada (J. Shamian), Accenture (M. Catz), COACH (D. Newsham, A. Gardner), ITAC (C. Adno), CHITTA (E. Huesing), Grand River Hospital (G. Kearns), Bell Canada (A. Ryan), IBM (S. Causi), Canada Health Infoway, 3M Canada, Ormed (C. Sherback), XJ Partners (W. Tatham), 3M Healthcare, Ontario Ministry of Health and Long Term Care and many others.

References

Section 3

Electronic Health Records
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Information Management Framework; a Model for Clinical Departments

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Abstract. The information management system of Department of Critical Care Medicine in Calgary Health Region was modeled using a departmental information management framework. The clinical, administrative, research and educational, decision-making and quality improvement information needs of the department are served by the system.

Keywords. information management, critical care, data warehouse, clinical information system, information management framework

Introduction

Information flow and transformation is paramount and ubiquitous within clinical departments. Bed-side Clinical Information Systems (CIS) are designed mainly to improve patient care at the point-of-care by improving the delivery and utilization of information. Another powerful use of these systems is to facilitate departmental management and research [1].

Clinical information collected by these systems can be transformed to support departmental quality improvement initiatives, administration and research. On this note, the Department of Critical Care Medicine (DCCM) in Calgary Health Region (CHR) adopted a simple and sustainable information management framework that extends its bed-side charting system to support multiple departmental initiatives to improve safety, efficiency and delivery of critical care service.

The Framework

An information management framework aims to structure the flow and transformation of information within a clinical department to simplify and improve the utilization of departmental information to support patient care and safety, quality improvement, research, education and administration. The framework at DCCM has three independent yet highly integrated components to manage patient-specific data, generate focus group information and provide a medium for communication among these groups.

Patient-specific information is the data documented by bed-side care providers, captured directly from patient monitoring devices or transmitted by auxiliary hospital systems at the point-of-care. The confidentiality, accessibility and integrity of these data which are shared among care providers are essential for patient safety and have a direct impact in health care delivery and outcome.
Focus group information is derived from the patient-specific data and combined with data from other departmental data sources. These data pieces are then integrated, correlated, aggregated and filtered to draw information pertaining to a specific area of activity in the clinical department. This information is studied and analyzed by focus groups with specific needs and agenda to support the department’s various needs.

Analysis of this information yields knowledge that is compared with publicly available evidences or results of similar research and is then fed back to the care givers to support their care practices or is used by administrators to plan and justify the utilization of the scarce resources. To close the loop in the information management cycle, a robust communication medium is also required (Figure 1).

Experience has shown that clinical practice changes constantly in order to adapt to newly gained knowledge. Agility must be a built-in feature in these interrelated components to facilitate the addition of new functionalities without the cascading effects of change.

To illustrate the effectiveness of this information management framework, we will describe the clinical information management in the CHR DCCM where this model has evolved during the past two decades.

1. Background

Caring for critically ill patients requires the integration of large amounts of demographic, clinical, laboratory, and outcome data. The increasing complexity and intensity of care for patients admitted to intensive care units (ICU) has necessitated the implementation of computerized information management systems. These systems are used across multiple ICUs mainly as an electronic patient record for direct patient care,
however, they also facilitate benchmarking, outcome research, and quality of care and safety initiatives. Research indicates that information management helps improve performance and quality in ICU units in many different ways [2].

CHR provides all acute hospital care to the residents of the cities of Calgary and Airdrie and a large surrounding area (a population of 1.2 million) in the province of Alberta, Canada [3]. All critically ill patients in CHR are managed in closed ICUs under the care of certified intensivists in DCCM. In 2007, approximately 3,600 patients were admitted to the four ICU units in the region’s three adults hospitals.

The CIS within DCCM has evolved dramatically since its initial inception to track admissions in 1989. Electronic charting began in 1996 in one of the sites and by 1999 became region wide. The department’s Information Technology Services is presently staffed by a group of six full time members consisting of a Project/IT Manager, Programmer Analyst, Data Analyst, Web Analyst, Registered Nurse System Coordinator, and a Registered Nurse System Instructor. This group is responsible for development, maintenance, troubleshooting, training and data quality of the three integrated components of the framework as discussed below. This group which also provide 24/7 hours support for end users, works collaboratively with a much larger regional IT group for network, hardware, interfaces and other non-ICU related software.

The current CIS is composed of three separate, but well integrated systems:

1. data collection system; a real time, mission critical, On-Line Transactional Processing (OLTP) system and its related interfaces for collecting data at the point of care.
2. data warehouse and reporting system; a near real time, On-Line Analytical Processing (OLAP) system, and its data Extraction, Transformation and Loading (ETL) processes for analyzing the data, generating aggregated reports and producing information.
3. intranet web site; a dynamic multipurpose communication medium. The role of the web site is to provide a user interface to the system and to deliver information to the end users and administrators in order to close the feedback loop, raise awareness, and increase knowledge.

Clinical work processes bear a huge amount of data related to demographics, assessments, diagnoses, treatments and interventions, resource utilization and outcome. These processes in some departments such as ER, OR, Critical Care, Cardiac Care are more data dependent than the regular care units and can take a better advantage of this framework. Real time collection of detailed, relevant, valid, consistent, and complete data on these processes results in valuable information used to enhance communication, care planning and quality.

These data, when merged with other relevant data sources, produce a powerful asset for the department. Often referred to as a “gold mine,” they are used to monitor and enhance the quality of care and patient safety, support administrative decision making, monitor the usage and better utilize valuable resources, enhance education and promote research and publications.

A dynamic intranet web site is essential in information distribution and knowledge management. It is used to access the quality review applications, distribute the quality and activity reports, educate and inform staff and provide a discussion forum. The rest of this paper describes these components and the benefits that our department is getting from this model.
2. Data Collection System - Bedside Electronic Charting and Documentation

Most of the data capture occurs at the bedside point of care using an electronic patient information charting system (Quantitative Sentinel; GE-Marquette Medical Systems Inc. Milwaukee, WI, USA). Interfaced with ICU bedside devices, QS, electronically acquires physiologic and respiratory data. Staff then validate these data by examining the degree to which they are representative and sensible.

An HL7 interface with the regional laboratory information system (Cerner PathNet Classic version 306, Kansas City, MO, USA) is utilized to collect laboratory and microbiology data. An interface to existing clinical systems such as the hospital information system enables demographic and Admission, Discharge and Transfer (ADT) data to be captured automatically.

Order entry is performed using the hospital information system (Sunrise Clinical Manager, Eclipsys Technologies Corp). Medications except for STAT and PRN orders are charted in this system which, in turn, feeds the data to the data warehouse. The system is also used for daily charting by pharmacists, nutritionists, social workers, occupational therapists and infection control practitioners working in the ICU.

A number of manual and systematic processes are used to maximize data integrity and quality. Direct downloading of data eliminates errors associated with manual data entry. Provisions such as limit checking, error flags, colored dots and reminder messages are used and displayed on nursing and physician chalkboards upon log in. Specific data quality queries and reports are run every morning to detect incomplete, inconsistent, unreliable and missing data. If any problems are found, a request-for-correction note is sent to the staff responsible for the chart.

Configurability, flexibility and expandability of this system are some of its most important success factors. An easy and user-friendly design and programming toolkit is used by the DCCM IT group to add system functionalities and perform in-house customization for new requirements like the addition of a new scoring system. Of course, clinician involvement, proper change management and executive support are some of the factors critical to success.

3. Data Warehouse and Reporting System

CIS’s easily accessible data are a great resource at the point of care; however that data are also a valuable source of information for other related purposes. The second component of our information management framework is storing, aggregating, analyzing and extracting information from these data. For that purpose we created a data warehouse where we can integrate these data with other disparate data sources. Clinicians and administrators use the warehouse to distill data into information.

Data are extracted from the charting OLTP system every night and imported into the data warehouse called TRACER, which was developed in house. While the charting system database is tuned for immediate response to transactions at the point of care, the TRACER is a relational database system that is tuned for complicated queries and time-consuming data aggregation. An Oracle 10g Relational Database System (Oracle Corporation, Redwood Shores, CA, USA) is the platform for TRACER.

TRACER extracts information from the source databases using programs developed in Visual Basic and Microsoft Access (Microsoft VBL; Microsoft Corporation, Seattle, WA, USA).
4. Intranet Website Knowledge Communication System

A dynamic departmental web site has been developed to distribute the information and reports to health care providers and administrators. The integration of the departmental web site into the bedside charting system has encouraged its use as a tool for the day-to-day activities and has increased the effectiveness of this communication medium. This medium allows the end users, care providers, data producers and data consumers to be included in the communication circle. Some of the features incorporated into the internal web site include a bed occupancy indicator dashboard, continuing medical education quizzes, and administrative and quality indicator reports. The intranet web site also includes call schedules; presentations for educational rounds; secured shared access to the data warehouse for quality review applications; links to e-mail, calendar, paging system, and search engines; and policies, protocols, guidelines, and research materials.

5. Results

Besides direct patient care, other purposes of information management in DCCM are:

1. Quality Assurance, Quality Improvement and Patient Safety
   Reports are automatically generated to ensure compliance with regional guidelines and protocols such as head of the bed elevation for preventing ventilator-associated pneumonia. The data are also used for case reviews and quality monitoring efforts such as mortality and morbidity reviews or review of readmitted cases. Table 1 lists the routine quality indicator reports that are submitted to the regional quality council on quarterly basis for review [4].

2. Administration
   The data also support administrative decision making not limited to areas surrounding capacity planning and re-distribution of ICU beds. Examples of administrative reports readily available to decision makers are displayed in Table 2.

3. Research
   Our system has served a major role in support of many published academic

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<th>Table 1. Examples of quality improvement indicator reports for critical care.</th>
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<tr>
<td>Rate of Ventilator Associated Pneumonia (VAP)</td>
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<td>Adverse events e.g. rate of unplanned extubation</td>
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<tr>
<td>Rate of readmissions within 72 hours of discharge</td>
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<tr>
<td>Deep vein thrombosis and stress ulcer prophylaxis</td>
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<td>Compliance with protocols and care bundles</td>
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<table>
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<th>Table 2. Examples of administrative reports for critical care.</th>
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<tr>
<td>Department and unit activity and acuity summary</td>
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<td>Bed utilization and unit occupancy</td>
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<td>Organ and tissue donation rates</td>
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<td>Length of stay</td>
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research studies by departmental members. Projects have primarily been observational epidemiologic or outcome studies in areas not limited to severe and ICU-acquired infections, cost effectiveness analyses, severity of illness scoring system evaluation, severe acute renal failure, and traumatic brain injury [5].

4. Education

Every month, a short quiz, designed and written by educators, covering some of the most important topics in critical care from hand hygiene and oral care to sepsis are posted on the intranet web site. The questions which are geared towards education are linked with relating protocols, papers and guidelines for reference.

A report of physician activities such as performance and supervision of different ICU related procedures and interventions is used monthly to evaluate residents and staff. Quality indicators and administrative reports get posted on the default home page and splash screen of our intranet web site.

6. Conclusions

The information management framework in the Department of Critical Care in Calgary Health Region, which has evolved and been enhanced over two decades, is now mature. It helps to supply departmental, clinical, administrative, research and educational needs. This proven framework can be used as a model in other clinical departments or services.

Acknowledgement

The authors acknowledge the leadership and physicians of the Department of Critical Care Medicine. We particularly wish to thank Dr. Dean Sandham, Dr. Paul Boiteau, Dr. Chip Doig and Dr. Tom Rosenal for their vision and unwavering support of information management within critical care. In addition, we wish to recognize the efforts of the past and present members of the department who have provided IT services, especially Mr. Don Whiting.

References

Clinical Support in Primary and Ambulatory Care: Canadian Lessons to be Learned from the UK Patient Summary Care Record (SCR) Initiative

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Abstract. There is an increasing requirement for interdisciplinary teams to share patient data to ensure optimal care. Healthcare providers in all settings from Emergency Medicine to long-term care management need access to patient information. In the UK, developments to address the need for information sharing have uncovered issues that the Canadian eHealth establishment would do well to heed when undertaking its own initiatives.

Keywords. Summary Care Record (SCR), Detailed Care Record (DCR), National Health Service (NHS), Connecting for Health (CfH)

Introduction

The drivers and benefits of the UK Summary Care Record (SCR) initiative have close similarities and implications to the Canadian provincial EHR adoption programs. For example, the Alberta Shared Health Record, which is similar to the SCR, takes clinical information from various health care information repositories and places it in the Provincial health information portal. This initiative is currently experiencing implementation challenges caused by physicians being unclear as to what the system benefits are and wary of potential extra work and legal responsibilities. This paper will address the challenges and lessons learned from the UK for similar initiatives to be successful here in Canada.

1. Background and Drivers

For more than ten years, UK GPs have maintained electronic patient records. As part of the National Program for Information Technology (NPfIT) the SCR initiative was formed to provide other health providers access to an undefined portion of these records through an extranet know as the “national data spine.” This initiative has been piloted by six early adopter sites. As of April 2008, two Primary Care Trusts composed of GPs, Nurse Practitioners and other primary care providers have begun utilizing the SCR and nearly 160,000 summary care records from GP offices have been uploaded.
onto the spine [1]. The SCR will only exist for patients with a GP located in England. At first, the SCR from the GP office was seen to benefit four major patient populations:

- travelers outside their home area,
- unconscious, emergency care patients with no accompaniment,
- unscheduled care for elderly patients in the community (including possibly unscheduled care for patients with long term conditions); and
- patients treated out of hours [2].

Despite these perceived benefits, emerging problems included defining the purpose and content of the SCR, how patient consent is obtained, who should have access, and how and where the repository should be maintained.

2. Issues and Challenges

2.1. Defining the Purpose and Content of the SCR

Initially, Connecting for Health (CfH), the enabling organization of NPfIT, intended this to be a true summary care record providing information on known allergies, known adverse reactions to medications and other substances, acute prescriptions in the past six months and current repeat prescriptions [2]. Using information from early adopter sites, the Department of Health (DH) stated that it was of mind to put additional information into the SCR around current patient health conditions and treatment and allow Primary Care Trusts to customize the range of information available. However, no specific information was released on how detailed this information may be. This apparent lack of standardization should be of real concern as the national applicability of the SCR could be compromised. Further, it calls into question when a summary record becomes a detailed record. This lack of standardization and growing levels of information has a number of impacts on people, namely:

1. the MDs who have to spend more time filtering out the relevant information as a result of adding more information into the health care record,
2. the owners of the source information who may become liable for inaccuracies and subsequent problems that may occur. What is the mitigation to this risk?
3. the MDs who are required to take notice of all alerts; but are the alerts still valid? Who is responsible and who takes them off?
4. the person who is generating and monitoring the quality standards of the information.

The overall implication is that the use of the SCR becomes diluted and regional inconsistencies may cause clinicians to question the validity of the record itself. Also, any benefits related to the initiative start to become either invalid or ignored and clinicians question whether using the SCR will take up more of their time. Current thinking by CfH states that if a patient so chooses, their record can grow to include more detailed medical history, such as diagnoses and infections. If this is the case then the four points above will still apply and this potential problem may not be resolved. Further, there is the potential that the record may also contain more sensitive information (so called “sealed envelopes”), such as mental and sexual health issues where patients can restrict access to specific pieces of information from certain healthcare professionals. Unfortunately, sealed envelopes were not implemented or
tested at the early adopter sites. There are two potential types of “sealed envelopes,” both attempting to protect the patient, but with different levels of access:

1. Sealed and locked envelopes allow only the care team that created the data to know there is hidden information and is inaccessible by others, even in emergency situations.

   If a SCR is to contain sensitive information, there needs to be assurance that the right to break the seal is only granted by the patient, except where there is a legal requirement to override this measure. However, potentially the contents of a sealed envelope may have a critical impact on the clinical interventions being considered in an emergency. As such a second, more diluted approach has been suggested.

2. Sensitive information can be available to the care team that created the data but remains “hidden” from general view. Other care providers can ask for permission to view it in emergency situations and where permission cannot be obtained, professionals can unseal it if they feel it is necessary for care.

   At issue is the term “necessary” but the situations requiring the need to open sealed envelopes without consent are far too many to make accurate generalizations. This will concern clinicians who will be wary about potential legal actions for alleged inappropriate access. Despite the concerns raised on the use of sealed envelopes, patients have welcomed them as they are seen to promote patient safety and confidentiality.

2.2. How Patient Consent Is Obtained

Consent to treatment is a cornerstone of medical treatment and there are many safeguards in place to protect the patient and clinician. Clinicians tend to favour explicit consent as it requires a definitive decision on the part of the patient, which in turn requires the patient to be made aware of all risks, implications and impacts of their decision. The explicit model also meets the sealed and locked approach as the patient has an opportunity to review information about him or herself at an appropriate time. However, explicit consent could mean that a significant percentage of the population, especially the most vulnerable, would not be able to take advantage of this advance in healthcare, and there is little doubt that it is this section of the population that would benefit most. As such, is it right that the benefits to most should be taken away by the wishes of the minority to whom explicit consent is seen as a protector, rather than a barrier to care? Further, the time taken to gather the explicit consent of a country’s population would take a disproportionate amount of time. If this is the case, then implied consent would seem to be the preferred way forward. However there are four important issues that still make this a difficult model to progress, namely:

   1. To what extent has the provider got a “relationship” with the patient?
   2. Do patients understand the consequences of what information is on the record?
   3. Do patients understand the implications of sharing health information?
   4. What are appropriate circumstances for this information to be viewed?

   A refined consent model has been proposed by the SCR advisory group which will require patients to give NHS staff permission to view their electronic record at every encounter, unless they are too ill to do so. This approach would seem a solution for the factors outlined above. The situation when access may be necessary should always be known to the patient as well as who is accessing it. Similarly, for sealed information, it
should remain sealed and left to the patient to decide whether to disclose it to the provider. One would have to hope, though, that the patient is competent enough to realize the situations when the information is indeed relevant. The approach does not really address the question of what should be on the record, but other factors such as capacity and access to data are arguably more relevant to this issue.

One of the main detractors from this model is that there would still need to be a strong and effective communications drive on informing patients on the workings of this model, either in advance at the setting up of the SCR or indeed at the time when critical care is required. This would be necessary to meet the requirements of point (3) above and needs to be supported by a mechanism that allows patients to be able to understand and corroborate what is on their record so at the critical time when the information is required, there is confidence on all parts that the information is correct.

2.3. Who Should Have Access?

Both in the Canadian and UK, the need to grant wide range access to patient health information to achieve a more integrated care system raises concerns around how to assure patient confidentiality yet still provide access to those who would benefit most from the data. More integration suggests the need for social care providers to have access, which may be one step too far for some patients who feel they have no medical relationship with social services and the sharing of medical information with these groups is inappropriate and unnecessary.

Paired with this challenge, GPs are concerned about giving up control over ‘their’ data and sharing them with others, potentially breaking the physician/patient relationship. This similar concern in North America was overcome in the UK by making the GP/patient relationships the primary one and also ensuring that GPs were fully consulted in the formation of the SCR model. As such, patients remain informed not only by central government, but also by their GP. The GP and the patient then work together to update the patient’s problem list and determine what information can and should be shared with others.

To control further access to the SCR, NHS staff are required to be authorized with an authenticated ‘Smartcard’, or pass code. These individuals must belong to a healthcare team directly involved in a specific patient’s care and should only see information applicable to their role in providing healthcare. For example, a booking clerk or office receptionist may have access to information needed to schedule an appointment, but would not have access to detailed medical information. Despite the rigorous user authentication and role-based access controls, there is concern around the novelty of these measures, particularly on this large of scale in the NHS. Also, this approach would mean that a medical secretary’s role could significantly change if they are perceived not to have the clinical right to see a patient’s record.

As a part of this, Governments must also look at the appropriate level of security measures in order to protect patient confidentiality and control access to the SCR. It is appreciated that no information system can be considered 100% secure, just as paper records cannot be either. There is a trade-off between levels of security and the need to ensure the system is user-friendly. However, there must be the threat of punitive action for attempts to breach security. In the UK, the DH and the Information Commissioner’s Office have called for custodial sentences for people who unlawfully access personal information.
2.4. How and Where the Repository Should be Maintained

So what information should make up the clinical data set in the SCR? This answer then determines whether an SCR should be a locally or a nationally managed depository of information. Further, this should also inform the debate as to whether there is a place for both a summary care record and a Detailed Care Record (DCR), and what the demarcation is. Depending on the scope of the SCR, the information will come from a fairly small number of locations, primarily the patient’s GP. This requires a great deal of standardization of material to ensure that information can be used across the country, both in terms of content and format. However, with only 50% of family physicians in Alberta using an EMR, this would suggest that any SCR will only contain information of patients whose doctor uses an EMR.

There may also be the need for systems to communicate with each other and to exchange data to create the integrated SCR. Again, the more national this system is, the greater difficulty in creating the communication and data sharing links. Bearing in mind the size of Canada, should we be more concerned about creating an effective DCR rather than an SCR? The confusion over the content and likely uses of an SCR have lead many to question the value of having separate national SCR and local DCR systems. It can be argued that there should be a sense of order in this, in that it should be more of a priority to get the DCR agreed and functional first and then work on the summary one later. This approach does seem a lot more sensible as it is normal to summarize from detail, not the other way around. Putting the SCR first has been seen as a distortion of priorities. However, regardless of the approach, there needs to be a clear consensus, certainly around clinical people, that this relatively small data set is a significantly useful clinical data set. As the complexity of the SCR increases, the levels and sources of information increase as well. This, then, has the effect of moving from a national system, where data can be assimilated fairly easily, to a local system due to increasing amounts of information being required with more providers providing information.

3. Discussion and Lessons Learned

Given the broad landscape structure of the Canadian healthcare environment, it makes sense for Canada to continue on the path of creating electronic care records at the jurisdictional level and then summarize and integrate the data at a broader, national level. Lessons learned from the UK SCR can be summarized as follows.

3.1. Define and Communicate the Purpose Up Front

The purpose and content should be defined, understood and agreed to in the initial stages of the project. A focus group of clinicians should be established to define the most clinically useful data set for the record. To start, the record should be easy to use to promote adoption and add value at local levels.
3.2. Set Expectations and Realize Quick Wins

Target goals should be set throughout the project lifecycle. Expectations on the project goals and anticipated benefits should be defined and communicated up front. Paired with this is an understanding the complexity of such an initiative should not increase until after key milestones have been reached and quick wins have been accomplished. Benefits must be seen in the early stages of deployment.

3.3. Communication to the Patient Population

Feedback on the SCR initiative has shown that the biggest concerns from the patient population are centered on consent and patient confidentiality. There needs to be a strong and effective communications plan to inform patients of the consent and confidentiality program. Patients must be made aware of the content of their records in order to grant appropriate access and help ensure their information is correct. This will help promote patient trust and confidence in the system.

3.4. Make the Physician a Key Player

Physicians hold the primary relationship with patients. They can help ensure patient information is up-to-date and accurate. Involving physicians from the early stages of the project will help with the success of the initiative. Physicians are the gateway to patient trust and confidence in the system.

3.5. Focus Efforts on Standardization

The initiative should focus on meeting standards for health information exchange. This will promote increased sharing of the data and allow for easier and faster replication and integration in other jurisdictions.

4. Conclusion

In light of the focus on integrating Primary Care Networks and promoting the sharing of vital information in Canada. This country should take note of the challenges faced by the UK when executing its own initiatives. Applying the lessons learned to the initiatives underway in Canada will allow us to realize the true benefits shared care records can bring to our population.

References


Technical and Architectural Issues in Deploying Electronic Health Records (EHRs) over the WWW

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Abstract. In this paper technical and architectural issues are described in deploying electronic health records (EHRs) over the WWW. The project described involved deployment of EHRs that have been designed to serve in the education of health professionals and health/biomedical informaticians. In order to allow for ubiquitous access to a range of EHRs remotely an architecture was designed with three layers: (a) the “Internet” or remote user access layer (2) the “Perimeter Network”, or middle firewall security and authentication layer (3) the “HINF EHR Network”, consisting of the internal servers hosting EHR applications and databases. The approaches allow for a large number of remote users running a range of operating systems to access the educational EHRs from any location remotely. Virtual machine (VM) technology is employed to allow multiple versions and platforms of operating systems to be installed side-by-side on a single server. Security, technical and budgetary considerations are described as well as past and current applications of the architecture for a number of projects for the education of health professionals in the area of electronic health records.

Keywords. EHR, education for health professionals, health informatics, computer architectures, web architectures, biomedical informatics

Introduction

The need to access electronic health records (EHRs) at any time and anywhere for the delivery of healthcare (and for health professional and health informatician education) requires utilizing modern technology to deliver applications, tools and resources to users universally, regardless of operating system, remotely over the WWW. In this paper we will discuss an architecture for providing access to a range of EHRs over the WWW for educational purposes. Given that most healthcare offices and institutions have stringent security policies and rules, and the need for strict privacy adherence, the challenge becomes how to deliver these modern medical applications to healthcare professionals and students virtually which can be utilized by instructors to integrate into healthcare curriculum frameworks.

In order to achieve this a server solution was designed that employs a combination of several hosted systems methodologies: one which involved providing remote access to traditional “thick client” (traditional desktop) applications (typical of many commercial EHRs) using thin client “viewers”, and the other using applications written for the web (and accessed in web browsers such as Microsoft Internet Explorer and Mozilla Firefox). In designing the solution and the remote access network, it was...
readily identified that it must be scalable to use by up to 1000 concurrent users in our first test application (hosting an educational EMR to be accessed by hundreds of medical students over the WWW). Previous research has indicated that little or no work has been conducted in the area of developing virtual servers for EHRs used for education purposes [1,2]. Having ubiquitous and remote access to a range of different EHRs over the WWW has the potential of radically improving the integration of IT into health professional education which goes towards improving patient care and the quality of health data for use by all stakeholders including the inter-disciplinary health teams, government policy makers, and managers of healthcare systems and facilities. This paper will describe the technical framework we have employed for the implementation and deployment of an EHR Educational Portal, known as the University of Victoria Interdisciplinary EHR Educational Portal. This Portal was designed to provide for widespread access to educational health records and this initiative is described elsewhere in this issue [3].

1. Methodological Approach

The overall approach to providing ubiquitous web-based access to electronic health records required that access not be limited by user operating system choice and so the framework implemented in this research allows for users to employ multiple computer systems running virtually any operating system from any location in the world. As illustrated in Figure 1, the framework for deploying the University of Victoria EHR Educational Portal is segmented into three essential components: 1) the “Internet”, or remote user access layer, 2) the “Perimeter Network”, or middle firewall security and authentication layer, and 3) the “HINF EHR Network”, the internal servers hosting EHR applications and databases.

1.1. Internet Component

As shown in Figure 1, the Internet component represents remote user computer systems, such as desktop and laptop computers. Users may be using any number of operating systems such as Windows, Linux, or Mac OSX, and using a web browser, the Microsoft Remote Desktop Connection software, or rdesktop (Linux systems), depending on which EHR the user will be accessing.

1.2. Perimeter Network Component

The Perimeter Network component represents the security and authentication layer, and is situated between an external firewall and an internal firewall, and requires each user to have a username and password to login. The Terminal Services (TS) Gateway Server is a Microsoft feature in Windows Server 2008, which provides connectivity via Remote Desktop Protocol (RDP) over Hypertext Transport Protocol Secure (HTTPS) using port 443 or Secure Sockets Layer (SSL). This essentially means that users login to a remote desktop on the server and interact with software applications running on that desktop. Figure 2 shows what a user would see when they logon remotely to the server. For example, the figure shows a Windows desktop with several icons representing various health record systems that users can simply double-click on to run and access the system remotely (and view a dummy patient record). Also in the figure
is shown an electronic health record (OpenVistaCIS) that is being accessed by a user remotely.

![Diagram of EHR Educational Portal](image)

**Figure 1.** Overall architecture of the University of Victoria EHR Educational Portal.

### 1.3. Internal Network Component

The Internet Network component represents the “secured” network where the Terminal Servers, database server, user account server, and web server are located. These servers are situated behind the Internal Firewall and are not accessible except through the firewall and authentication services. The security framework limits what a user has access to when they login so that systems cannot be compromised, and in the Windows environment the implementation of Group Policies limit and manage the terminal servers so that user desktops are self-contained, i.e. each user has their own desktop and user file space on the server when they are interacting with electronic health records. The server technology deployed utilizes Microsoft Hyper-V software [4]) with Microsoft Windows Server Enterprise 2008 that allows for the hosting of more than one type of operating system simultaneously, i.e. the physical server machine is presented to the virtualized operating system as if it is a separate physical machine. Therefore, on the same physical server hardware we can have running side-by-side a number of Microsoft Windows operating systems and Linux operating systems, which are virtually partitioned from each other and do not know of each
others existence. This capability allows for the scalability and expansion of the amount of users and number of EHRs that can be implemented without having to reconfigure all the server hardware, and prevents rogue applications or operating system crashes from crashing an entire server.

1.4. Technical and Budgetary Considerations

To be creative, and to be mindful of budget restraints, licensing costs for the Microsoft remote servers and Windows client access licenses were utilized from an ASP (application service provider) hosting platform where licenses could be rented for a limited duration time (month-to-month), and where open source EHR software was employed on the Linux platform, licensing costs were negligible. The requirement to host multiple EMR/EHR application products made the need to be conscious of software licensing costs paramount. Other researchers wishing to employ the architectural approach described in this paper will need to take into account licensing costs for Microsoft Windows Server Enterprise 2008 and Hyper-V technology.

![Screen capture of the remote user desktop.](image)

With the need to manage space in server data centres, where space is a premium, as described above the servers were constructed in such a manner that using virtual machine (VM) technologies, the solution allowed for multiple versions and platforms of operating systems to be installed side-by-side on a single server (thus maximizing
the use of the processors and memory on a single server, and allowing for disaster recovery of a virtual machine instead of an entire physical server). Furthermore, in the event of server downtime, the VM could be loaded on another server (restored from a backup) with minimal downtime occurring. The benefit of using multiple VMs on a single server architecture allows for maximizing the amount of people that can remotely connect to a particular EHR solution, without the need for adding more and more servers. The need to scale to up to a 1000 concurrent users did not abrogate the need for multiple physical servers, of which the project has 7 available for virtual machine hosting, with up to 4 virtualized servers on each for a total of 28 systems, which fit tightly in a single vertical server rack enclosure. The need to balance cost and performance with end user expectations for speed and agility were considered in the design of the architecture, and cost and performance will be measured during usability analysis that will occur in future testing.

2. Range of EHRs Deployed and Technical Considerations

A range of EHRs have been successfully deployed on the University of Victoria EHR Educational Portal using the architecture and framework described above. This has included simultaneous access to educational EHRs by up to several hundred health professionals, health informatics instructors and their students, i.e., fourth-year nursing students and undergraduate and graduate health informatics students. The system has also allowed access remotely to users connecting from other countries and overseas.

The systems deployed to date have included Digital Health Designs EMR, Veterans Affairs system as implemented as OpenVistaCIS, the eNursePHR open source Windows application, the OpenEMR and OscarMcMaster open source health record applications (the latter two systems being implemented as Linux VM web servers). We are continually testing and deploying new EHRs on the portal to increase the range of systems that are available virtually via the Portal.

3. Experiences to Date

To date we have successfully deployed the above architecture to support educational initiatives with a number of educational organizations and institutions (to be described in a paper by Borycki et al in this issue). This has included projects with the Vancouver Island Medical Program, the University of British Columbia Medical Program and the University of Northern British Columbia Medical Program, as well the University of Arizona’s medical program and the University of Victoria’s nursing and health informatics programs. In addition, we have recently deployed the OpenVistaCIS application using the above architecture to over 150 nursing students and instructors at the University of Victoria. The approach has also been used in health informatics classes where students have used the architecture to access representative examples of electronic health records.
4. Conclusions

In this paper we have described a novel approach to providing web-based access to electronic health records for education. It is concluded that by providing a practical multi-OS and multi-EHR remote access environment (for application areas such as medical and nursing education) the benefits of electronic health records will be readily seen. It is expected as health professional students become more educated and knowledgeable about health information technology they will be more likely to adopt and effectively use such systems. In this paper we have focused on technical and architectural issues for deployment of educational EHRs over the WWW and have found that the challenges are not insurmountable and a practical technical solution is achievable.

Acknowledgements

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References

Ontario’s Province-wide Paediatric Electronic Health Record

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**Abstract.** The electronic Child Health Network (eCHN) is an advanced implementation of an electronic health record (EHR). This is a case study of the building of an integrated and shared EHR from multiple systems at multiple sites for the benefit of patients and clinicians. Optimal patient care requires that information about a person’s overall health and interactions with the health care system be available to the appropriate providers when and where it is needed. eCHN is a pioneering response to the need for such shared records. A key to its success is that it is a flexible, scalable, open, multi-vendor solution designed to work with existing hospital systems and other networks. As Canada’s largest functioning integrated EHR, eCHN is serving three million people and transforming the quality of health record keeping and clinical decision-making. eCHN enables health care providers across Ontario to share accurate patient data – in real time.

**Keywords.** eCHN, EHR, clinical data, paediatrics, eHealth, CHI blueprint

**Introduction**

The electronic Child Health Network (eCHN) is an advanced implementation of an electronic health record (EHR). This is a case study about an integrated and shared EHR constructed from multiple systems at multiple sites for the benefit of patients and clinicians. For optimal patient care, information about a person’s health and interactions with the health care system must be available to the appropriate providers when and where it is needed. Up-to-date, accurate, and comprehensive patient health data is vital to the process of medical decision-making. eCHN’s key objective is to improve the quality of health care delivered to children in the Province of Ontario.

The task of providing coordinated care to Ontario’s children has grown ever more challenging as health care delivery has become increasingly specialized. Patients, especially those with complex conditions, often move among different care providers in different settings, yet there is no system for circulating vital patient information. Common records to support continuum of care are needed for many situations, for example, care of chronic diseases, rehabilitation of patients, or acute care episodes. Similarly, common records must be available to a patient’s providers in many settings, for example, a teaching hospital, a community hospital, a chronic care facility, a rehab facility, a community clinic, or a doctor’s office.

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Transfer of information among facilities has been a haphazard process. Physicians and other care providers have had to make inquiries by telephone, FAX, or letter and the ensuing response may come days or even weeks after. The parents of patients have had to collect and carry paper documents to medical appointments or rely on their memory of previous visits elsewhere. Crucial information could be missing or unavailable. The need for a seamless transfer of patient information among care providers has long been evident.

1. The History of eCHN

eCHN is a pioneering response to the need for shared records. It began 10 years ago as a proof-of-concept project of the Hospital for Sick Children and the Government of Ontario. The network went live in 2000, with just five hospital sites and a few doctors’ offices. It has grown to over 100 hospital sites, including all six tertiary centres, plus hundreds of doctors’ offices, home care providers, and chronic and rehabilitation facilities. eCHN has experienced explosive growth in the past 8 years in patient numbers and in the amount of shared health care information. Figure 1 shows the growth based on the number of patient encounters recorded in eCHN data repositories.

2. eCHN Features

With eCHN, health care providers can instantly access the latest medical data about a child. These data come from many different sources consolidated into a single medical chart. Using the network, the data from patient health care interactions are aggregated to provide an accurate and comprehensive patient health record. Patient health information as such as admission, discharge, and transfer data; lab reports; clinic notes; discharge summaries; consultants’ letters and surgical notes; and radiology images and reports are collected from different sites. Data are structured and displayed in an easy-to-use web format that looks like an actual medical chart.

eCHN serves as a data integrator for multiple information systems, aggregating data sources and making patient data available to health care providers at the point of care. Users, in a hospital that has multiple specialized electronic records, must locate and aggregate the data manually in order to compile a complete patient medical record.
eCHN, however, automatically extracts data from existing clinical record systems and, through interfaces and web services, integrates them into a single electronic record. The data is integrated from any system that is in use at a hospital in Ontario, regardless of the vendor that sold it.

eCHN is a flexible, scalable, open, and a multi-vendor solution; it is designed to work with existing hospital systems and other networks. No hospital needs to replace its existing information systems in order to become inter-operable with eCHN. Organizations and individual users participate in eCHN voluntarily.

3. eCHN Status

eCHN is Ontario’s fully functioning paediatric EHR. It serves three million people who are under the age of 19. From the beginning, eCHN was intended to be a pan-Ontario, population-wide shared EHR. It has been growing, evolving, and adapting since 2000. It conforms to the standardized requirements of Canada Health Infoway and Ontario’s eHealth Program.

The results of interviews with providers, patients and families of patients show a high satisfaction level. eCHN replaces a paper-based system that was time-consuming and unreliable with an information transfer system. The electronic system makes the latest patient data readily available to all health care providers who are members of a patient’s circle of care.

4. The eCHN Approach

New tools and greater experience make it easier to integrate hospital information system data. Detailed analyses of hospital business processes and workflows are used to evaluate the readiness of a hospital to participate in EHR integration. eCHN has worked with all of the hospital application vendors in Ontario to construct data interchange interfaces. One key factor in eCHN’s success is the minimized time investment of hospital staff who are overwhelmed with work. Case scenarios in system use are performed in hospital test environments. Tools are used to analyze the quality and integrity of the HL-7 data generated by the hospital. Precise data specifications, transformation blueprints, and gap analysis documents are produced. eCHN staff assist hospital staff from initial data analysis to the integration of paper with “glass” and “glass” to “glass.” Transformation blueprints are used to develop the layers of the interface engine and regression testing is performed on the HL-7 data produced.

The process of integration does not stop even though a site has joined the eCHN network. Because hospital sites constantly change their solutions and their data; eCHN staff provides ongoing maintenance of interfaces and repositories through daily error correction and recovery analysis.

Physicians use a clinical solution when that solution provides accurate and current information. eCHN has a dedicated team in charge of the medical entities dictionary that obtains and analyses tests, procedures and reports from sites. The correctness of test codes is constantly reviewed to ensure system integration (SI) compliance. eCHN maintains the most sophisticated, complete test nomenclature synonyms system in Canada today; it supports both the LOINC and SNOWMED code standards.
The greatest challenge for EHR implementations worldwide has been the runaway costs and poor of utilization by physicians. eCHN has turned out to be highly cost effective and utilization continues to grow every day. The key has been the involvement of physicians in the design and implementation of the solution itself. Functional enhancements have been driven by physicians as much as by the need to adhere to the Canada Health Infoway (CHI) Blueprint principles. The attention given to data quality has been responsible for the trust that physicians have in the eCHN solution.

eCHN has built its solution in accordance with open standards and in adherence to Provincial and Federal guidelines (CHI Blueprint). Proven technologies and commercial applications have been used wherever possible. A strong middle tier is used on a highly performant, scalable, reliable and flexible platform. Support is provided for multiple-device viewers and points of service applications. Provincial registries, third-party systems and other electronic health record infrastructures supply data to the network.

Although industry standards are followed, a pragmatic approach is emphasized. Standards are not implemented for the sake of standards; rather, as hospital information system vendors implement EHR industry standards, eCHN incorporates them.

5. eCHN Benefits

The flexible architecture of eCHN has enabled it to deliver and adapt to Ontario’s EHR needs. Benefits will be realized as disease-specific monitoring and management makes greater use of the system. With over one million patients in its clinical paediatric repositories and close to 100 member hospitals, eCHN is uniquely positioned to support efforts in the management of diabetes. The eCHN group already has extensive experience integrating clinical data relating to chronic diseases. It has already worked with Bloorview Kids Rehab and various cardiac and asthma groups over the past few years. eCHN has been highly successful in translating clinical needs into a working solution that provides immediate benefits. eCHN’s record of achievement comes from its ability to to produce tangible results quickly in months, not years.

Using eCHN to build a strong chronic disease management solution is vital for the success disease treatment and reduction of disease incidence. Healthy children produce healthy adults; conversely, if efforts are not taken to manage and prevent these diseases in the early years of life, the problem is compounded as the children mature.

eCHN, as an agent of the Province’s health information custodians, protects the privacy of personal health data. Only those authorized health care professionals involved in a patient’s circle-of-care are granted access to the patient chart. Although eCHN adheres to all of the government’s privacy law requirements, the data is not available to the government itself. eCHN does not own the data but guards it for the patients and owners.

eCHN follows the highest level of security safeguards specified by Provincial and Federal authorities. The data is encrypted and is transmitted over a secure Provincial health network, not the Internet. A rigorous audit system tracks those who sign in. eCHN’s security policies are continually subjected to internal and external review, updating and testing.

The eCHN system has proved to have multiple benefits for patient health care. For instance, health care providers in remote locations have immediate access to results and
to the notes of their colleagues at tertiary care centres in major cities. This makes it
easier to care for patients locally, even with a small paediatric staff, thereby reducing
the need for patient travel.
eCHN makes it possible to improve the continuity and coordination of patient care,
across a spectrum of health care delivery. Emergency care workers, who must make
rapid decisions, can be confident that the medical information they use is current,
complete and accurate. Family physicians are able to discharge their primary care
obligations more effectively when they can stay apprised of the details of patient visits
to specialized providers. Diagnostic tests of patients need not be repeated when results
available elsewhere.

Health care professionals can be more efficient and focussed when they can spend
time delivering care rather than searching for patient data. Some providers particularly
appreciate that they can use their computers to share test results and radiology images
with their patients. Thus, the eCHN EHR enables care providers to deliver a higher
quality of patient care, particularly to those patients with chronic conditions who
require continuing, prolonged care.

6. Conclusion

In the first few years, eCHN responded to the need for a general all-purpose integrated
EHR. In recent years, it has been trying to use its data repositories to solve the pan-
Ontario needs of specialized practice groups such as Paediatric Oncology, Provincial
Newborn Screening Program, Paediatric Cardiac Network, Paediatric Diabetes,
Paediatric Asthma, and Paediatric Surgery.

Since participation in the project is voluntary, eCHN relies on champion users who
help to recruit physicians. eCHN provides individual user help. Each hospital or
organization has its trainers and coordinators and eCHN provides train-the-trainer
sessions. Users with questions or problems get one-to-one assistance. Synergies with
specialized groups are identified and eCHN provides operational solutions. Champion
users provide feedback on ways to enhance the system by adding new functionality.
eCHN follows up with its users in order to increase utilization and satisfaction.

eCHN is Canada’s largest functioning integrated EHR. It serves three million
people and transforms the quality of health records and clinical decision-making in
Ontario. It enables health care providers across Ontario to share accurate patient data in
real time. It is helping the Province to understand the challenge of building a
population-wide EHR.
Section 4

Ethics, Policy and Government
Failure of Electronic Medical Records in Canada: A Failure of Policy or a Failure of Technology?

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Abstract. This paper utilizes three frameworks described in the literature to better understand the reasons why Canada lags other OECD countries in EMR implementation. First, we use an EMR policy framework to evaluate three provincial EMR implementation programs across Canada. Second, we use an EMR implementation multi-theoretical framework that is predictive of EMR success to evaluate those same programs. Finally, we use a cost-benefit framework developed in the USA to compare the cost-benefits of EMR implementations in Canada compared to those in the USA. We draw conclusions and make recommendations based on our findings.

Keywords. EMR implementation, policy, implementation frameworks

Introduction

Canada’s EMR implementation programs have not had the success enjoyed by other OECD countries. A recent international comparison showed that less than 30% of the Canadian physician population use any of e-prescribing, electronic lab review or several other eHealth technologies in comparison to rates of greater than 90% in the Netherlands, the UK and Denmark [1]. A more recent survey of physicians in Canada indicates that only 9.8% of physicians use an electronic form of record keeping in their practice [2]. This is not due to a lack of programs and policies to encourage EMR uptake. Some provinces, including Ontario, Alberta, Manitoba and Nova Scotia have had such programs for several years. British Columbia and Newfoundland have active programs in the start-up phases. However, in spite of active programs and tens of millions of dollars in expenditures, EMR uptake has grown exceedingly slowly in Canada. Ontario has had a series of EMR implementation programs over the last decade and has budgeted over $150 million for EMRs, yet adoption has increased by less than 10% of physicians across the province.

We explore the underlying reasons for poor EMR adoption in Canada using multiple theoretical lenses described in the EMR literature.
1. Methodology

Three frameworks were utilized to help elucidate reasons for poor EMR uptake in Canada. Each framework is described in greater detail below. For each component in a particular framework, the provincial program was given a score of “Yes” (program has implemented substantial aspects of that component of the framework), “Partial” (some aspects of the component have been implemented, but that important aspects of that component are not implemented) or “No” (this component has not been implemented).

Although several provinces in Canada have EMR implementation programs, three provinces were selected that have relatively mature and/or well-documented programs. The three provincial programs were compared against the three frameworks to determine the type and extent of short-falls in these provincial EMR roll out programs.

1.1. Frameworks for Analysis

1.1.1. EMR Implementation Policy Framework

The first policy framework used was developed by Keshavjee for a white paper on EMR implementation in Ontario [3]. This policy framework concentrates on macro level drivers of EMR implementation, including such factors as subsidy models for encouraging uptake, engagement of key stakeholders, creating an enabling environment for EMR uptake, creating and leveraging network effects and engaging patients and patient advocacy groups.

For each element, if an EMR program incorporates that feature (Yes), we gave it a score of 1. If the program does not have that feature (No), we gave it a score of 0 and if there was a partial match (Part), we gave it a score of 0.5.

1.1.2. EMR Cost-Benefit Evaluation Framework

The second framework was developed by Wang et al [6] to better understand the macro level economic drivers of EMR uptake. On the cost side, their framework includes the usual elements: hardware, software, support, implementation and a one-time productivity loss. We include scanning and government subsidies into the framework, as these elements are common in Canadian EMR implementations. On the benefit side, they include decreased chart pulls, billing errors and transcription; prevention of adverse events; decreased utilization of drugs, lab tests and radiology tests; and increased revenues from improved charge capture. Their findings indicate that for a large physician-based health care organization in the USA there is a net benefit to implementing EMRs based on savings in drug utilization, laboratory utilization, radiology utilization and increased revenues from improved charge capture. This framework is applied to the Canadian context, utilizing Canadian experience, costs and benefits to see how well the Canadian environment allows for these economic benefits to be realized.

1.1.3. Multi-theoretical, Best Practices in EMR Implementation Meta-framework

The third framework is a multi-theoretical best practices EMR implementation framework that is predictive of success in EMR implementations [4,5]. This meta-framework, a composite of multiple frameworks on EMR implementation described in the literature, was developed using a systematic review of the literature on EMR...
implementation and includes 17 factors that are discussed in the literature as being important for EMR success. This framework is relevant to individual EMR implementations and their success at a micro, practice level. We examine each of the three provincial programs to see how well they help physicians make their implementations a success.

2. Results

2.1. Policy Framework Analysis

All provincial programs fare poorly in the EMR Policy Framework analysis. Table 1 shows how each province is performing on some key policy areas. Ontario has not yet engaged specialists in their EMR implementation programs, leaving out 50% of physicians. Both Ontario and BC do not fund practice management services, electing to provide these themselves. However, government programs are rarely responsive to client needs, which continue to evolve. In most cases, policy lags client needs significantly; for example, in Ontario, physicians are asked to take time away from clinical work to select software yet could purchase EMR selection services easily and save a significant amount of effort and angst.

Table 1. EMR Policy Framework analysis.

<table>
<thead>
<tr>
<th>EMR Policy Framework Element</th>
<th>Ontario</th>
<th>Alberta</th>
<th>British Columbia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage All Physicians (Specialists and GPs)</td>
<td>Part</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fund Practice Management Services</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Fund Information Management Services</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Provide CDPM Incentives</td>
<td>Yes</td>
<td>No</td>
<td>Part</td>
</tr>
<tr>
<td>Self-Help and Peer Sharing</td>
<td>Part</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Engage Key Medical Players</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Provide Key ICT Infrastructure (secure e-mail)</td>
<td>No</td>
<td>Part</td>
<td>Part</td>
</tr>
<tr>
<td>Set and Implement Interoperability Standards</td>
<td>No</td>
<td>Part</td>
<td>Part</td>
</tr>
<tr>
<td>Engage Patients and Patient Advocacy Groups</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Score</td>
<td>2</td>
<td>5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

LEGEND: Maximum Score = 9  No = 0  Yes = 1  Part = 0.5

None of the provinces provides any information management services or funding for them. The Ontario Ministry of Health has embarked on a program of providing prevention and chronic disease management incentives, which is likely to be one of the drivers of EMR uptake. Peer support and self-help programs are important to allow physicians to learn from each other. Yet, most provinces do not have an active program. Canada Health Infoway has implemented a peer support program, but it is ad hoc and lacks a proper structure and outcomes measurement process.
None of the provinces has engaged key medical associations that drive clinical change, such as the College of Physicians and Surgeons, which licenses physicians nor the College of Family Physicians and the Royal College of Physicians and Surgeons, which certify physicians and provide accreditation of continuing medical education programs. Although most provinces work with their local Medical Association, these bodies tend to be political organizations that generally don’t have the legitimacy to drive clinical change that the other associations have.

Other areas of poor performance include a lack of success in the provision of ICT infrastructure, such as secure high speed Internet connections, secure e-mails, electronic transmission of laboratory data, radiology reports, hospital reports and specialist reports; poor implementation of interoperability standards and little meaningful engagement of patients and patient advocacy groups [6].

Overall, from a maximum possible score of 9, all three provinces score less than four on the Policy Framework analysis.

2.2. Cost-Benefit Analysis

Applying Wang et al’s [7] cost-benefit framework to the Canadian context, we get the results which are presented in Table 2. There are slight differences in the cost structure between the two countries, which are explained in the footnotes. We include government subsidies in the Canadian cost structure, as these are not a feature of the US framework. The dollar figure comes from Ontario’s EMR implementation program. Essentially, we find that the cost of EMR implementation, in spite of government subsidy, is much higher in Canada than in the typical large US clinic to which this framework applies. The major cost difference comes from the need to scan documents into the EMR in Canada. This is a feature of most clinics which have gone paperless in Canada, but imposes significant overhead costs which can make EMR implementations cost-prohibitive. Most US clinics absorb the cost of integrations into their operational budgets, as the cost of integrations are one-time costs and tend to be offset by decreased cost of filing paper reports and results.

Canadian physicians do not accrue as many benefits as their US counterparts; chart pulls are cheaper in smaller clinics and most Canadian general practitioners do not dictate their notes [8]. In addition, opportunities for increased revenues and decreased billing errors are also typically smaller and are not realized with EMR implementations. In the USA, physician reimbursement is dependent on clear documentation which is facilitated with EMR. We assume that cost avoidance for drug, lab and radiology will be the same in Canada as in the USA, although this is not a foregone conclusion.

Overall, we can see that there is indeed a net benefit to EMR implementation in Canada, as there is in the USA. However, while US physicians do see a small direct economic benefit to themselves from EMR implementation, Canadian physicians are likely to see a significant net cost to themselves, in spite of government subsidies.

2.3. EMR Implementation Meta-Framework Analysis

The final analysis revolves around an EMR implementation meta-framework that has recently been developed [4,5]. Table 3 provides a listing of the factors and the odds ratio that this particular factor has in determining success of an implementation; i.e., how often a factor was seen in successful implementations compared to less successful
implementations. This table also lists whether the three provincial programs have implemented, partially implemented or not implemented the various factors.

Table 2. Cost-benefit analysis.

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Cost</td>
<td>Annual</td>
</tr>
<tr>
<td>Hardware(^1)</td>
<td>$6,600</td>
<td>(q 3 yrs)</td>
</tr>
<tr>
<td>Implementation(^2)</td>
<td>$3,400</td>
<td></td>
</tr>
<tr>
<td>Software(^3)</td>
<td>$1600</td>
<td>$1600</td>
</tr>
<tr>
<td>Support(^4)</td>
<td>$1500</td>
<td>$1500</td>
</tr>
<tr>
<td>Scanning(^5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity Loss(^6)</td>
<td>$11,200</td>
<td></td>
</tr>
<tr>
<td>Government Subsidy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL Cost/MD</td>
<td>$46,400</td>
<td></td>
</tr>
</tbody>
</table>

Benefits (Savings)

MD Benefits

<table>
<thead>
<tr>
<th></th>
<th>Chart Pulls(^7)</th>
<th>Transcription(^8)</th>
<th>Charge Capture(^9)</th>
<th>Billing Errors</th>
<th>Total MD Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$5</td>
<td>$9,600</td>
<td>$383,100</td>
<td>$9,700</td>
<td>$58,896</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>28%</td>
<td>2%</td>
<td>78%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$15,000</td>
<td>$13,440</td>
<td>$15,324</td>
<td>$15,132</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$4,800</td>
<td>0</td>
<td>$188,000</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td></td>
<td>24%</td>
<td>0</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$5,760</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td></td>
</tr>
</tbody>
</table>

System Benefits

<table>
<thead>
<tr>
<th></th>
<th>Drug Reactions(^10)</th>
<th>Drug Utilization</th>
<th>Lab Utilization</th>
<th>Radiol. Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$6,500</td>
<td>$109,000</td>
<td>$27,600</td>
<td>$59,100</td>
</tr>
<tr>
<td></td>
<td>34%</td>
<td>15%</td>
<td>8.80%</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>$8,840</td>
<td>$65,400</td>
<td>$4,858</td>
<td>$16,548</td>
</tr>
<tr>
<td></td>
<td>34%</td>
<td>15%</td>
<td>8.80%</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>$8,840</td>
<td>$65,400</td>
<td>$4,858</td>
<td>$16,548</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TOTAL System Benefit</th>
<th>Total Benefits (MD+System)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$95,646</td>
<td>$101,406</td>
</tr>
</tbody>
</table>

Net Benefit from EMR (Savings-Cost)

|                      | $108,142              | $23,406                   |

Net MD Benefit (Savings-Cost)

|                      | $12,496               | -$72,240                  |

---

1 Hardware cost differences exist because the US has larger clinics which can achieve economies of scale.
2 Implementation costs in Canada are higher because clinics are smaller and geographically dispersed.
3 Software license costs in Canada tend to be one-time, but are recurring costs in the US.
4 Support costs include software maintenance costs in Canada.
5 In the US, large clinics integrate their EMRs with lab, radiology and hospital systems. In Canada, physicians need to scan documents into their EMRs. Based on ½ FTE per physician per year [7].
6 In the US, HMOs typically decrease physician workloads by 20% for about 4 weeks during EMR implementation.
7 Chart pulls in Canada are less costly than in the US, where large clinics incur huge filing costs.
8 Most primary care physicians in Canada do not dictate their notes, however specialists will dictate letters.
9 There is no evidence that EMR implementations increase billings or decrease billing errors in Canada. In any case, the situations in the two countries are sufficiently different that this does not apply in Canada.
10 We assume that reductions in adverse drug reactions and drug, lab and radiology costs would be the same in both countries.
Governance is about setting the mission and vision for a program, allocating resources to meet those goals and engaging the right stakeholders in providing oversight. None of the provinces has fully implemented appropriate governance for their EMR programs yet. Ontario has a board which lacks transparency; there is no public listing of board members for their EMR program nor does the board have true directive oversight of the program. Ontario also has not made a long-term commitment to implementing EMRs for all physicians. Alberta and BC have made long-term commitments to financing EMRs, but still do not have good policies for helping physicians who fail in EMR implementation. Given that the EMR implementation failure rate is somewhere between 20 and 35% [10,11] and the costs of implementation are so high, a policy that does not explicitly take this into account is likely lead to poor uptake. In the literature, projects which were successful were 6 times more likely to have good governance than those that failed.

Project leadership speaks to project management and project championship. EMR implementations are complex, yet many implementations in all three provinces lack proper project management expertise. Some vendors have good project managers, but by and large, project management is left to chance and the vagaries of vendor capabilities in most provinces. British Columbia and Alberta do train local project champions who will get stakeholders involved, sell the benefits of the program and spearhead the software selection process. Projects which are successful were 26 times more likely to have good project leadership than those that did not.

The process of choosing software is quite important and was seen 17 times more frequently in successful projects. The software selection process is a central activity which bundles additional factors, including involving local stakeholders and selling the benefits. All of the provinces do a poor job of helping physicians select software and its associated activities. Most physicians get mired in the mechanics of the selection process and have little or no time to devote to getting their partners on board, to sell the benefits of the EMR and get the buy-in necessary for a successful start to the implementation.

Technology usability, pre-load of data and integration with outside systems, such as lab, e-prescribing, radiology and hospital systems, are important factors in EMR implementation success. In fact, these factors are the largest determinant of success seen in the literature. Yet, none of the provinces pays much attention to these factors. BC has some integration, but Alberta and Ontario are still struggling with these. None of the provinces assists physicians with pre-load of data, even though this is identified as a major barrier to EMR implementation by physicians [3]. None of the provinces addresses the issue of EMR usability, even though successful projects were 96 times more likely to have usable technology than did failed projects. Provinces are letting the marketplace decide on usability. This may be a reasonable approach; however, none of the provinces has an explicit strategy for dealing with the inevitable failures when you leave such an important component for the marketplace to decide.

The next cluster of important activities includes Early Planning (10-fold preponderance in successful projects) and its associated activities of Workflow Redesign (36-fold), Implementation Assistance (5-fold), Training (9-fold), Privacy & Confidentiality (not significant) and Feedback & Dialogue (9-fold). All three provinces do a poor job of providing this cluster of services. All provide training, but this is outsourced to vendors, most of whom know little about clinical practice and the information management needs of physicians. Only Alberta provides on-site
implementation assistance and privacy and confidentiality services. The biggest
determinant of success, Workflow Redesign, is ignored by all provinces.

Table 3. EMR Implementation Meta-Framework analysis.

<table>
<thead>
<tr>
<th>Number</th>
<th>Factor</th>
<th>Success-Failure Odds Ratio</th>
<th>Ontario</th>
<th>Alberta</th>
<th>British Columbia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Governance</td>
<td>5.83</td>
<td>No</td>
<td>Part</td>
<td>Part</td>
</tr>
<tr>
<td>2.</td>
<td>Project Leadership</td>
<td>26</td>
<td>No</td>
<td>Yes</td>
<td>Part</td>
</tr>
<tr>
<td>3.</td>
<td>Involve Stakeholders</td>
<td>4.47 NS</td>
<td>No</td>
<td>Part</td>
<td>Part</td>
</tr>
<tr>
<td>4.</td>
<td>Choose Software</td>
<td>17.25</td>
<td>Part</td>
<td>Yes</td>
<td>Part</td>
</tr>
<tr>
<td>5.</td>
<td>Sell Benefits</td>
<td>13.5</td>
<td>No</td>
<td>Part</td>
<td>Part</td>
</tr>
<tr>
<td>6.</td>
<td>Pre-load/Integration</td>
<td>999</td>
<td>No</td>
<td>Part</td>
<td>Part</td>
</tr>
<tr>
<td>7.</td>
<td>Tech Usability</td>
<td>96</td>
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<td>8.</td>
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<td></td>
<td>6 (3.5)</td>
<td>11.5 (7.5)</td>
<td>9.5 (6)</td>
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</table>

LEGEND Maximum Score = 17 No = 0 Yes = 1 Part = 0.5 NS = Not significant (x) = score for items which reached statistical significance. Max score = 12

The last important factor in the meta-framework is incentives. The literature is quite clear that incentives are mostly information incentives, not just monetary ones. Information incentives come from the ability to know more about the patient when using the EMR than when using paper. This includes knowing the patient’s medication list when prescribing, knowing the latest lab result when ordering lab tests and being able to find information easily and quickly while seeing patients. Few physicians find drug-drug interactions checkers to be information incentives, as there are many false positives and the noise level generally is much higher than the useful information. Information incentives properly executed are 70-times more likely to be seen in successful implementations.

3. Discussion

Canada’s continued difficulty in implementing EMRs on a national level is difficult to understand, given the significant investments made over the last decade. This analysis points to why Canada lags other OECD countries using EMRs. Clearly, Canada’s policies lack the desired effects when it comes to the speed of rolling out EMRs and
successful usage outcomes. The provinces studied in this paper have either not implemented or only partially implemented key policies that are required for EMR uptake. Provinces need to provide funding for change management, project management, practice management and information management services so that physicians implementing EMR’s can benefit from their use. Key medical stakeholders who license physicians and provide continuing medical education also need to be engaged. Patients are another group that need to be better engaged. Interoperability standards need to be aggressively set and implemented. Provinces also need to carefully consider the cost-benefit ratios of EMR use in Canada and ensure that funding and policies lead to positive benefits for all stakeholders, especially physicians. If not, physicians are unlikely to invest time, energy and money into ventures that have a high risk of failure and lead to certain losses.

Provinces need to learn the lessons from other jurisdictions which have been successful in EMR implementation. Good governance needs to be instituted that provides transparency and oversight over implementation of EMR programs. Funding for EMR implementations need to include project management and appropriate training for project champions. Finally, provinces need to think about information incentives and integrate them with policies more carefully to leverage the huge benefits available from implementing EMR’s successfully.

References


[8] Personal communications with Hamilton area physicians who use EMR.


Is It Appropriate, or Ethical, To Use Health Data Collected for the Purpose of Direct Patient Care To Develop Computerized Predictive Decision Support Tools?

Wilfred BONNEY

Tooling Work Group, Health Level Seven, Inc. (HL7)

Abstract. The increasing use of clinical decision support systems (CDSS) to assist clinicians in decision-making is pushing the limits of information technology. The emergence of Electronic Health Records (EHR) coupled with enriched health information standards such as HL7 CDA, SNOMED, ICD-10 and LOINC have provided a rich environment for massive data collection and analysis by healthcare providers. This immense increase in data collection has also provided a gateway for the application of various data mining techniques on clinical datasets so as to measure health status (i.e. function, comfort and likelihood of dying) of patients. In measuring health status, many clinicians have opted to use CDSS to assist in decision-making and enhance clinical experience. However, even as the use of CDSS in clinicians’ office continues to grow, the question that remains in the minds of many patients and the general public is whether it is appropriate, or ethical, for researchers to use health data collected for the purpose of direct patient care to develop computerized predictive decision support tool. In this paper, a systematic review is used to highlight the relevant technical barriers and ethical issues surrounding the secondary use of health data in developing CDSS.

Keywords. CDSS, EHR, secondary use of health data, ethics, data mining

Introduction

The quest to provide optimal and evidence-based care has resulted in the increasing use of CDSS in clinicians’ office. There is also a demand by healthcare providers to use primary care data, collected at the point of care for direct patient care, to measure clinical quality at the individual clinician level. This demand has necessitated the need to have a “timely, accurate data at the point of care to inform decision-making and facilitate patient-centred care; aggregate data for system-wide analysis; de-identified data to be exported to multiple stakeholders” [1].

CDSS uses built-in inference rules or engines that are usually extracted by data mining existing health data or clinical databases. This practice of utilizing health data, collected for direct patient care, to develop CDSS often meet technical and ethical challenges For most patients consenting to the initial data collection does not necessarily mean that they are consenting for the data to be used in the development of

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CDSS. Furthermore, the use of CDSS “has raised ethical concerns about care standards, appropriate use and users, and professional relationships” [2].

This paper examines the technical barriers and ethical issues surrounding the use of health data by researchers in developing CDSS. The first part gives an overview and benefits of using CDSS. In the second part, the focus is on the technical barriers arising from the use of the health data in developing CDSS. The third part focuses on ethical implications for researchers and gives recommendations for best practices.

1. Methodology

The methodology used in this paper involves a systematic review of relevant publications, found and accessed with the help of PubMed, IEEE Xplore, Mesh Browser, and Google Scholar. In so doing, the author focused on searching for a combination of keywords/phrases including: (a) ethics, (b) clinical decision support systems, (c) health data, (d) secondary use of health data, and (e) patient care.

The methodology also involved the review of grey literature including (a) the Personal Information Protection and Electronic Documents Act (PIPEPA) [3] published by the Office of the Privacy Commissioner of Canada, and (b) the November 2002 case studies publication on Secondary Use of Personal Information in Health Research [4] by the Canadian Institutes of Health Research (CIHR).

2. Understanding Clinical Decision Support Systems (CDSS)

Clinical Decision Support Systems (CDSS) are “computer-based information systems used to integrate clinical and patient information and provide support for decision-making in patient care” [5]. CDSS aid in clinical decision-making not only by providing physicians and other healthcare stakeholders with computerized advice regarding drug doses, medications, laboratory results and diagnosis but also by enhancing a clinician’s ability to process data and information [6].

Inference or logical rules forms the basic building blocks of any given CDSS. These inference rules are usually extracted by data mining existing health data or clinical datasets. The trustworthy of CDSS is based on how effective the extracted inference rules correlates with the experiential knowledge of domain experts. The advices, obtained from CDSS, often enable clinicians to provide optimal care at each patient encounter and further help to reduce waiting times during consultations. A clinician's level of trust in CDSS to support decision-making is affected by how well medical knowledge is translated and represented in them as well as their ability to make reasonable decisions that are in consistency with experiential knowledge of clinicians [2]. The use of CDSS can be highly effective at improving care quality and physicians’ performance; ensuring patient safety; and reducing medication error [6],[8].

Besides the benefits mentioned above, CDSS are very difficult to design, develop and deploy. Most existing CDSS are proprietary and tightly integrated with Electronic Health Records (EHR) [9]. There is also growing evidence that when poorly designed, developed, deployed and/or used, CDSS may lead to more harm than good [8].

Machine-related errors, attributed to the use of CDSS, often result from the use of poor quality health data [8]. These qualities of the CDSS coupled with technical and ethical challenges facing the secondary use of health data often impede the adoption of
CDSS in the healthcare community. Furthermore, cultural consideration cannot be ignored when it comes to the adoption of CDSS. The cultural practice “based on the belief that medicine is an art that relies on individual clinical judgments” [10] makes CDSS less attractive to some clinicians. Successful adoption of CDSS depends entirely on healthcare providers’ receptivity to using these systems [11].

3. How Appropriate Are Health Data?

The introduction of CDSS in the healthcare arena has brought up anticipation as to how appropriate the usage of the tool is effective in meeting the ethical standards of the medical community. This is because the use of health data in developing CDSS and other Hospital Information Systems (HIS) has always been met with complex social, technical, ethical, and political challenges [12],[13],[14],[15],[16],[17]. These challenges could be attributed to the fact that CDSS depend profoundly on large volumes of readily-accessible, existing health data [4]. Large volumes of health data are “generally needed in order to assemble unbiased samples from which health researchers can draw meaningful conclusions that are representative of populations” [4].

The secondary use of health data is important because it “can enhance individuals’ health care experiences, expand knowledge about diseases and treatments, strengthen understanding of health care systems’ effectiveness and efficiency, support public health and security goals, and aid businesses in meeting customers’ need” [12]. These properties of health data have provided a gateway for many health researchers into consuming primary care data in the development of CDSS. Health research based on the secondary use of health data contributes to our present level of knowledge of the causes, trends and natural history of diseases and symptoms [4],[12].

Even so, many critics question the appropriateness of the secondary use of health data in developing CDSS. They argue that the inappropriate use of health data could introduce machine-related medication and diagnosis errors [8]. This is because if the data mining algorithm used in generating the inference rules is flawed then there is a complete tendency that the tool will be giving wrong medications and diagnosis. This vulnerability of the tool requires proper utilization of a standardized data mining algorithms that works very well with clinical datasets [18],[19],[20],[21],[22],[23]. For example, it would be unrealistic and problematic to use inference rules generated by data mining algorithms that do not work very well with clinical datasets [23]. The correct choice of data mining algorithm could influence how well the machine-related errors emanating from the CDSS is minimized or completely eliminated.

The controversy even grows broader and deeper when there are inconsistency in the presentment and coding of the health data. Inconsistency in data representation and coding affect the data collection process and consequently affect the trustworthy of the generated inference rules. The use of health information standards such as ICD-10, SNOMED, LOINC and UMLS will ensure uniformity and consistency of the health datasets, used in generating the inference rules [18]. This is because a standardized data collection process will always enforce rules that are needed to make the data complete thereby improving the quality assurance of the health data. CDSS built with inference rules, generated with standardized health data, have a great potential to ensure interoperability with other legacy systems and support distributed computing [6],[18].

Another issue worth considering is the quantity and quality of the health data used in developing the CDSS. It is often true that the quantity of health data used in
generating inference rules for CDSS determines the effectiveness and trustworthy of the tool. For example, if a small sample size of health data is used in generating the inference rules, it would be difficult to apply the rules to the population at large. Using large datasets are the ultimate requirements to generalize the inference rules to the larger population. The key here is that where there is not enough health dataset to use, no attempt should be made to generate inference rules that are based on small sample size data. Outliers from the small sample size data could have a significant impact on the inference rules, thereby introducing machine-related errors to the CDSS [24].

4. Ethical Implications for Researchers

Across the globe, health researchers are often affected by ethical concerns relating to data sharing and data confidentiality [25]. Ethical principles form the foundations of decision-making and are particularly important in medicine. Ethics is “the philosophy or code pertaining to what is ideal in human character and conduct” [5]. Ethics is thus of great importance when it comes to the protection of health data, and researchers are encouraged to practice safe handling of health information [28],[29].

Patients usually entrust healthcare providers to collect sensitive health information pertaining to their health and other social matters as part of seeking treatment from primary care physicians. Patients do so “in confidence and with the legitimate expectation that the healthcare professionals will respect their privacy and act appropriately” [30]. However, in several cases the data collected for the primary care is used for another purpose without the informed consent of the patient. Healthcare providers are motivated by the need to aggregate data for system-wide analysis so as to aid in forecasting disease trends; and exporting the data to multiple stakeholders [1].

It is, therefore, not very surprising that the most frequently raised objections to the secondary use of health data are concerns about patients’ privacy and confidentiality [25][26]. Critics argue that the use of health data in developing CDSS serves as a mechanism for invading patient’s privacy and confidentiality. For example, making primary care data readily accessible to third-party organizations violates the confidentiality and respect for autonomy of patients [31]. These violations tend to interfere with the use of personalized health information stored in an electronic format.

Other critics argue that electronic processing of health data, on its own, is a major research issue [14] and “poses security challenges far more complex than paper processing does” [32]. To these critics, the use of paper charts in storing personalized health information is the best option in securing the privacy and confidentiality of patients. However, this assertion is not entirely true in that electronic health data “can be better secured than paper records, because authentication, authorization, auditing, and accountability can be facilitated” [33]. Furthermore, the ability to access electronic health data in a comprehensive and efficient manner makes it possible not only to perform quality assurance checks on the data but also enable the identification of disease trends and expected outcomes hidden in the health data [11][29][34].

Policies for privacy protection and informed consent and their interpretations present different security problems, which in turn may call for distinct security architectures and protocols in developing CDSS [35][14]. To ensure strict protection of personal health information, different governments have enacted polices regarding safe and proper use of personal health information [29]. In Canada, for example, the Personal Information Protection and Electronic Document Act (PIPEDA) came into
effect on January 1, 2004. One of the main purposes of the Act is to protect personal information from the private sector. It grants rights to individuals for the protection of their personal and health information collected, used or disclosed within Canada [36].

Although, knowledge and consent of any person is required before collection, use or disclosure of such information [36], the Act provides exceptions in extraordinary circumstances. PIPEDA applies only to commercial entities and excludes governmental or federal organizations, which are the largest collectors and users of health data. Notably, the Act does not address the conflict between a patient’s right to withhold consent and the requirement to disclose health information for insurance applications and the like.

5. Recommendations for Best Practices

The following recommendations for best practices have been proposed by several researchers to handle the challenges facing the use of health data in developing CDSS:

1. Interdisciplinary research approach should be used to evaluate and identify factors related to successful implementation, adoption and potential benefits of CDSS [37]. Involving healthcare stakeholders in the technology’s development and evaluation would help reduce ethical tensions [2].

2. The development of CDSS should utilize health information standards so as to ensure its interoperability with other legacy systems and support distributed computing [6][18].

3. The development and deployment of the CDSS should fit the workflow of clinicians so as to ensure that the system is enabling without constraining [39].

4. The traditional consent model needs to be modified to accommodate the overall balance of benefits and risks of using health data in developing CDSS. An innovative and constructive consent model will help to control how personalized health information is “used without necessarily requiring that express consent be obtained from every individual in every instance” [4].

5. A third-party authority should be established to monitor and ensure that informed consent protocols that are part of any HIS security environment satisfy ethical standards [35].

6. Research education should be improved to include knowledge about the benefits, technical and ethical barriers in sharing and processing electronic health data. This will help minimize the controversy arising from the secondary use of health data [25].

7. The secondary use of health data should not only utilize transparent policies and practices but it should also focus on data control ownership of the individuals involved [12].

6. Conclusion

Even though the debate for the appropriateness of using health data in developing CDSS will continue to grow, the benefits of CDSS cannot be ignored. In most cases, the benefits outweigh the risks and challenges identified in this paper and a good ethical practice will require a balancing of benefit and harm when utilizing health data [25][29]. It is of much understanding in the healthcare community that in order to be
efficient and provide optimal and evidence-based care, health information systems need to be widely implemented and used by the healthcare providers [40][41][42]. And as the adoption of health information systems in hospitals continues to grow, the quest of using health data in developing CDSS will also continue to grow, irrespective of the critics’ view of technical barriers and ethical concerns. It is a transition that the healthcare industry needs to comprehend, explore and endure in order to be competitive in the information age [15].

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References

National Health Information Management/Information Technology Strategies in Hong Kong, Taiwan and Singapore

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Abstract. A national health information management/information technology (IM/IT) strategy is crucially important for a country in planning and implementing healthcare priorities. However, little comparative research has been performed in this area, especially in Asian countries. This paper reviews, assesses and compares the healthcare systems, as well as the national health IM/IT initiatives and strategies in Hong Kong, Taiwan and Singapore. Although the proportion of public and private health services, IT infrastructure development, and government involvement in these three jurisdictions are different, they experience similar challenges with limited resources. By outlining the approaches being taken in the three Asian jurisdictions, this paper provides comparison, evaluation and insights that may be useful to other jurisdictions.

Keywords. national health information management, national health information technology, international comparative analysis, national health strategies, Hong Kong, Taiwan, Singapore

Introduction

The main purpose behind national health information management/information technology (IM/IT) strategies is to ensure that health information is accurate and available to those who need it, thereby improving the nationwide health services and outcomes. This paper reviews the healthcare systems in Hong Kong, Taiwan, and Singapore, focusing on three key areas of each region’s healthcare system. First, the financing model and health expenditure of each healthcare system are examined. Second, each region’s new initiatives involving health IM/IT solutions are examined and evaluated. Last, at the end of each section, the national/territorial scale health IM/IT strategies are evaluated and compared. This study will contribute to the knowledge base of national IM/IT health planning and strategy development.

This study presents a number of challenges regarding terminology. First, from the three selected regions only Singapore can be referred to as a nation without political debate. For the convenience of research and discussion, the word “territory” or “region” will be used rather than “nation.” Second, the terms EHR, EMR, and EPR are used interchangeably in many academic or non-academic works. In this paper, EMR will refer to the health records created and held by a general practitioner, EPR for hospital used health records, and EHR for both longitudinal view of health record and
hospital used health records. The term “ePR” in this paper is quoted from academic papers and official documents particularly related to the Hong Kong EHR system.

1. Healthcare Systems Overview

In Hong Kong, the Department of Health, whose statutory body is the Hospital Authority (HA), is responsible for healthcare policies and the provision of basic healthcare services. This department is part of the Food and Health Bureau. The HA manages a Head Office, 41 public hospitals/institution, 47 specialist clinics and 74 general outpatient clinics, which provide a total of 28,176 hospital beds [1,2]. Approximately 50% of Hong Kong’s healthcare spending is funded by general taxes [3]. Private payments and insurance account for the remainder of the funding. Primary care is mainly private, while secondary care is mostly public.

Healthcare in Taiwan is managed by the Bureau of National Health Insurance (BNHI), which is responsible for managing public hospitals, public health services and the national health insurance. The healthcare providers in Taiwan are a mix of public and private institutions. Ninety percent of hospitals are private and they provide 65% of hospital beds. Funding for the healthcare system in Taiwan primarily comes from the National Health Insurance Scheme (NHIS), which covers 97% of the population [3].

In Singapore, the Ministry of Health oversees the healthcare system. Both private and public sectors exit in their healthcare system. As of 2007, 72% of all hospital beds in Singapore are provided by public hospitals [4]. The two groups that are responsible for delivery of public healthcare are the Singapore Health Services (SingHealth) and National Healthcare Group (NHG) [5], both formed in 2000.

The healthcare systems in the three East Asian regions varies in many respects. The detail data can be found in Table 1. As it is very hard to find statistical data for all three healthcare systems from any single source, the numbers used in this section are, if not otherwise specified, from the World Factbook 2008 [6].

<table>
<thead>
<tr>
<th>Table 1. Healthcare Statistics for Hong Kong, Taiwan and Singapore.</th>
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<td>Population</td>
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<td>Population Growth Rate (%)</td>
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<td>Average Life Expectancy</td>
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<td>GDP (billion $)</td>
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<td>Outpatient Care by the Public Sector</td>
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Every region has recognized the need to strengthen and sustain the provision of primary healthcare to achieve a high performing healthcare system. They also have emphasized continuity and integration healthcare for chronic diseases. In addition, all three systems stressed the capacity of healthcare systems to respond rapidly and decisively, especially for infectious diseases [12-14].
2. Health Informatics Status, Initiatives and IM/IT Strategies

2.1. Hong Kong

Since the 1990s, Hong Kong HA has been developing and deploying clinical applications at its constituent 41 hospitals and 121 clinics. The development of the Clinical Management System (CMS) began in 1994, and the Electronic Patient Record (ePR) was developed in 2000. The CMS and the ePR have formed an essential clinical and management tool for the HA and have been able to give clinicians an integrated, longitudinal, life-long view of a patient’s record [15]. Together, CMS and ePR handle over two million clinical transactions per day and have become the platform for development of subsequent clinical modules [1]. Unlike many high profile national initiatives, the total expenditure on system development and implementation of the entire clinical information portfolio in Hong Kong has been less than US$ 200 million [1]. However, the CMS and ePR systems only work within the public hospitals under the HA, which covers 95% of the healthcare in Hong Kong. To expand the benefits of EHR to the remaining 5% of the healthcare sector, a pilot project, the Public Private Interface – Electronic Patient Record (PPI-ePR), was started in mid 2005 [15].

PPI-ePR allows private doctors to review a patient’s health records from the HA with the patient’s consent. The record is extracted from the ePR in the HA’s internal network to a PPI database. Encryption algorithms, firewall, intrusion detection, security token techniques, and cell phone alerting text message are involved in the process to ensure privacy, security and confidentiality. As of 2007, a total of 131 healthcare providers from private hospitals and 7800 patients have joined the program [15].

The development and implementation of healthcare IM/IT systems can be very expensive. With strong government leadership and involvement, Hong Kong has achieved impressive progress at a modest cost. However, there are still some challenges in the way towards a territory-wide EHR system, such as its institutional set-up, the legal implications and privacy concerns, as well as its technical standards, etc. To address these challenges, the Hong Kong government is taking the lead and working on policy making and coordination across the healthcare sectors. In its reform document, the government indicates that it will only increase and not reduce commitment to public health. The development of a territory-wide EHR infrastructure has been identified as an essential pillar in Hong Kong’s healthcare reform [7].

2.2. Taiwan

In 2003, Taiwan was the first region to introduce a territory-wide card-enabled e-health network. Taiwan’s National Health Insurance (NHI) program is one of the key factors that contributed to the success of the smart card system. Since every citizen in Taiwan must be enrolled in this program, NHI provided a basic social platform for the smart card system.

In 1999, the BNHI in Taiwan launched a project for implementing smart cards as the health insurance cards. The project is under the larger umbrella of the National Health Information Infrastructure (NHII) project, aiming to provide better quality of services and to improve the effective use of medical resources [10]. Smart cards not only allow patients to access medical services electronically, but also allow the BNHI to discover in a timely fashion the inappropriate use of medical resources and to investigate medical frauds [16]. It has been estimated that, as of 2006, 22 million smart cards...
cards had been issued to Taiwanese citizens. Unlike most of the smart card applications in the world, the Taiwanese cards store not only personal identification but other data such as insurance details, treatment information and medical costs [17,18]. As the smart card system entirely replaces the paper-based medical certificate system, the workflow in Taiwan’s healthcare system has changed considerably. Using smart cards, hospitals and clinics can electronically upload health records daily to the BNHI. After every 6 patient visits, card information will be uploaded online for data analysis and audit. The smart card system also makes the reimbursement process faster. According to the BNHI, significant savings were achieved and the system became profitable after less than a year of operation [17].

The smart card system in Taiwan has created a unique territory-wide health IM/IT situation for Taiwan. On the one hand, the smart card system improves the communication and data exchange across healthcare sectors, streamlines healthcare processes, and provides a platform for many other health IM/IT applications. On the other hand, it also has brought unique challenges such as health information privacy and confidentiality. For example, the smart cards’ data analysis usage allows the government to track patterns of use. To address these issues, the BNHI has established open communications with human rights and patient activist groups [19]. As the online information provided by the Taiwan government is very limited, it is hard to find government documents about its territory-wide IM/IT priorities or strategies. However, from academic literature about the health IT initiatives and the analysis of the region’s health IM/IT status, it is predicted that for the foreseeable future Taiwan’s health IM/IT plan will be centered on the territorial smart card system and the current health information infrastructure. The IM/IT platform will be built around these [20].

2.3. Singapore

Singapore has been viewed as one of the leading territories in the world for aggressively adopting IT in their healthcare delivery. In late 1990s, Singapore had started online medical research projects [21,22]. It also made a special effort to use IT to improve telegeriatrics. In recent years, both the NHG and SingHealth have taken various initiatives to use IT to improve the quality of healthcare. In 2005, Siemens Medical Solutions signed a major deal with the NHG for an enterprise-wide implementation of its next generation Soarian EPR solution. With this initiative, the NHG hopes to achieve integrated financial, clinical, administrative and diagnostic processes to enhance the quality of patient care across the various facilities within the NHG. SingHealth has implemented a synchronized information system across all facilities within its jurisdiction [5]. They also took initiatives to promote telehealth for patients with chronic diseases. Their telehealth systems use ubiquitous technologies such as low-cost health monitors and Internet portals or SMS [23]. In addition, the NHG and SingHealth also emphasize the use of wireless technology in sharing EHRs, which matches with their national level iN2015 plan.

In 2005, Singapore government started an ambitious nation-wide program, called Intelligent Nation 2015 (iN2015). The iN2015 is a 10-year master plan that will provide a territory-wide information and communication platform that connect diverse businesses, individuals and communities [24]. Part of this master plan is the iN2015 Healthcare and Biomedical Sciences sub-plan. This sub-plan aims to bring the following outcomes to healthcare and biomedicine by 2015: well-integrated quality healthcare, cost-effective healthcare services, increased public ability to manage its
health, and strong clinical and health services research. To achieve these goals, the iN2015 Healthcare and Biomedical Sciences Sub-Committee has made a series of territorial strategies and a development schedule with three, five and 10-year key milestones [14].

Singapore has emphasized the importance of developing standards and enabling inter-operability. The integration among healthcare services, increase of healthcare continuum, as well as improved integration between health services and research are strategic thrusts. The iN2015 plan identifies many health-related IM/IT initiatives that Singapore will carry out within the next 10 years. The plan includes the development of a personal health record for each individual to enhance patient-centered healthcare and empower the public to manage its healthcare [14]. In fact, health related IM/IT is viewed as a part of the national information and communication plan rather than a part of the healthcare plan. From this perspective, Singapore has adopted a wider interpretation of health IM/IT.

2.4. Comparison

All three regions are vibrationly experiencing rapid health IM/IT development. Hong Kong has achieved the primary goal in the first stage of ePR system adoption and started trials to expand into the private sector. In Taiwan, an important part of the plan is to expand the usage of the smart card system and to develop other applications based on smart cards. For Singapore, healthcare has become a profitable industry and health related IM/IT has been adopted as a component in the national information and communication plan.

All three regions enjoy sound economic and relatively stable politics and their governments have the opportunity to plan health IM/IT expansion in an unhurried manner. The commitment of these governments to the promotion and utilization of IM/IT tools and techniques is high, which is an advantage for territory-wide, large-scale projects. All three regions anticipate that information systems will reduce administrative and clinical costs and improve the quality of healthcare service. In fact, all of them have already realized some healthcare quality improvement and financial rewards from their projects.

3. Conclusion

This paper has reviewed the healthcare systems of Hong Kong, Taiwan, and Singapore. The systems, initiatives and current strategies related to health IM/IT have been examined and compared to determine their similarities and differences. Although the three regions confront similar issues, each government has taken unique actions to address them. Hong Kong has undertaken EHR system development using its CMS and ePR systems as a platform on which to build other IM/IT applications. Taiwan has implemented a territory-wide smart card system that is integrated with the NHI system. The result has realized cost-savings and efficiency-improvements. Singapore, with its superior IT infrastructure and health related Internet experience, has planned its health IM/IT strategy as a part of a territorial cross-business information and communication plan.

No single East Asian model can provide an off-the-shelf solution for other countries to adopt. However, a study of these health systems provides insights from
which policy makers may learn. Many countries are facing similar healthcare issues such as shortages of healthcare resources, “skyrocketing” healthcare expenses, and social and legal challenges associated with healthcare IM/IT applications. The purpose of this study is to provide information about IM/IT for national/territorial healthcare and to highlight the value of studying international systems and collaborating globally.

References


Section 5

Health Information Systems and Their Status
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Pharmacy Information Systems in Canada

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Abstract. The goal of Canada Health Infoway is to provide at least 50% of all Canadians with an electronic health record (EHR) by 2010. The goal of the Infoway Drug Information Systems Program is to develop an interoperable drug information system that will keep each patient's medication history: prescribed and dispensed drugs, allergies, ongoing drug treatment, etc. Drug and drug-interaction checks will be performed automatically and added to the patients’ drug profiles. Physicians and pharmacists will be supplied with data to support appropriate and accurate prescribing and dispensing, thereby avoiding adverse drug interactions and drug-related deaths [1]. This paper describes Canadian developments in pharmacy eHealth. It presents the results of the Pharmacy Informatics Pharmacy Special Networks (PSN) survey about computer systems used in hospital pharmacies across Canada including information concerning Computerized Provider Order Entry (CPOE) systems deployed; which may reduce the number of errors in orders.

Keywords. pharmacy, information systems, CPOE, patient safety

Introduction

Canada Health Infoway is working with provincial governments, clinicians, vendors and key stakeholders to promote the vision of an Electronic Health Record (EHR) for all Canadians. One of the main building blocks of the EHR is a Drug Information System (DIS). Although there are provincial systems such as British Columbia Pharmanet most of the other DIS initiatives have been for retail pharmacies outside of hospitals. Although representatives from organizations representing community pharmacists have been involved with DIS initiatives, until very recently hospital pharmacists have not.

Canadian hospital pharmacists are represented by the Canadian Society of Hospital Pharmacist (CSHP), a voluntary organization of pharmacists working in hospitals and related health care settings. CHSP is committed to the advancement of safe effective use of medication. CSHP has Pharmacy Specialty Networks (PSN’s) that are discussion forums for pharmacists working in similar practice areas. The Informatics PSN members have discussed topics related to computers and pharmacy practice. In recent months discussion has focused on two key areas: 1) work at federal and provincial levels on EHRs, and, 2) Computerised Provider Order Entry (CPOE). Members of the PSN are aware of the ongoing work on the EHR and are aware of Canada Health Infoway’s activities. Because of work done by Norton et al [2] on patient safety and

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adverse reactions in hospital settings, emphasis has been placed on hospital-based systems. Several researchers such as Bate *et al.* [3] have suggested that problems related to medication could be averted through the use of technology. During discussion, the Informatics PSN realized there was no inventory of hospital-based systems.

Members of the PSN were aware that one of the pharmaceutical companies, Eli Lilly, produced an annual survey [4]. This survey, known as the “Hospital Pharmacy Survey in Canada,” considered issues that include workload, drug costs, staffing, education, medication safety and technology. However, because the data collected by the survey were of a general nature, the PSN decided to make its own survey of DIS and CPOE deployment. Members of a subgroup designed the survey and invited feedback from members of the PSN. The survey was then pre-tested on members of the PSN before it was released to the CSHP membership. This process took three months to complete.

1. Methodology

On May 31, 2008 an e-mail was sent out that included a link to a Survey Monkey survey [5]. This e-mail was sent to a director or person responsible for pharmacy computer systems as listed by the CSHP head office. A total of 191 e-mails were sent out. A reminder e-mail was sent out on June 14, 2008. The survey was available in both English and French. The survey submission deadline was June 27, 2008. The survey asked questions relating to Pharmacy Information Systems (PIS) and CPOE systems.

The response rate was 47%; there were 89 responses in all. (This rate was inexact because there were some duplicate responses: a respondent could have had multiple e-mail addresses, or a respondent may have completed more than one survey – one for each of the health facilities in his or her region.) The responses were filtered using a Survey Monkey criteria to remove any incomplete responses. Duplicates were removed and 75 responses remained in the survey.

2. Results

The greatest number of responses (44%) came from Ontario. Quebec had the next highest rate of responses (15%). Sixty-one percent of the facilities responding are part of a larger health region. Note that this survey was performed prior to health facility collapsing in Alberta.

2.1. Pharmacy Information System

The top three vendors of Pharmacy Information Systems (PIS) were:

- Meditech (41%)
- GE (16%)
- Cerner (12%)

The distribution of PIS scope was nearly evenly split between respondents from single facilities (53%) and those representing regional health systems (47%). Seventy-one percent of respondents indicated that their PIS generated a Medication
Administration Record (MAR) but 97% still used a paper MAR. Sixty-seven percent of respondents indicated that they had an integrated hospital system.

Eighty-nine percent of respondents indicated that the PIS could be interfaced with the laboratory system. Of that 89%, 71% were currently interfaced with the laboratory system. Of those who did not have a laboratory system interface, 83% planned to do so in the future. Most of the respondents indicated that their PISs perform traditional pharmacy system activities.

Figure 1 shows the distribution of functions used in the facility’s Pharmacy Information Systems.

2.2. PIS Safety

One of the safety measures of PIS is to allow tall-man letters to differentiate between look-alike drug name pairs. Sixty-four percent of respondents indicated that this was an active feature in their system. Another safety feature is to allow the user to change font and colour to distinguish look-alike drug name pairs. Only 10% of respondents indicated that this feature was available. The majority of systems were updated quarterly.

Alerts are an important part of Pharmacy Information Systems. Thirty-six percent of respondents had clinical decision support alerts (CDS alerts) suppressed in their PIS system but slightly more than half (54%) indicated that alerts that had little or no clinical significance routinely appeared in their PIS system. Sixty percent could suppress those clinically insignificant alerts. The majority of the systems permitted alerts to be built for serious error-prone situations.

![Figure 1. Distribution of Pharmacy Information System functions.](image-url)
2.3. Bar Coding Technology

Only 23% of respondents used bar coding technology with their system. Of those people, 43% used Symbol (a Motorola Company) as their vendor and the applications used are shown in Figure 2. If pharmaceutical vendors employed bar-code technology then over 60% of respondents were either somewhat or very likely to use it.

2.4. CPOE

Only 11% of respondents had a CPOE system at their facility. The top two vendors were:

1. Meditech (28%)
2. Cerner (17%)

Of the respondents with CPOE, only 4 respondents had CPOE running “live.” Of those respondents without CPOE, 35% are in the process of implementing one.

Seventy-six percent of CPOE systems provided reports of drug warning overrides made by physicians. Sixty percent were integrated with a point-of-care bar coding system used on patient care units during drug administration. Sixty-three percent of drug orders went directly into the PIS through an interface.

Sixty-five percent of respondents indicated that Clinical Decision Support alerts (CDS alerts) were enabled (not suppressed) in their CPOE system. Quite a few respondents (78%) said that those alerts with little or no clinical significance are not routinely displayed by their CPOE system. Eighty-three percent indicated that these alerts could be suppressed. Almost all (96%) of the respondents indicated that their CPOE system permits alerts to be built for serious error-prone situations.

Figure 2. Bar-coding applications currently in use.
3. Discussion

This survey was conducted to initiate a discussion on the needs of Canadian hospital pharmacies. Several key issues require further investigation: 1) trends toward regionalization, and, 2) slow uptake of new technology to enhance patient safety.

Most Canadian provinces are moving towards regionalization and regional systems. This is reflected by the survey results - almost 50% of those surveyed reported that they were part of a regional system. Also, a significant number of the pharmacy systems are part of an integrated hospital system. However, the marketplace for enterprise solutions is relatively small and there is movement away from “best-of-breed” systems.

In the past, a pharmacy department had some control over the selection of its pharmacy system but with the trend toward regionalization and integration, there may be less choice and control over the pharmacy solution. This is in contrast to the community pharmacy practice where pharmacy system is often stand-alone and the selection of the system is made by the pharmacy manager.

Results from this survey indicate that there is poor uptake of new technology as an enhancement to patient safety. For example, bar-coding is being used but its use is typically limited to packaging and inventory control. Significantly, CPOE is at a very low level of deployment, although several respondents reported that CPOE implementation is in the planning stage.

4. Next Steps

This survey was a first step to improved understanding of pharmacy systems in a hospital setting. The information will be shared among different venues and used as a springboard for further discussion. There are several key groups and organizations that will be interested in the results. These include the Canadian Society of Hospital Pharmacists (CSHP), the National Pharmacy e-task Force (NePT), Canada Health Infoway (CHI) and the Canadian Patient Safety Institute (CPSI). In addition, a more detailed analysis of the survey results will be published in the Canadian Journal of Hospital Pharmacy (CJHP). Finally, there will be further research on CPOE, Bar-Coding and those new technologies that have an effect upon pharmacy and pharmacy information systems.

References

Findings from Evaluations of the Benefits of Diagnostic Imaging Systems

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Abstract. Canada Health Infoway and its partners in the provinces and territories have made significant investments in diagnostic imaging (DI) systems across Canada. Infoway's DI Investment Program is to implement storage for diagnostic digital images so that clinicians can view images regardless of where they are stored. Specifically, Infoway is investing in Picture Archiving and Communications Systems (PACS), which are those systems with the modern digital archiving capabilities used by DI systems.

eHealth implementations in Canada are responsible for demonstrating the value of eHealth investments to users and stakeholders and driving benefit optimization. Canada has a rich set of results from British Columbia, Ontario, Nova Scotia, and Newfoundland and Labrador due to early Infoway investments in DI systems. The positive evaluation results are encouraging but they indicate that continued effort and investment are required to fully realize the benefits. This paper discusses findings from evaluation studies, the pan-Canadian aggregation study, and possibilities for benefit optimization from investments made in the Electronic Health Record (EHR).

Keywords. diagnostic imaging, eHealth, Canadian Health Infoway, EHR, benefits evaluation, PACS

Introduction

As core components of the EHR, and a proven technology for improving the delivery of health care, DI/PACS systems are being deployed across all provinces and territories. Infoway has supported many of these deployments as part of its mandate to work in collaboration with health ministries, regional authorities, other health care organizations and information system vendors to accelerate the implementation of electronic health information systems in Canada. DI systems, along with Laboratory and Drug Information systems, provide the majority of clinical data required for the EHR.

One of Infoway’s core business strategies is supporting solution adoption and benefits realization, including the measurement of the impacts of EHR investments on healthcare quality, productivity and access. With DI systems being a leading EHR technology and among Infoway’s first programs to be set in motion, evaluations have now been conducted in four provinces: British Columbia, Ontario, Nova Scotia and Newfoundland and Labrador.
This paper explores the impacts on the Canadian healthcare system of DI system investments, employing both qualitative (i.e., key information interviews, literature review, surveys) and quantitative evaluation methods.

1. Background on Diagnostic Imaging Systems in Canada

Infoway’s DI Investment Program focuses on implementing the digital storage of diagnostic images to enable clinicians to collect, store, manage, distribute and view patient radiology reports and images, entirely in digital format, without the need for film, and regardless of where they are located or where the test was conducted. As of September 2008, Infoway has invested $316 million in 21 DI projects throughout the country. The implementation of DI systems was 64% complete in public hospitals and clinics across Canada in March 2008, and is anticipated to be 88% complete by 2010 [1].

DI systems must be supported by modern digital archiving capabilities known as Picture Archiving and Communications Systems (PACS). These systems consist of servers, a storage subsystem, acquisition interfaces and special display stations. Because of the significant investment needed for a PACS system, a stand-alone PACS installation is typically not financially viable for small hospitals or clinics conducting fewer than 20,000 exams per year. Since smaller facilities represent some 80 per cent of Canada’s DI hospitals, Infoway has invested in projects to develop a shared DI services model that lets facilities large and small share in the benefits of a modern DI system. This model features a single PACS DI repository installed in a hub hospital, making regional service available to all health care facilities in the area.

DI systems in Canada are contributing to improved quality of care through faster turnaround of reports, improved physician collaboration, reduced test duplication due to lost or unavailable materials, better access to radiology services, efficiency improvements from radiologists, technologists and referring physicians, elimination of the costs associated with film processing and handling, and immediate retrieval of images.

2. Pan-Canadian Aggregate Study Benefits Evaluation Results

Benefits evaluation is an important component of a successful long-term strategy for health information systems. Evidence of the impacts of investments is needed to provide accountability to funders and justify future funding. As well, to drive adoption of these systems, clinicians and other users need evidence of the benefits on their work and the patients they serve. Project teams also need evaluation evidence to optimize the benefits of the systems.

The analysis of benefits presented in this report is based on Canada Health Infoway’s Benefits Evaluation (BE) Framework (Figure 1), which evaluates the impact of health information systems on health care access, quality and productivity [2]. Infoway’s strategic investor model is applied to evaluation; with the Infoway BE framework establishing the parameters for BE projects which are executed by the jurisdictions.

DI evaluation work has been completed in British Columbia, Ontario, Nova Scotia and Newfoundland and Labrador. The evaluations DI projects address the key
projected benefits of DI investments including: provider productivity and efficiency improvement; decreased patient transfer and duplicate exams; decreased cost per case; and decreased turnaround times.

The qualitative opinion surveys completed pre and post-PACS by a sample population of radiologists, technologists and referring physicians, and the quantitative research studies conducted at select healthcare facilities in the four provinces were important sources of data for this analysis. The PACS opinion survey captured radiologists’ and referring physicians’ opinions on report turnaround time, patient care, patient transfers, duplicate exams, communication among professionals and efficiency and productivity.

Figure 1. Canada Health Infoway’s Benefit Evaluation Framework.

The quantitative research studies used a variety of methodologies and data sources. Examples of the types of data sources used include: administrative claims data from the Ontario Health Insurance Plan to determine the frequency of duplicate imaging; financial data from Fraser Health Authority, Thames Valley, Newfoundland and Nova Scotia to look at PACS impact on the cost per case; and data from radiology information systems for the turnaround time studies.

As the sample sizes and methodologies across surveys, questions and studies was constrained and in some cases inconsistent, key informant interviews and a literature review were used to validate and fill gaps in the data. Using these data sources, a method of triangulation using multiple references was applied. Estimates were developed from the bottom-up (i.e., by modality, by province, by year) using the key sources of information and are risk adjusted where necessary. Simplified top-down estimates provide additional triangulation and validation of the benefits associated with PACS.
3. Pan-Canadian Aggregation Study

Tangible benefits are already emerging from these DI systems and the aggregation study shows the value of Infoway’s investments (Table 1). The study finds that DI systems have resulted in significant benefits pertaining to healthcare quality, access and productivity.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
<th>Resources</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Referring physicians</td>
<td>Efficiency improved by 50-60 minutes</td>
<td>420-500 specialists</td>
<td>6-7M 10-min consults</td>
</tr>
<tr>
<td>Turnaround time</td>
<td>30-40% improvement in exam turnaround times</td>
<td>N/A</td>
<td>TAT reduced 10-24 hrs</td>
</tr>
<tr>
<td>Patient transfers</td>
<td>Avoided unnecessary patient transfers</td>
<td>N/A</td>
<td>10,000-17,000 avoided patient transfers</td>
</tr>
<tr>
<td>Access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved remote reporting</td>
<td>Enables 30-40% of radiologists to support care delivery and improve access for remote areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technologist</td>
<td>25-30% improvement in technologists’ productivity</td>
<td>2,400-2,900 equivalent technologists</td>
<td>8-10M exams</td>
</tr>
<tr>
<td>productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiologist</td>
<td>25-30% improvement in radiologists’ productivity</td>
<td>450-540 equivalent radiologists</td>
<td>9-11M exams</td>
</tr>
<tr>
<td>productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate exams</td>
<td>2-3% reduction in unnecessary duplicate exams</td>
<td>43-63 equivalent radiologists</td>
<td>0.8-1.3M exams</td>
</tr>
<tr>
<td>Film costs</td>
<td>Elimination of film-related cost of materials and operations</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Having DI systems in place means that physicians can provide more efficient care, with easier access to information, greater collaboration, faster turnaround time and reduced time spent searching for films.

With the PACS surveys serving as the primary sources of data, more than half of referring physicians indicated PACS improved their clinical decision making by 30 to 90 minutes per week, with 52 minutes being the average. Improving referring physicians’ efficiency by 50 to 60 minutes is equal to 420 to 500 full-time-equivalent specialists capable of delivering between six and seven million, ten-minute consults.

The Infoway-funded turnaround time (TAT) studies found that TAT in both rural and urban centres have improved by 51% and 23% respectively, with an overall improvement of 41%. A 30 to 40% improvement in TAT means that clinical decisions, and subsequent treatment of patients, can occur 10 to 24 hours sooner, thus reducing patient wait times and lengths of stay.
DI systems are also improving the quality of care by reducing the number of patient transfers in rural and remote locations. Based on calculations derived from referring physicians’ responses to the PACS survey, it is projected that DI systems will eliminate 10,000-17,000 unnecessary patient transfers annually. This reduction will improve access to care and time to treatment for patients.

DI systems have improved remote reporting to populations with limited access to health care providers. The systems’ ability to provide remote access to images enables 30 to 40% of Canadian radiologists to deliver care and improve access for remote geographies and populations. The results from the PACS Survey indicate 40% of the radiologists found PACS improved remote reporting for various sites.

Yet another benefit in terms of patient access to DI services is realized through the additional capacity created through efficiency gains, reduced duplication, and reduced length of stay, which results in more patients getting access to health care. These access and capacity improvements, combined with IT-supported health care transformations, such as improved workflows, are supporting improvements in patient wait times.

Productivity improvements make a compelling business case for investment in eHealth systems, particularly as they are the most measurable, quantifiable benefits of DI systems. Using peer-reviewed literature, supported by key informant interviews, the evaluation studies found that after implementation of a large-scale PACS, technologist productivity increased by 34% above that of the national standards and 48% above that of the local control site. Improving technologists’ efficiency and productivity by 25 to 30% is equivalent to 2,400 to 2,900 more technologists or 8 to 10 million more exams annually, for the Canadian health system.

In the PACS survey, the majority of radiologists identified PACS as improving reporting and consultation efficiency by an average of 27%. This improvement in radiologists’ productivity results can be compared to the addition of 450 to 540 full-time equivalent radiologists delivering an additional 9 to 11 million exams each year for the Canadian health system on an annual basis.

DI systems are also improving productivity by reducing the number of unnecessary duplicate exams. The PACS Survey, together with the Infoway-funded duplicates study, found that a 2 to 3% reduction in duplicate tests could result in $47 million to $71 million of savings or annual avoidance of 0.8 to 1.3 million unnecessary exams for the Canadian health system.

According to literature reviews, the elimination of film-related materials and operations costs present a near break-even value proposition for DI systems. Taking into account the one-time implementation and refresh costs of PACS, PACS expenses ranges from 10% less to 25% more than a film environment. Thus, the results show that the reduced film and storage space costs has the capacity to cover the costs of implementing and operating new DI systems, while increasing the productivity of radiologists and technologists.

4. Challenges in Evaluating DI Benefits

There are several limitations concerning the data from evaluation surveys and studies and in the body of literature about diagnostic imaging systems. The timing of evaluations was often six months post-implementation, meaning the full benefits might not yet have been fully realized. In addition, consistent methodologies were not applied across all projects. The surveys were used to assess perceptions of improvements in
key areas, including efficiency gains, rather than quantitative research. Deriving quantitative estimates from qualitative data can result in lower levels of validity. Therefore, to increase confidence in the findings, the triangulation method of combining multiple approaches and data sources was used to increase confidence in the findings.

The supporting literature used in the methodological triangulation varied in volume and depth between topics, which reflects the challenges in conducting certain types of studies. And, although there is confidence in the estimates of national benefits, the benefits vary by location based on such factors as setting, geography, and staffing. Consequently, the estimations should not be viewed at a regional or provincial level, due to these limitations.

It is also important to note that while the estimated results are indicative of the benefits being realized, they do not necessarily translate into cost savings. Time savings, utilization reductions and cost avoidance identified through this analysis certainly benefit the health care system in terms of increased capacity, efficiency of care delivered and provider satisfaction. However, the cost is rarely recoverable.

5. Conclusion

The results from the pan–Canadian aggregate DI benefits evaluations highlight how DI systems are positively impacting Canada’s healthcare system; however, the information available to healthcare providers through DI systems is a mere fraction of what is needed to provide high-quality, timely, efficient care. While the benefits discussed in this report are significant, there are many opportunities to realize even greater benefits from DI systems and other EHR components. Infoway’s leadership in benefits evaluation has ensured that evaluation activities are increasingly part of EHR projects, but work in this area has not been without challenges.

Capturing and measuring tangible benefits from EHR investments has proven to be a difficult undertaking. The focus in the health informatics community has been on project implementation and adoption progress, without emphasis on the longer term impacts on quality, access and productivity. Part of the challenge has been engaging people with the skill set necessary to effectively evaluate outcomes. This area of work provides and opportunity for greater partnership between the research community and policy makers and other stakeholders. Research on the benefits of EHR technologies will not only elucidate how diagnostic imaging, drug information, laboratory information and other electronic systems are changing healthcare, but the research findings will also drive adoption and inform improvement of existing and future projects.

References

Availability and usage of ICT applications among European primary care physicians

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Abstract. While differences in Information and Communication Technology (ICT) infrastructure in European general practices are decreasing more and more, actual use rates – in particular, for more advanced applications – are about as different as the languages spoken by GPs throughout the European Union. This is one finding of a representative survey among GPs in Europe carried out by empirica on behalf of the European Commission. The resulting patchwork pattern of eHealth use shows that there is still some distance to go before all the potential benefits of eHealth in general practice can be reaped by all the EU member states.

Keywords. primary care physicians, ICT availability and use, European Union member states

Introduction

Information and Communication Technology (ICT) based solutions may substantially contribute to better, safer and more efficient primary healthcare. The study “Benchmarking ICT use among General Practitioners in Europe” [1] sheds light on the role ICT-based applications play in general practice in the 27 member states of the European Union. It surveyed ICT infrastructure and eHealth readiness on the one hand, and actual use of ICT applications and impact as perceived by General Practitioners (GPs) on the other. This allowed the role, potential, and impact on optimizing care by eHealth to be measured in more detail than any earlier research. The study was commissioned by the European Commission and carried out by empirica. It is the first in a series of three linked studies to develop eHealth benchmarking at European level. The second study, “eHealth Benchmarking” [2], currently collects information on eHealth data sources in Europe and beyond to develop an eHealth benchmarking indicator framework. More information on the GP study and a full report including all results are available from the study web site.

1. Methodology

The data presented in this paper were collected by means of a survey of primary care physicians in all 27 member states of the European Union, Norway and Iceland. The universe consisted of all GPs in the countries. From the universe a random sample of practices/institutions with a quota on region and, where possible, private practice/institution was drawn. The target respondent within the practice/institution was selected...
via a random procedure if more than one GP were present. A total of 6,789 computer aided telephone interviews was carried out.

2. The eHealth Use Patchwork

Despite a rapid development in the eHealth area in Europe over the past five years, the use of ICT for health purposes by GPs in the EU still varies considerably across the Union's 27 member states. The pattern that emerges is related to the complexity of the eHealth application in question. On the one hand, the more complex the application gets — in terms of the necessary infrastructure, skills needed by the user, the number of actors and the complexity of the processes involved, etc. — the more substantial are the differences between the countries. On the other hand, the overall use rates decrease with growing complexity so that the most complex applications, i.e., those involving the electronic transfer of medical patient data across a network, are used to a larger degree only in a few countries.

The result is a patchwork of eHealth use that is graphically depicted in Table 1. The differences between the countries are described in some detail in the following.

2.1. Electronic Patient Data Storage

The patchwork shows that electronic storage of patient data either for administrative or for medical purposes is used to quite some extent in a majority of the 27 member states. Administrative patient data, e.g., patient name and address, information related to paying/reimbursement, are stored electronically in 80% of the GP practices in Europe on average. Usage rates of 90% and more can be found in nine out of the 27 countries, with administrative patient data storage being next to omnipresent among GPs in Estonia, Finland and Hungary (usage rates 98% or higher). At the same time it can be as low as 26% (in Latvia) or 38% in Lithuania.

A similar average usage rate (74% of all GPs) can also be found for the electronic storage of individual medical patient data (e.g., basic medical parameters such as allergies, laboratory results, the medical history of a patient, diagnoses and medications etc.). Rates higher than 90% are reached by GPs in Denmark (96%), Finland (93%) and Hungary (92%). Rates below 50% can be found in Poland (49%), Latvia (46%), Romania (43%) and Lithuania (21%).

2.2. Computer Use in Consultation

When it comes to the use of computers during consultation, the pattern starts to become more fragmented. While computers in the consultation room are used by most or all of the GPs in Finland (100%), the UK (95%), Estonia (94%), the Netherlands (94%) and Denmark (92%), they are an exception rather than the rule in Greece (20%), Slovenia (18%), Poland (11%), Lithuania (8%) and Latvia (3%). A similar picture emerges when looking at the use of Decision Support Systems (DSS).
Table 1 The eHealth use patchwork in the EU member states.

<table>
<thead>
<tr>
<th>Country</th>
<th>Electronic storage of individual administrative patient data</th>
<th>Electronic storage of individual medical patient data</th>
<th>Use of a computer during consultation with the patient</th>
<th>Use of a Decision Support System (DSS)</th>
<th>Transfer of lab results from the laboratory</th>
<th>Transfer of administrative patient data to reimbursers or other care providers</th>
<th>Transfer of medical patient data to other care providers or professionals</th>
<th>ePrescribing (transfer of prescription to pharmacy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>80.3</td>
<td>74.7</td>
<td>53.8</td>
<td>42.0</td>
<td>37.1</td>
<td>13.0</td>
<td>12.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Belgium</td>
<td>83.5</td>
<td>85.9</td>
<td>76.3</td>
<td>49.2</td>
<td>73.5</td>
<td>7.7</td>
<td>12.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>93.7</td>
<td>84.8</td>
<td>76.7</td>
<td>42.2</td>
<td>5.3</td>
<td>7.8</td>
<td>3.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Cyprus</td>
<td>56.9</td>
<td>76.9</td>
<td>31.9</td>
<td>10.4</td>
<td>9.7</td>
<td>2.8</td>
<td>2.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>67.1</td>
<td>67.7</td>
<td>59.2</td>
<td>46.1</td>
<td>24.7</td>
<td>9.4</td>
<td>5.6</td>
<td>0.0</td>
</tr>
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<td>Denmark</td>
<td>96.9</td>
<td>96.3</td>
<td>91.6</td>
<td>76.5</td>
<td>96.2</td>
<td>60.9</td>
<td>73.6</td>
<td>97.3</td>
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<tr>
<td>Estonia</td>
<td>98.0</td>
<td>60.5</td>
<td>94.0</td>
<td>72.7</td>
<td>39.3</td>
<td>3.3</td>
<td>1.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Finland</td>
<td>99.6</td>
<td>93.3</td>
<td>100.0</td>
<td>86.8</td>
<td>90.0</td>
<td>14.2</td>
<td>54.8</td>
<td>0.4</td>
</tr>
<tr>
<td>France</td>
<td>74.2</td>
<td>83.0</td>
<td>72.2</td>
<td>29.5</td>
<td>32.8</td>
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2.3. Electronic Transfer of Patient Data

As regards the most advanced applications under observation here, i.e., those having to do with electronic patient data transfer, the transfer of lab results is the only application used to a greater extent in some countries. This includes again Denmark (96%) and Finland (90%), but also the UK (85%), the Netherlands (84%), Sweden (82%), and - to a lesser extent - Germany (63%). Usage rates at or below 10% can be found in eleven countries.

The transfer of administrative patient data to reimbursers and other care providers is done most frequently in Denmark (61%), the UK (38%) and the Netherlands (37%) as is the transfer of medical patient data to other health professionals, which is also practiced by a comparatively high share of GPs in Finland (55%). ePrescribing can be considered a reality in only three countries: Denmark (97%), Sweden (81%) and the Netherlands (71%). Apart from those countries and another 17 countries where usage rates are around or below 5%, there are seven countries where the electronic transfer of prescriptions to pharmacies is not done by any GP according to the results of the present survey.

2.4. The Good, the Bad and the Ugly?

From the eHealth use data presented in Table 1, Denmark, the Netherlands, Finland, Sweden and the UK emerge as the European frontrunners in eHealth use by General Practitioners. Within this group, Denmark takes a leading role as the only EU member state where all of the applications analyzed here are utilized to a large extent.

On the other side there is a group of countries where either the use of eHealth at large or the use of advanced applications still leaves considerable room for improvement. This group consists of Greece, Latvia, Lithuania, Poland and Romania.

There is the large group of average performers, consisting of the remaining 15 member states. Here, countries show either an average performance on most of the indicators analyzed, such as in the case of France or Austria, or they can be considered “specialists” in relation to one or two types of applications where they perform outstandingly well while being sub-average in other areas. One example for this is Estonia with high usage rates for storage of administrative patient data and use of computers in consultation, but low shares of GPs transmitting administrative data, medical data and prescriptions. Another example is Slovenia, where only the storage of administrative patient data is done by a majority of the GPs while all other application areas show comparatively low usage rates.

3. Making Sense of the Pattern

Simple - or simplistic - assumptions fail to explain why eHealth use patterns among GPs in Europe are as they are. In fact, there is no single factor that can explain the variations in eHealth use the study identified. There is no clear geographical pattern, for example in the form of a North-South or East-West divide. Segmentation also does not follow the borders of the former old member states (which joined the EU during or before 1995) and the new member states (which joined during or after 2004).

Both structural variables, size of the GP practice and age of the GP, and the practitioners' attitudes towards eHealth explain only part of the differences in eHealth
use across Europe. Next to complexity due to the number of actors involved, skills needed and technological sophistication of processes, actual eHealth deployment and use among GPs seems to be related to (political) framework conditions. An eHealth policy strategy can today be found in all EU member states, either as a dedicated approach or as part of larger initiatives, e.g., targeting the health system as a whole or the eGovernment domain. The strategies however vary in their maturity and in the scope of activities they apply, reflecting how much eHealth has arrived on the wider political or societal agenda and the role it plays in comparison to other issues. The maturity and the level of sophistication of these strategies match well with the actual eHealth use among GPs found by this study. In some countries, such as Denmark or France, there is a longstanding eHealth tradition while at the same time eHealth use is either high (DK) or average (FR). In other countries, such as Latvia, eHealth has arrived on the agenda only recently and use is therefore not yet very widespread.

4. Conclusions

Globally, when compared with surveys from other parts of the world, European GPs have a leading role in optimizing patient-centered healthcare through eHealth. Nevertheless, there is still ample room for improvement, particularly when it comes to the considerable differences among the member states. Achieving greater coherence will therefore be one of the key challenges in eHealth in Europe. One main area to be tackled concerns the electronic exchange of patient data by networks such as the Internet. Many of the benefits that could be reaped from applications such as ePrescribing, telemonitoring as well as medical data exchange between health professionals and across national borders remain untapped. The analysis of explanatory factors carried out by the study strongly suggests that eHealth must be viewed as part of a larger context and measures on different levels are needed to realize the benefits. These measures should include eHealth education and training, better networking of health actors and also strengthening of national or regional eHealth strategies and infrastructure implementations.

Recent research of the “eHealth Benchmarking” study also showed that multinational/multi-thematic surveys similar to the present GP study do not exist to a large extent for any other group of health actors like hospitals, specialists, patients and others. The resulting lack of reliable and comparable data is surely another factor hampering wider eHealth uptake.

References

Section 6

Nation-Wide Canadian Initiatives
How Can We Know Whether Short Term Trends in a Hospital’s HSMR are Significant?

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Abstract. The Hospital Standardized Mortality Ratio (HSMR) has been chosen by CIHI as its primary mortality measure. The indirect standardization used in the calculation of HSMR does not allow for valid comparison between hospitals but it does invite the assessment of quarterly trends in hospital mortality. However, statistical methods for assessing HSMR trends are not well-developed. In 2007 one large hospital in our health authority had four consecutive quarters of apparently increasing HSMR. As a result, we needed to assess the significance of this trend which, if it were to continue into the next quarter, would lead to an HSMR that significantly exceeded 100. We explored four methods to assess statistical significance of time trends in HSMR data: the WINPEPI “Describe” module, the CUSUM representation of Observed-Expected differences, the Variable Life Adjusted Display (VLAD) plots with CUSUM overlays, and the Change Point Analysis using Monte Carlo simulation.

Keywords. standardized mortality ratio, quality improvement, time series analysis, case mix adjustment

Introduction

Hospital Standardized Mortality Ratio (HSMR) is a ratio of observed to expected mortality that has been widely used in the UK and subsequently adopted by the Canadian Institute for Health Information (CIHI). HSMR is a form of standardized mortality ratio (SMR) based on indirect standardization. SMR measures have been widely used in occupational health studies, but have not been as commonly used in other types of studies because many epidemiologists prefer to utilize direct standardization. Direct standardization adjusts population parameters based on a reference population for which the numbers of persons in each increment of the category to be adjusted for is known. In contrast, indirect standardization creates a separate weighted average of each group’s outcome based on the overall outcome in a defined real-world reference group - for HSMR this is a logistic regression model based on 2004-2005 Canadian data. Indirect standardization allows direct comparison between the reference group and any other group whose mortality has been standardized using that reference. However comparing outcomes among the non-reference groups is often not possible, because the method does not account for differing case mix among the groups.
CIHI has offered mixed messages on such comparison between (non-reference) hospitals, on the one hand stating that such comparisons are impermissible, and on the other hand devising “peer” groups of hospitals whose similarities are inferred but not established empirically. Not surprisingly, despite warnings from CIHI and others [1], HSMR results have been widely used to compare hospital “performance”.

HSMR has come under recent criticism for its uncertain relationship to quality, its insensitivity to rare unexpected deaths, and its problematic use for inter-hospital comparisons [2,3]. As Shojania and Forster observe [4], HSMR is highly dependent on case mix, with simulation studies demonstrating the effect of altering age and co-morbidity distributions in the absence of any underlying change in mortality. The decision to include or exclude patients receiving palliative care can also have major effects on the measured HSMR [2]. By providing confidence limits for HSMR, CIHI implies that sequential changes of a hospital’s SMR can be addressed by assessing whether these limits overlap. Unfortunately, as Spiegelhalter has argued, data over-dispersion potentially threatens the validity of the underlying Poisson model used to estimate HSMR confidence limits [5]. Even ignoring over-dispersion, interpreting overlap of three or more quarterly HSMR measures confidence limits is problematic. In the remainder of this paper we will address potential options for evaluating HSMR trends in the context of a real clinical experience with sequential quarterly increases in HSMR.

1. Methods

The data for this discussion was based on the Discharge Abstracts Database (DAD) of a large health authority. HSMR-related data for discharges between April 1, 2004 and March 31, 2007, inclusive, were abstracted from DAD in accord with CIHI protocols, analyzed by CIHI, verified by the health authority, and reported to the public as a single annual HSMR for each hospital whose HSMR case numbers exceeded an arbitrary threshold of diagnoses included within the HSMR calculation. Quarterly HSMR results were also reported to the health authority but not released to the public. CIHI’s model is based on a logistic regression model derived from 2004-2005 Canadian national data [1]. CIHI provided the individual regression model estimating probability of death for each inpatient whose primary diagnosis was included in the HSMR calculation. This data was analyzed in Excel 2003 (SP1) and then transferred to STATA-9, WINPEPI Describe 1.88, VLAD [6], and Change-Point Analyzer [7] for further analysis. Predicted deaths were calculated by summing individual mortality probabilities for each time interval of interest. Analyses discussed in this paper all excluded persons receiving palliative care.

2. Results

In fiscal years 2006 and 2007, one hospital in the Health Authority had a four quarter steady increase in HSMR. While the confidence intervals of all adjacent quarters overlapped, and the final quarter still had confidence limits that included 100, projecting this linear rise in HSMR for one additional quarter risked leading to a HSMR whose value was significantly higher than the 100 “normal” value. We needed to know whether this trend was due to chance, seasonal influences, or a true worsening
of mortality in this hospital. If the latter were the case, we felt it prudent to address a significant trend before HSMR rose above 100. Neither the CIHI nor readily accessible literature offered easy guidance for how to assess the statistical significance of HSMR trends.

We began our analysis with WINPEPI’s Describe module. Because there is evidence that adjusted data may falsely indicate a trend [8], we first examined crude mortality rates and found a significant upward mortality trend during the four quarters (Cochrane-Armitage test and Mantel test for trend: $p \leq .001$). The quarterly HSMR data, in contrast, were not statistically significant ($p = 0.057$), possibly due to the smaller denominator used in HSMR (expected deaths for HSMR versus all cases for crude mortality rate). Pairwise Tukey tests confirmed the overlapping confidence limits of HSMR quarterly data, showing no statistical difference between adjacent pairs. When the preceding year’s data was also included in a time series analysis to adjust for seasonality, the nearly significant ($p=0.057$) upward HSMR trend was clearly without statistical significance ($p = 0.04$). However a “change point” in seasonally-adjusted HSMR (indicated as an inverted triangle in Figure 1) was noted between August and September 2006. Using different distribution-free methods, Change Point Analyzer [7], assigned a 93% probability to the validity of this change.

Using Sherlaw-Johnson’s VLAD display with integral CUSUM signaling, we were able to show that a worsening trend in the difference between observed and expected deaths began around the end of November and resulted in a CUSUM “signal” around December 22 (Figure 2). This relatively adverse trend continued until March 8 and was associated with about 11 deaths more than expected – HSMR for this period was 116. Between November 30 and the December 22 signal, 24 deaths occurred when 22 were predicted (HSMR 108). Chart reviews were performed retrospectively and did not reveal evidence of preventable deaths. HSMR returned to normal the following quarter and has stayed under 100 through the ensuing year, confirming that the trend observed – despite its apparent statistical significance on some testing – was most likely due to random variation compounded by season fluctuations in mortality.

Parenthetically, in separate unpublished work utilizing data from our health authority we had found that when divided into risk deciles, the correlation between predicted and observed death using the CIHI model is quite high, despite the absence of any physiological data, with a correlation coefficient of 0.995 and an $R^2$ of 0.99.

![Figure 1. WINPEPI two year time series results, 2005-7 by quarters.](image-url)
3. Discussion

Even though tracking changes within a single hospital is a potentially appropriate use of HSMR, this report illustrates the difficulties of addressing trends and describes a number of tools which can prove useful in responding to an apparent trend. While some have argued that death reviews and prevention should be targeted to conditions and services with high mortality [4], an alternative mortality review process could focus attention on mortality among persons at low estimated risk or on “runs” of unexpected death detected by VLAD or CUSUM representations. Had we been monitoring mortality at this hospital with the CUSUM methodology, we would have detected a reason for concern in December and would have focused review efforts on a small number of charts accounting for an apparent excess mortality. While time series analyses such as those described cannot distinguish among quality deficits, changes in case mix, or random fluctuations in mortality, they can identify periods during which focused review can be used to assess the preventability of individual deaths. Despite difficulties in assigning statistical significance, CUSUM may be more useful for this process than change point analysis since it reflects “real time”. For example, analysis of our data stopping March 2007 suggests a December 2006 change point, but the same analysis stopping January 2007 fails to identify the change. While a two month lag in recognizing a change may not be seen as critical (compared to the more than ten years before Dr. Harold Shipman’s murders were recognized), CUSUM allows a more timely analysis that can be confirmed later, if desired, by the more statistically sophisticated method of change point analysis.

While not overcoming the problem of multiple univariate testing, VLAD charts coupled with CUSUM have some inherent attractiveness for ongoing monitoring.
VLAD (variable life adjusted display) is a cumulative measure of the difference between observed and expected deaths which has a set of “distribution tails” built into it to enhance the intuitiveness of the display. Each new discharge changes the calculation of observed vs. expected deaths and in consequence generates a new distribution. One can think of this distribution as akin to a standard deviation (though technically this is incorrect), and on Sherlaw-Johnson’s elegant “rocket tail” VLAD chart, results with a 5% or less probability of occurring by chance are displayed in the dark blue upper region of the rocket tail (representing relatively large numbers of net lives saved) or in the dark red lower portion (representing excessive net lives lost). Unfortunately, as the number of total cases accumulates it takes more deaths to move a point to the color extremes of the rocket tail. Hence the chart is inherently more useful when changes or CUSUM signals occur relatively close to the origin at the left side. This means that data must be loaded into new rocket tail charts quite frequently to gain full benefit of the graphic potential of this display.

Despite some shortcomings, we think that the VLAD/CUSUM representation of mortality data is of particular value for ongoing monitoring of hospital deaths. It is important to recognize that CUSUM “alarms” are based on multiple sequential tests of the null hypothesis that there is no difference in the log likelihood of observed versus expected. Because there is a finite probability of type 1 error (usually 5% depending how the CUSUM alarm property is set), all CUSUM measures will eventually “signal” that an unexpected number of deaths has occurred. Some of these signals will of necessity be false alarms and will lead to mortality reviews when no unexpected deaths have occurred. Considerable work is currently being directed toward developing alternatives to CUSUM that take into account the “false discovery rate” [9]. We have recently trialed the substitution of the output of Change Point Analyzer as our major reporting format for retrospective presentation of HSMR data to health authority administrators and board.

4. Conclusion

HSMR has many flaws as a measure, and the monitoring of deaths may indeed make only marginal contribution to improving quality and safety. However monitoring and reviewing deaths has a time-honoured place in health care practice. CIHI’s administrative data regression model provides one estimate of the likelihood of inpatient death occurring in association with a subset of diagnostic codes. Combining that model with a different representation of mortality than CIHI has so far supplied may prove to be useful for health care administrators and thoughtful physicians seeking “triggers” to prompt further in-depth case analysis.

Acknowledgements

David Spiegelhalter provided advice, Eugene Wen and Liudmila Husak provided CIHI raw data, and Chris Sherlaw-Johnson allowed us to use his VLAD software with superimposed CUSUM plots.
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An Embarrassment of Data: How e-Assessments Are Supporting Front Line Clinical Decisions and Quality Management Across Canada and around the World

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Abstract. A unique collaboration between the Canadian Institute for Health Information (CIHI) and interRAI, an international research network, is supporting jurisdictions across Canada in collecting client-level clinical and administrative data for both primary and secondary uses. Standardized interRAI assessments, captured electronically and sent to CIHI, provide real-time decision support for clinicians as well as a rich longitudinal source of aggregate data for system planning, quality improvement and accountability. With over a million assessments in three CIHI-RAI data holdings, important benefits have already been realized at individual and organizational levels across eight Canadian jurisdictions. The evolution of a pan-Canadian interoperable EHR presents an exciting opportunity to optimize the value of these investments for the future.

Keywords. interRAI, EHR, decision support, standardized assessments

Introduction

This paper showcases the benefits of a unique collaboration providing high quality real-time and retrospective information to support quality care in Canada and beyond. The Canadian Institute for Health Information (CIHI) is an independent, not-for-profit organization that provides essential data and analysis regarding Canada’s health system and the health of Canadians. \cite{McDaniel2009}interRAI is an international not-for-profit network of researchers and clinicians in over 30 countries. Its activities relate to the development of assessment systems for elderly, frail, or disabled persons, and the use of the information derived from these systems for health research. Systems are compatible with each other, but are tailored for locations of care, for example facility-based care, home care, or community mental health.

We provide an overview of the interRAI assessments and outputs, a brief history of the development of CIHI-RAI reporting systems, and examples of the data in action.
We also look ahead at the opportunities presented by an embarrassment of data and emerging EHR initiatives.

1. interRAI Assessments and Outputs

The interRAI assessments are designed to be captured electronically during the process of care and to become part of the individual’s health record. The assessments capture key information in all important health domains, including health conditions, functional and cognitive statuses, social and informal support, and service utilization. Information in the assessments generates outputs for use at individual or organizational levels by clinicians and managers.

Figure 1 shows the outputs derived from an assessment and how they can be applied. In essence, information from a single assessment is used for multiple purposes with no incremental collection burden. Based on interRAI algorithms and CIHI vendor specifications, vendor software installed on laptops, tablets or PCs can generate these outputs in real time.

The interRAI Clinical Assessment Protocols (CAPs) are real-time decision-support tools to guide care planning in community and residential care settings. Triggered by specific items in an assessment, they identify a person who is at risk of specific adverse outcomes. Based on current international research and knowledge of best practices, CAPs provide a structured approach for clinicians. There are 27 different CAPs available for important clinical domains such as falls, medications, institutional risk, and pain [1].

Outcome measurement scales have been developed and validated for important health domains, such as physical function, cognitive impairment, pain, and health instability. These can be employed at the individual level, or aggregated for management purposes.

![Figure 1. Component Diagram of interRAI Assessment and related outputs.](image-url)

Sets of quality indicators (QIs) have been developed to help health system managers understand where differences in quality occur and to measure when an improvement or a decline in quality is happening.
Case mix classification, the grouping of similar clinical cases that tend to use similar amounts of resources, has been an important component of interRAI instrument systems. In addition to its usefulness to payment organizations, case mix information is also used to compare groups of care recipients, adjust for differential risk in quality measurement, and support staff planning. The need for a valid and reliable case mix measures has often been a central reason for a jurisdiction to mandate the use of an assessment instrument.

The Personal Health Profile (PHP) combines the best elements of these outputs. It is a one-page summary of significant client health information extracted from the RAI-Home Care assessment. There are PHPs for primary care, service providers and long term care facilities to enhance continuity of care and interdisciplinary communication.

2. The Evolution of CIHI-RAI Data Standards

The collaboration between CIHI and interRAI began when the Province of Ontario mandated the collection of interRAI assessment data for patients in hospital-based Complex Continuing Care. The implementation was envisioned to provide the Province with standardized data across Ontario hospitals for planning, funding and accountability. In 1996, following release of vendor specifications and a province-wide education program, CIHI began accepting RAI MDS 2.0© data from 156 facilities. In 2003, CIHI replaced the previous reporting system in Ontario with the Continuing Care Reporting System (CCRS) to foster pan-Canadian participation and to enhance data quality and privacy processes.

With support from CIHI and interRAI, the residential care sector (e.g., long term care and nursing homes) rapidly began to adopt MDS 2.0. There are now almost 500 facilities participating in CCRS.

Meanwhile across Canada, there was a growing interest in other RAI instruments. In 2003, the Province of British Columbia approached CIHI to build a reporting system for its RAI-Home Care (RAI-HC©) data. The CIHI Home Care Reporting System (HCRS) was launched in 2005 to accept RAI-HC data as well as the data needed for indicators identified by the Federal/Provincial Health Accord, such as home care wait times [2].

Eight Canadian provinces and territories are in various stages of implementing the RAI MDS 2.0 and the RAI-HC. Others are in discussion with CIHI as they plan their clinical data collection to conform with information infrastructure initiatives.

In 2005, CIHI launched a reporting system in response to an Ontario mandate to implement interRAI-Mental Health (RAI-MH©) for adult inpatient mental health. Since that time, 70 facilities have been participating in the Ontario Mental Health Reporting System (OMHRS). Other Canadian jurisdictions are piloting or are exploring possible implementation of the RAI-MH for making data submission to CIHI.

© RAI MDS 2.0 is Copyright© interRAI Corporation, 1997, 1999. Modified with permission for Canadian use under license to the Canadian Institute for Health Information. “Canadianized” items and their descriptions are Copyright© Canadian Institute for Health Information, 2002.


© RAI-MH is Copyright© Queen’s Printer for Ontario, the Ontario Hospital Association and interRAI, 2003.
Figure 2 illustrates the current status of CIHI-RAI reporting system implementations. The CCRS and HCRS currently hold more than half a million assessments each and OMHRS holds nearly 300,000 assessments.

3. The Data in Action

CIHI provides all participating organizations and their respective health regions and ministries with quarterly statistical reports. These include trend analyses and comparative information on volumes, length of stay, intake profiles, quality indicators, outcome scales and case mix. CIHI also provides the Ontario Ministry of Health and Long-term Care with a case mix weighted-day methodology for use in hospital funding.

Since 2001, the Ontario CCRS data have been used by the Ontario Hospital Report Research Collaborative [3] to generate a balanced scorecard for Complex Continuing Care. The reports include quality indicators (QIs) addressing key issues such as skin ulcers, medications, depression, and physical restraints. MDS 2.0 QIs are now included in Accountability Agreements between Ontario Local Health Integration Networks and the Ministry of Health and Long-term Care.

The Hospital Report initiative and the CCRS comparative reports initiated a dialog among clinical leaders and administrators who seek to understand the performance of their facilities with respect to those of their peers. Groups of quality champions have met to compare notes. This has resulted in new awareness of the potential uses for RAI data.

Since the 1990’s, use of physical restraints in Ontario hospitals, as in other jurisdictions, has become increasingly scrutinized. In 2001, the Government of Ontario passed Bill 85, the Patient Restraints Minimization Act [4]. Figure 3 shows the rate of daily restraint use, as measured by the RAI assessment, between 1996 and 2006. The rate fell to approximately one-third of the rate measured when the interRAI assessment use began. Clearly assessment is not the central reason affecting this important care practice, but it has provided a means to consistently measure the practice in the diverse settings across the Province.

Planners in Nova Scotia used the information from a recent CIHI report, “Caring for Nursing Home Residents with Behavioural Symptoms: Information to Support a Quality Response” [5], to determine the number and distribution of specialized units in...
new nursing homes. Clinicians in a Newfoundland nursing home were alerted by their MDS 2.0 QIs that there was room for improvement in their continence program. They collaborated to identify and implement a “best practice.” Not only did they improve the quality of life for their residents, but the staff felt more empowered and the organization realized significant financial savings on products for incontinence. Stories are emerging of “small miracles” at individual levels, such as the Yukon nursing home resident with depression who was flagged by an MDS 2.0 assessment and, after appropriate treatment, was given a vastly improved quality of life.

Community case managers across the country are using the MAPLE (Method for Assigning Priority Levels), a scientifically sound RAI-HC decision support tool, to inform allocation and prioritization of community or facility-based resources [6].

4. The Road Ahead

There are opportunities and challenges in our future. There is momentum for the adoption of RAI-based CIHI data standards, particularly in home and continuing care, for primary and secondary analysis. Where RAI assessments are incorporated into an electronic health record (EHR), not only does the clinician receive immediate decision support for care planning and risk management, but providers, such as primary care physicians, can receive a clinical summary or, in the case of transfers between care settings, a full assessment.

Regions, provinces and territories are now beginning to use the data for planning, quality assurance and accountability. As data holdings grow, there will be an increasingly rich source of data for those sectors of growing importance in the Canadian health system – home and continuing care and mental health.

![Figure 3. Daily restraint use rate in Ontario Complex Continuing Care.](image)

Health jurisdictions are seeing the benefits of integrated health information systems that include reliable and comparable clinical and functional measures across health service settings. There is strong interest in other interRAI instruments that provide consistent health measures in settings such as community mental health, emergency departments, primary care, and assisted living.

In planning for their new information systems, provinces and territories are now exploring opportunities for their RAI data to be incorporated into an emerging pan-Canadian interoperable EHR. This is the next critical step toward optimizing the benefits of these unique clinical assessment systems.
This partnership between clinicians and researchers from around the world and a national health information organization has enabled the adoption of a common language for assessment that supports interdisciplinary communication, quality and continuity of care, and research-based evidence for planning and resource management. Our embarrassment of data is only the beginning. We are just discovering the potential for the data not only to inform us but to transform our health system for optimal quality and sustainability. CIHI, interRAI and other stakeholders will continue to collaborate to support this vision.

References

Capturing Pan-Canadian Primary Health Care Indicator Data Using Multiple Approaches for Data Collection

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Abstract. The Canadian Institute for Health Information (CIHI), in collaboration with diverse stakeholders, led the development of pan-Canadian indicators to measure primary health care. In 2006, CIHI released a set of 105 pan-Canadian Primary Health Care (PHC) indicators that were developed with the assistance of national, provincial and territorial representatives, clinicians and researchers. Additionally, data gaps were identified in a series of reports. In 2006 and 2007, CIHI assessed options for closing the data gaps so that the indicators could be measured and reported. CIHI then began a program to build the data infrastructure needed for the PHC indicators. The program included the development of content standards for electronic medical records, a prototype of a voluntary reporting system, enhancements to surveys, and the development of reports. In 2006, fewer than 10% of the 105 indicators could be calculated with existing data sources. Now, four projects have begun and over 50% of the indicators are being captured. Important relationships have been established with key collaborators. These relationships will lead to the development of a reporting system prototype and to the refinement of PHC indicators and electronic medical record (EMR) content standards. The project for pan-Canadian PHC indicators has encouraged consultation and synergy. It has motivated CIHI to establish an information program to fill data gaps and to make PHC indicators available.

Keywords. primary health care, data collection, health care indicators

Introduction

Primary health care (PHC) is the gateway to other services and is the most common type of health care that Canadians experience [1]. However, despite the number of PHC visits made by Canadians, there is a relative lack of information about what happens during those visits and what the outcomes are. In addition, there is little information about access to these services and the best way of structuring the PHC system. Much of the information that is available is not comparable at the pan-Canadian level. There is a need for comprehensive, comparable PHC information to guide service planning, delivery and evaluation, policy development and research. PHC information needs to be available at multiple levels for informed, trend-sensitive decision-making.

The Primary Health Care Transition Fund (PHCTF) was established September, 2000 to improve PHC across the country and examine new ways to deliver PHC. The National Evaluation Strategy was part of the PHCTF and it developed a series of objectives, supports, and evaluation questions that were the guiding framework for the
Canadian Institute for Health Information (CIHI) indicator development project. The PHCTF provided funding to CIHI to develop a series of pan-Canadian PHC indicators and to provide advice on the needed data collection infrastructure.

1. Objective

In collaboration with a broad range of stakeholders, CIHI led the development of pan-Canadian PHC indicators to measure and understand PHC. Subsequently, CIHI launched an implementation program to establish the necessary PHC data infrastructure to support development and reporting. These indicators will provide the framework for reporting on PHC and will be used to assist in decision-making and health care system planning, policy development and research.

2. Methods

In 2006, CIHI released a set of 105 pan-Canadian PHC indicators that were developed over 18 months with support from Federal, provincial and territorial representatives, PHC providers, researchers and associations using a Delphi consensus process. The final list of indicators may be used for analysis of PHC performance on a wide range of issues including:

- access,
- continuity,
- coordination,
- primary and secondary prevention,
- outcomes of care, and
- service delivery and organization of care.

Selection of the indicators has been based on the perspectives of multiple stakeholders including patients and providers. The final 105 indicators were published in a two-volume report entitled “Pan-Canadian Primary Health Care Indicators” [2]. The report describes the consultation and development process and provides detailed definitions and technical specifications. Although all of the indicators were rated as important, a fewer number of high-priority indicators were identified that could be used as a starting point for data collection and reporting. These are listed in Table 1. This abridged set of indicators can provide important information related to health promotion, chronic disease prevention and management, and the effectiveness of different models of care.

The availability of an existing data source was purposefully not a criterion for indicator selection. An additional report entitled “Enhancing the Primary Health Care Data Collection Infrastructure in Canada” [3] describes the current data availability to report on PHC indicators, identifies data gaps and provides options to enhance the pan-Canadian data collection infrastructure. Reporting on these indicators requires a number of data sources including existing CIHI databases, other administrative databases, data from electronic medical records, as well as patient, provider, and organizational surveys.
Table 1. Sample abridged list of PHC indicators.

<table>
<thead>
<tr>
<th>Access to PHC Through a Regular Provider</th>
<th>Comprehensive Care, Preventive Health and Chronic Condition Management</th>
<th>Continuity Through Integration and Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Population with a regular PHC provider</td>
<td>• Scope of PHC services</td>
<td>• Collaborative care with other health care organizations</td>
</tr>
<tr>
<td>• Difficulties accessing routine PHC*</td>
<td>• Health risk screening*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PHC client/patient registries for chronic conditions*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PHC programs for chronic conditions*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Client/patient participation in PHC treatment planning</td>
<td></td>
</tr>
<tr>
<td>24/7 Access to PHC</td>
<td>Patient-Centred PHC</td>
<td></td>
</tr>
<tr>
<td>• Difficulties obtaining urgent, non-emergent PHC on evenings and weekends</td>
<td>• Client/patient satisfaction with PHC providers</td>
<td></td>
</tr>
<tr>
<td>• PHC after hours coverage</td>
<td>• Language barriers when communicating with PHC providers</td>
<td></td>
</tr>
<tr>
<td>• Difficulties accessing routine PHC*</td>
<td>• PHC client/patient registries for chronic conditions*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PHC programs for chronic conditions*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Specialized PHC programs for vulnerable/special needs populations</td>
<td></td>
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<tr>
<td>Enhancing Population Orientation</td>
<td>Quality in PHC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary Prevention</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Influenza immunization, 65+</td>
<td></td>
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<tr>
<td></td>
<td>• Pneumococcal immunization, 65+</td>
<td></td>
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<tr>
<td></td>
<td>• Cervical cancer screening</td>
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<tr>
<td></td>
<td>• Health risk screening*</td>
<td></td>
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<tr>
<td></td>
<td>Secondary Prevention for Chronic Conditions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Screening for modifiable risk factors in adults with coronary artery disease</td>
<td></td>
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<td></td>
<td>• Screening for modifiable risk factors in adults with hypertension</td>
<td></td>
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<tr>
<td></td>
<td>• Screening for modifiable risk factors in adults with diabetes</td>
<td></td>
</tr>
<tr>
<td>Patient Safety</td>
<td>Treatment Goals and Outcomes</td>
<td></td>
</tr>
<tr>
<td>• Use of medication alerts in PHC</td>
<td>• Glycemic control for diabetes</td>
<td></td>
</tr>
<tr>
<td>• Antidepressant medication monitoring</td>
<td>• Blood pressure control for hypertension</td>
<td></td>
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<tr>
<td></td>
<td>• Treatment of dyslipidemia</td>
<td></td>
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<tr>
<td></td>
<td>• Ambulatory care sensitive conditions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Treatment of depression</td>
<td></td>
</tr>
<tr>
<td>PHC Inputs and Supports</td>
<td>Information Technology</td>
<td></td>
</tr>
<tr>
<td>• PHC organizations accepting new clients/patients</td>
<td>• Uptake of information and communication technology in PHC organizations</td>
<td></td>
</tr>
<tr>
<td>Interdisciplinary Teams</td>
<td>Allocations for PHC</td>
<td></td>
</tr>
<tr>
<td>• PHC FPs/GPs/NPs working in interdisciplinary teams/networks</td>
<td>• Average per capita PHC operational expenditures</td>
<td></td>
</tr>
<tr>
<td>Provider Payment Methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• PHC provider remuneration method</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Indicators are repeated because multiple dimensions are reflected.

In 2006 and 2007, CIHI worked in collaboration with key stakeholders. Together, they explored the feasibility of expanding data collection and other options for closing data gaps that prevented the calculation of the indicators. Work began to modify the existing data sources, which included a feasibility study to assess the quality of data in electronic medical records (EMRs) in PHC settings and explore options for further data collection. Additionally, CIHI provided co-funding and worked with the National Physician Survey (NPS) to align questions with the PHC indicators in order to understand the perspectives of providers and to collect data on 26 CIHI PHC indicators.
Provider perspective surveys will offer information on elements such as access, uptake of information technology, use of interdisciplinary teams and medication alerts, and scope of the services provided.

In late 2007, CIHI launched a primary health care information program and initiated work with key stakeholders on four projects to establish a data infrastructure. The Canadian infrastructure for measurement and reporting was intended improve availability of PHC information. It was:

- to develop and release PHC indicators electronic medical record (EMR) content standards, and support uptake and adoption across Canada;
- to pilot a PHC reporting system prototype that could support standardized, comparable data capture of up to 12 quality indicators from PHC settings using EMRs;
- to expand existing surveys and conduct a feasibility project on developing a new, national practice-based survey; and
- to initiate PHC indicator reporting using a new and expanded data set and explore options to further enhance PHC data sources.

Data collection for the PHC indicators requires multiple data streams and approaches. In response to provincial and territorial requests, CIHI led the PHC Indicators EMR Content Standards project in consultation with experts from across Canada, including clinicians, Federal, provincial and territorial representatives, PHC researchers and standards experts. These content standards were defined to ensure consistent, comparable data capture of 12 CIHI PHC clinical quality of care indicators in the areas of prevention, patient safety, quality and outcomes. This data set, which will be released during the winter of 2008, includes data elements related to the patient, provider, encounter and outcomes of care, in cases where the most likely source of data is from an EMR. The standardized data set can also be used by existing chronic disease registries (“collaboratives”) to support the capture of standardized data in the areas of diabetes, coronary artery disease, hypertension and depression. The data could be used by jurisdictions for them to better measure and understand their performance. Where possible, the PHC Indicators EMR Data Set has been aligned to Canadian and international standards.

Early in 2009, CIHI will work with interested PHC providers and jurisdictions across Canada to test the CIHI PHC Indicators EMR Data Set. Pilot testing will suggest enhancements and revisions for future versions of the standards. CIHI will also work with the jurisdictions and other stakeholders to assist in the uptake and adoption of these standards into PHC-based EMRs across Canada. There is a plan to refine and release periodic updates as clinical practice guidelines and other EHR standards evolve.

CIHI is developing a PHC reporting system prototype. This prototype will be useful in efforts to collect and analyze selected data from PHC settings and will provide a comparable source of Canadian data for clinical quality indicators. It will assist in longitudinal monitoring and measurement of PHC in Canada. CIHI will collaborate with stakeholders such as clinicians, Canada Health Infoway, provinces and territories, chronic disease collaboratives, researchers and EMR vendors. The prototype will be used to pilot test the CIHI PHC Indicators EMR Data Set and will assess the feasibility of and preferred options for EMR data collection in primary and secondary prevention of disease, patient safety, and outcomes of chronic disease management. The Phase One pilot will also explore processes for data collection and extraction, establish the prototype PHC reporting system to receive pilot EMR data, and develop
preliminary pilot provider feedback reports. At the end of the Phase One pilot, the PHC Voluntary Reporting System (VRS) Prototype Project will allow CIHI to evaluate project results and develop preliminary analyses on the data such as: access, utilization, continuity, quality of care and outcomes.

CIHI will continue to provide expertise and support to the Canadian Primary Care Sentinel Surveillance Network (CPCSSN). CIHI, in collaboration with the College of Family Physicians of Canada and the Public Health Agency of Canada, intends to establish a Canadian chronic disease surveillance system using EMR data. Initially, surveillance will include diabetes, depression, hypertension, osteoarthritis and chronic obstructive pulmonary disease.

CIHI is working to gather a representative, population-based sample to report on key elements of PHC. In collaboration with clinicians, researchers, and Statistics Canada, CIHI has begun to evaluate the feasibility of a national, practice-based survey. Activities include consulting; designing the sample frame; designing the encounter, patient, and provider/organization survey questionnaires; and pilot testing each survey module. This survey will provide a comprehensive, comparable data source that includes encounter information for a representative sample of patients among three PHC models of care: solo, group and interdisciplinary teams. Patient demographics, health conditions, vital signs, medications, current interventions and a small amount of historical information will be collected. This data, which can be linked, may be used to analyze practice models and outcomes, service utilization, complexity of care, and other key elements of interest to health system planners and policy makers. The national, practice-based survey will be pilot tested in 2009.

Patient PHC experiences are an essential aspect of evaluating the system’s effectiveness. Patient surveys can provide important information about patient experiences and satisfaction, for example, ease of access to a PHC provider, length of wait times, and problems with language barriers. Data about patient perspectives are being gathered with the Canadian Community Health Survey and the Canadian Survey of Experiences with Primary Health Care. As well, in 2008, the Health Council of Canada led a survey with CIHI that investigates 27 of CIHI’s PHC indicators. Results from the 2008 survey will be released in the form of two CIHI analytical products in May 2009 and December 2009.

The data that is being gathered from these activities will be disseminated by, for example, developing reports, presentations and information to be delivered at conferences and workshops, collaborative stakeholder meetings, and website postings.

The first PHC product, to be released in the winter of 2008, will be a chartbook entitled “Primary Health Care Indicators Chartbook: An Illustrative Example of Using PHC Data for Indicator Reporting.” It profiles aspects of PHC in Canada using provincial and territorial, national and international data on 23 PHC indicators in the areas of access to care, receipt of recommended care, and organization and delivery of services. The chartbook will illustrate by example how PHC data can be used to populate a subset of PHC indicators.

The second product will be released in early 2009. It will describe the quality of diabetes care in Canada by drawing on data from the Canadian Community Health Survey diabetes module to highlight information on trends in diabetes incidence, the type of care received in comparison with clinical practice guidelines, and self-care management practices. It examines the impact of socio-economic and demographic factors in diabetes rates, receipt of recommended care and self-care practices.
3. Results

In 2006, less than 10% of the 105 indicators could be calculated at the pan-Canadian level with existing data sources. Since the release of the PHC indicators, four projects have begun, resulting in the creation of a data infrastructure to facilitate the capture of over 50% of the indicators at various levels. Ongoing work will continue to increase the number of indicators that can be calculated and continue to improve availability of data to provinces and territories, PHC providers, researchers and other stakeholders. Furthermore, important relationships have been established with collaborators to develop a reporting system prototype and refine PHC indicators and EMR content standards. The PHC information program has begun to publishing reports to support knowledge transfer and exchange, highlight the PHC data gaps, and emphasize the importance of building an infrastructure to improve the PHC system across Canada. Several organizations and ministries, for example, the Alberta Primary Care Initiative and the Ontario Ministry of Health Performance Framework, are adopting the PHC indicators.

4. Conclusions

The implementation of the PHC indicators project encouraged consultation and collaboration with other organizations that have common goals. CIHI has worked with health system decision-makers to increase the uptake of the indicators and information. It established an information program to fill data gaps to measure and understand PHC in Canada. A variety of data sources, combined with multiple approaches, will provide several perspectives on PHC. This information will be a valuable resource for decision-makers, policy development, researchers, and others. It will be used to further our understanding of key issues such as the most effective models of care, patients’ access to primary health care services, costs and utilization of services, quality of care, receipt of recommended care and associated outcomes.

References

[3] Canadian Institute for Health Information. Enhancing the Primary Health Care Data Collection Infrastructure in Canada[0]. Ottawa; 2006.
Development of Electronic Medical Record Content Standards to Collect Pan-Canadian Primary Health Care Indicator Data

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Canadian Institute for Health Information, Canada

Abstract. In 2006 the Canadian Institute for Health Information (CIHI) released a set of 105 pan-Canadian Primary Health Care (PHC) indicators. This was followed by an assessment of data gaps, which prevented the calculation of the indicators, and the data collection options available to close the gaps. A quality review of Electronic Medical Record (EMR) data indicated a requirement for content standards. In order to assist the provinces as they developed requests for proposal for PHC-based EMRs, the EMR content standards project was born. Considerable effort was made to identify standards for the Electronic Health Record (EHR) including existing national and international EHR content. As well, CIHI attempted to align the content standards with those of other projects such as the Physician Office System Requirements (POSR). The outcome of this project was a set of EMR content standards for 12 pan-Canadian PHC indicators. The standards will be used to develop a prototype of a PHC reporting system that collects and analyzes data to generate clinical quality indicators for regional and longitudinal comparisons. In late 2008, CIHI will release the pan-Canadian PHC Core Reporting Data Set. This project has developed EMR content standards to better understand PHC in Canada.

Keywords. primary health care, quality standards, quality indicators, EMR, core reporting data set

Introduction

Primary health care (PHC) has been described as the foundation of Canada’s health care system and is the most common type of health care experienced by Canadians. Ninety-four percent of Canadians aged 15 and over use “first contact” services each year [1] and Canada’s First Ministers agreed that PHC is one of the priority areas for improvement [2]. However, despite the importance of PHC in the overall management of Canadians’ health and the health care system, PHC lacks comparable, standardized data to support system-level analysis for better understanding and delivery. With the increasing use of electronic medical record (EMR) applications in PHC settings across Canada, the use of common EMR content standards in PHC is necessary in order to have relevant and standardized data to support decision-making related to key elements of care such as access, quality and outcomes.

Primary health care is, for most people, the first point of contact with the health care system, often through a family physician. It is where short-term health issues are...
resolved, where the majority of chronic health conditions are managed, where health promotion and education efforts are undertaken and where patients in need of more specialized services are connected with care. Dieticians, nurses, occupational therapists, physiotherapists, pharmacists, psychologists, social workers and other health care workers also deliver PHC services [3].

The Canadian Institute for Health Information (CIHI) led the development of pan-Canadian indicators to measure primary health care across the country in collaboration with a broad range of stakeholders. In 2006, CIHI released a set of 105 pan-Canadian Primary Health Care (PHC) Indicators in a series of reports [4,5] that were developed with support from national, provincial and territorial representatives, clinicians and researchers. In 2006 and 2007, CIHI assessed the feasibility of data collection and specific options for closing data gaps in order to measure and report on the indicators. Reporting on these indicators requires a variety of data sources including data from electronic medical records, existing CIHI databases, other administrative databases, as well as patient, provider, and organizational surveys.

To close the PHC information gap related to clinical quality of care indicators and in response to provincial and territorial requests, CIHI led the PHC Indicators EMR Content Standards Project and developed the CIHI PHC Indicators EMR Data Set for use in EMR applications and chronic disease registries. This data set includes data elements related to the patient, provider, encounter and outcomes of care and supports consistent, comparable data capture for 12 CIHI PHC clinical quality of care indicators in the areas of prevention, patient safety, quality and outcomes. This product is meant to support the needs of the provinces and territories as they develop requests for proposal in order to short-list EMR vendors or refine requirements with existing vendors. This standardized data set can also be used in existing or new chronic disease registries (collaboratives) to support the capture of standardized data in the areas of diabetes, coronary artery disease, hypertension and depression. The data set would enable jurisdictions to better understand their performance. Additionally, several provinces have implemented quality improvement projects using a subset of the CIHI PHC indicators, which increased the desire to provide content standards so that data would be comparable within and beyond provincial boundaries (e.g., blood pressure values for patients with a hypertension diagnosis and A1C values for diabetes patients).

1. Objective

The two main goals of the PHC Indicators EMR Content Standards Project were:

1. To lead the coordination and development of common content standards that can be used to increase the availability of the clinical and administrative data required for calculating and reporting on a subset of 12 PHC clinical quality of care indicators.

2. To promote the adoption and uptake of the CIHI PHC Indicators EMR Data Set for use in EMRs by a wide range of stakeholders, including provinces and territories, PHC providers, the College of Family Physicians of Canada, Canada Health Infoway, provincial health quality councils and the EMR vendor community.
2. Methods

The PHC Indicators EMR Content Standards Project was comprised of five phases:

- Phase 1: Planning and Information Needs Assessment,
- Phase 2: Requirements Definition and Gap Analysis,
- Phase 3: CIHI PHC Indicators EMR Data Set Refinement,
- Phase 4: CIHI PHC Indicators EMR Content Standards Dissemination, and
- Phase 5: Uptake, Promotion and Pilot Testing.

2.1. Phase 1: Planning and Information Needs Assessment.

This phase involved the development and approval of the project charter, the development and implementation of a communications strategy, and plan an environmental scan. During this phase extensive consultation occurred with diverse stakeholders including: provinces and territories, the College of Family Physicians of Canada, PHC providers, provincial and territorial Chief Information Officers (CIOs), Canada Health Infoway, the Western Health Information Collaborative and chronic disease management collaboratives. The Content Standards Working Group (CSWG), which was an external expert working group, was established to provide strategic direction and assist in the CIHI PHC Indicators EMR Data Set validation and alignment. The preliminary list of data elements was developed and mapped to their respective 12 CIHI PHC indicators to ensure alignment. This preliminary list was shared with provincial and territorial CIOs in January 2008.

2.2. Phase 2: Requirements Definition and Gap Analysis

This phase resulted in the development and validation of a business requirements document, evidence-based review and gap analysis using information from the environmental scan and meetings with key informants. Phase 2 also saw the implementation of the communication plan, continued consultation with provinces and territories, PHC providers, Canada Health Infoway Standards Collaboratives and an EMR vendor forum. The CSWG convened three times during the first half of 2008 to provide input and validate updates. An evidence-based review was conducted to ensure the changes in clinical practice guidelines were reflected in the indicators and respective CIHI PHC Indicators EMR Data Set validation and alignment. The information from the consultation, gap analysis and evidence-based review resulted in additional consultation with jurisdictions and standards experts and further validation of the CIHI PHC Indicators EMR Data Set.

2.3. Phase 3: CIHI PHC Indicators EMR Data Set Refinement

Based on the feedback received from the CSWG and additional environmental scanning, this phase addressed revisions of the data set and the associated indicator mapping document. The external CSWG, Canada Health Infoway Standards Collaboratives and others (e.g., physician consultant to CIHI) reviewed the CIHI PHC Indicators EMR Data Set and Indicator Mapping and provided feedback. Additional
input to ensure alignment with pan-Canadian and international standards, e.g., EHR and the interoperable electronic health record (iEHR) standards as well as ISO standards, was completed and validated as data element definitions were finalized.

2.4. Phase 4: CIHI PHC Indicators EMR Content Standards Dissemination

The dissemination phase focused on the targeted release of the CIHI PHC Indicators EMR Content Standards to key stakeholders that included Federal and provincial representatives, health regions, PHC providers and associations, Canada Health Infoway Standards Collaboratives, chronic disease collaboratives, EMR vendors, researchers and community health centres. Ongoing collaboration with the provinces and territories occurred through key business and information technology contacts.

2.5. Uptake, Promotion and Pilot Testing

This phase will focus on maximizing the uptake and implementation of the standards into PHC-based EMRs and existing or new chronic disease collaboratives across Canada. It will also include pilot testing of the standards to formulate subsequent versions. Both of these activities will involve a broad range of stakeholder consultation.

3. Results

In 2008, CIHI released the first iteration of the continuum of PHC Indicators EMR Data Set as part of the PHC EMR Indicator Content Standards Project to a wide range of pan-Canadian stakeholders. This product has been developed in consultation with experts from across Canada, including PHC providers, Federal, provincial and territorial representatives, PHC researchers and standards experts. Where possible, the elements are aligned to pan-Canadian and international standards. This standardized data set will allow consistent data capture that will improve understanding and ability to report on PHC utilization and access, chronic disease prevention and management, health promotion, medication usage, patient safety, quality of care practices and outcomes. Table 1 lists the 12 CIHI clinical quality of care indicators that can be calculated using the CIHI PHC Indicator EMR Data Set, which are included in the shortlist of high-priority indicators recommended for use as a starting point for data collection and reporting.

The CIHI PHC Indicators EMR Data Set can be used by PHC providers to:
- Support chronic disease prevention and management;
- Identify select patient populations within a practice and determine the proportion receiving treatment according to select clinical practice guidelines and resulting outcomes of care;
- Inform care management and patient self-management program planning;
- Support population health analysis at the provider-level; and
- Monitor PHC performance in the areas of prevention, patient safety, quality and outcomes and promote an understanding of socio-demographic variations and unique population needs to support program planning.
Table 1. CIHI PHC Indicators available with the CIHI PHC Indicator EMR Data Set.

<table>
<thead>
<tr>
<th>Primary and Secondary Prevention</th>
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<tbody>
<tr>
<td>• Health risk screening</td>
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<td>• Cervical cancer screening</td>
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<td>• Influenza immunization, 65+</td>
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<td>• Pneumococcal immunization, 65+</td>
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<tr>
<th>Patient Safety</th>
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<tr>
<td>• Antidepressant monitoring</td>
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<tr>
<th>Outcomes</th>
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<tr>
<td>• Glycemic control for diabetes</td>
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<tr>
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<tr>
<td>• Treatment of dyslipidemia</td>
</tr>
<tr>
<td>• Treatment of depression</td>
</tr>
</tbody>
</table>

The CIHI PHC Indicators EMR Data Set can be used by provinces, territories and others to:

- Strengthen the requirements for PHC-based EMRs; and
- Increase the collection of standardized information about chronic disease prevention and management from PHC settings and existing collaboratives in the areas of diabetes, coronary artery diseases, hypertension and depression.

Table 2, provides a list of the PHC data elements, established in consultation with PHC field experts across Canada, required for reporting on the 12 clinical quality of care indicators.

4. Conclusion

The use of the CIHI PHC Indicators EMR Data Set at various levels (locally, regionally, nationally) will improve the relevance and comparability of PHC data captured at the point of care using EMRs and will:

- Enable monitoring and evaluation of PHC to understand and improve overall performance within provider practices and nationally;
- Provide structured data capture so that a provider can more easily create disease registries within their practice and assess whether or not their patient populations are receiving the recommended care;
- Permit development of provider feedback reports in order to improve the quality and continuity of patient care, particularly for patients with chronic diseases;
- Support reporting of the current status of PHC in Canada and identify areas for improvement;
- Increase the quality and availability of PHC data for research and clinical practice guidelines; and
- Provide data to support ongoing health planning and policy development.
Throughout this project CIHI collaborated with standards experts, initiatives and stakeholders from across Canada, which in some cases resulted in better alignment of the visions for EMRs and increased interest in a common approach to data collection and reporting.

Early in 2009, CIHI will work with interested PHC providers and jurisdictions across Canada to pilot test the CIHI PHC Indicator EMR Data Set. Pilot testing will suggest enhancements and revisions for future versions of these standards. Pilot testing will also work with the jurisdictions and other key stakeholders to support the uptake and adoption of these standards into PHC-based EMRs and chronic disease collaboratives across Canada.

### Table 2. Required data elements for reporting on the 12 PHC Clinical Quality of Care Indicators.

<table>
<thead>
<tr>
<th>Service Recipient Demographics</th>
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<tbody>
<tr>
<td>• Service Recipient Date of Birth</td>
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<td>• Service Recipient Gender</td>
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<td>• Service Recipient Identifier Number</td>
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<td>• Service Recipient Identifier Issuer</td>
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<td>• Service Recipient Province/Territory of Residence</td>
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<td>• Service Recipient Postal Code of Residence</td>
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<tr>
<td>Health History and Encounter Information</td>
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<td>• Encounter Date</td>
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<td>• Date of Initial Encounter with PHC Provider</td>
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<tr>
<td>• Current Encounter Service Recipient</td>
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<td>• Diastolic and Systolic Blood Pressure Value</td>
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<td>• Height Value</td>
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<td>• Hip and Waist Circumference Value</td>
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<td>• Medication(s) Non-adherence Indicator</td>
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<td>• Observation History</td>
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<td>• Allergy Type</td>
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<td>• Health Issue(s) and Diagnosed Date</td>
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<tr>
<td>• Lab Test Code(s), Performed Date and Value</td>
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<tr>
<td>• Medication(s) Prescribed, Dose, Frequency, and Strength</td>
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<tr>
<td>• Diastolic and Systolic Blood Pressure Value, and Date</td>
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<td>• Intervention(s), and Date</td>
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<td>• End of Life Indicator</td>
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<td>• End of Life Date</td>
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<tr>
<td>• Anti-depressant Treatment Follow-up and Indicator</td>
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<td>• Current Encounter</td>
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<td>• Health Issue(s)</td>
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<td>• Intervention(s)</td>
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<td>• End of Life Indicator</td>
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<td>• End of Life Date</td>
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<tr>
<td>• Lab Test Date Ordered, Code(s), Value and Performed Date</td>
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<tr>
<td>• Medication(s) Prescribed, Dose and Frequency</td>
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<tr>
<td>• Diagnostic Imaging Code, and Result</td>
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<tr>
<td>• Referred to Encounter Occurred Indicator</td>
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| Prevention |
| • Current Encounter |
| • Influenza Vaccine Indicator |
| • Pneumococcal Vaccine Indicator |
| • Interventions ‘Life-Style’ Advice Indicator |
| • Papanicolaou Test (PAP) Screening Indicator |
| • Observation History (Past Medical History) |
| • Influenza Immunization Date |
| • Influenza Immunization Indicator |
| • Pneumococcal Immunization Date |
| • Pneumococcal Immunization Indicator |
| • Current Encounter Service Recipient (Screening Indicators) |
| • Depression |
| • Eating Habits |
| • Physical Activity |
| • Smoker |
| • Unintentional Falls |
| • Unmanaged Psychosocial Stress |
| • Unsafe Drinking |
| • Unsafe Drug Use |
| • Unsafe Sexual Practice |

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<th>Provider and Service Delivery Information</th>
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<td>• Referred to Provider: Identifier Number, Expertise and Role type</td>
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<td>• Diagnostic Imaging</td>
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References


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Section 7

Nursing Informatics
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Health Information Systems Design to Support a Nursing Model of Care: Opportunities and Challenges

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Abstract. The design and implementation of health information systems (HISs) in team-based settings is complex owing to the multiple users with different perspectives who interact with the system. We argue that such perspectives must be understood prior to designing and implementing HISs. One specific type of team-based model is a nursing care model. In such a model, care is provided through an interdisciplinary team that is lead by the nursing staff. We analyze a nursing-based model of care according to the context of the organization, clinical unit, and individual as defined by the Contextual Implementation Model [1]. We then discuss how the nursing model will be affected by automation using different HISs.

Keywords. health information system, contextual implementation model, nursing care model, interdisciplinary team

Introduction

Despite a number of different systems design approaches, many healthcare information system (HIS) projects end up being problematic after implementation. It has been reported that up to 30 to 50% of implemented HIS fail [2] and in fact we may not know the true rate of HIS failure due to the disincentives to publish failures [3]. Reasons given for HIS projects being unsuccessful include developing systems based on assumptions, problematic models of care, and poorly articulated user needs [4].

As patient care moves from individual provider to collaborative team based care, there is a need to understand how to design HIS to support team based delivery. Lenz and Reichert [5] make a distinction between organization processes and medical treatment processes. An example of an organizational process is order entry while the
medical treatment processes are the diagnostic and therapeutic processes carried out in patient care. Therefore organizational processes are the summation of a number of clinical processes. Further, Shortliffe [6] points out that in order to understand the complexity associated with automating medical records, we must understand the processes associated with the creation and use of such records. Thus part of HIS design must understand how the automation of organizational processes will impact the underlying medical treatment processes. As more patient care is delivered through team based approaches, there is a need for research that looks at HIS usage in the context of multiple users, such as collaborative care delivery. Reddy et al [7] point out that clinical information systems such as an electronic medical record or computerized physician order entry (CPOE) can sometimes mediate more collaborative activities than intended. However, we argue that spontaneous collaborative mediation of patient care activities is not always a good thing depending on the circumstance. Rather we need to proactively understand the impact a HIS will make during the system design phase so that needs can be mapped to the system and undesirable consequences can be prevented.

This paper addresses the need for increased understanding of team based activities and how they will be impacted by HIS implementation. One example of a team based model is a nursing care model. This paper uses the Context Implementation Model [1] to describe the organizational, clinical and individual contexts of a nursing care model and how that model will be impacted through automation using various HIS.

1. Study Design

1.1. Methods

This research was done using an interpretative perspective. Field observations were collected by non-participant observation by a trained qualitative researcher. Structured interviews were also collected from study participants by the same researcher. The data were coded using a grounded theory (GT) approach. The hallmark of GT is three coding cycles: open, axial and selective coding [8].

1.2. Data Sources

The nursing model we studied is implemented at a nine bed inpatient hospice that offers an alternative place of care for terminally ill patients who do not require admission to a palliative care unit or the acute care hospital, but are unable to remain in their homes for a variety of reasons. In collaboration with the patient’s family physician, care is provided by the hospice’s inter-professional team of nurses, patient care assistants, social worker and volunteers with 24/7 access to expert palliative care consultants if needed.

The data sources consisted of 90 hours of non-participant observations and 30 interviews with nurses, physicians, residents, volunteers, and personal support workers. The observations were conducted at different times in the day in order to observe different processes such as morning interdisciplinary rounds, shift change, patient admission and training of residents and new staff. As the data were collected it was coded using constant comparison where new were coded and compared to existing data to allow concepts and categories to evolve through the data.
2. Results

We used the Contextual Implementation Model (CIM) [1] as a way of structuring the concepts and categories we obtained through GT. The CIM model was chosen because it considers systems change from both a technical (hard) and organizational/cultural (soft) system perspective. CIM proposes that the use of clinical information systems will be influenced by three contexts: organizational, clinical unit and individual. Organizational context refers to dimensions such as organizational culture & structure; clinical unit context refers to team culture and clinical profile of the unit, and individual context refers to dimensions such as individual ways of thinking, communicating and collaborating.

We present our results in two sections. First we describe care delivery through the nursing care model, including challenges within the model, structured according to the three CIM contexts described above. Second we describe how automation of some of the work processes in the nursing model through different HIS will impact care delivery, again using the three CIM contexts to discuss the changes.

2.1. Nursing Care Model

2.1.1. Organizational Context

Although the hospice is the primary organization, the patients also have a family physician and in some cases that physician may have a long term relationship with the patient. Part of the hospice’s mandate is to maintain those patient-physician relationships. Therefore the organizational context is very complex as it involves multiple settings that are tied together by the patient. If we consider an HIS in the organizational context we really need to consider multiple contexts. Each organization will have its own cultures, mandates and goals and if they are not communicated effectively then clashes will occur.

An issue that arises from the presence of multiple organizational mandates is the sharing of information across the organizations as conflicts can occur if there is not common ground related to a care decision. The hospice receives patients from different locations in the community and part of the organizational mandate of the hospice is that patients are not admitted if they are undergoing life sustaining therapies. An incident occurred where a patient was denied admission to the hospice because he was undergoing a number of acute interventions. The patient’s physician was quite angered that admission was denied. After further investigation it was determined the reason the patient was undergoing the acute interventions was to keep him alive for at least a week to attend his daughter’s wedding. That contextual information was not shared at the time of the admission request, which a hospice coordinator described as “you don’t know what you don’t know.” Another example occurred where a patient was admitted from the community who had a very complex history and had care needs that went beyond what the hospice could provide. However, because that data were not available at time of admission the patient was admitted to the hospice and it resulted in a less than ideal situation for the patient. A physician stated that if the data on the complexity of the patient’s case were available at admission than the patient’s situation could have been dealt with better.
2.1.2. Clinical Unit Context

The clinical unit context is perhaps the most important context in team based care as that is where the patient care processes take place. However the processes are complex owing to the multiple care providers that are involved in the care delivery process. Communication, workflow, and charting were three key themes that emerged from the clinical unit context.

2.1.2.1. Clinical Unit - Communication

Nurses are the primary front line staff and thus they are involved in almost all the communication activities. Communication in a team based care model such as a nursing model is complex. We classified communication tasks as either pushing or pulling of information. Pushing communication is when the nurse is pushing information to other parties such as in response to an inquiry made by a family member or physician. Pulling information is when the nurse requires information that he/she pulls from someone else. An example of pulling is confirmation of task completion, such as phoning a pharmacy to confirm that a prescription has been received. Despite the different types of communication tasks we observed that nurses were constantly under a heavy communication load. Further, interruptive communication devices such as telephones or pagers were commonly used and thus the nursing staff was frequently interrupted by pages or phone calls.

Different communication structures were also identified on the clinical unit. In particular there was a difference between internal communication, such as for day-to-day patient care on the unit, and external communication, such as communicating with a patient’s family physician. The external communication was observed to be particularly challenging because it often took place in an asynchronous manner that involved physicians being paged, or reading notes left by the staff on the hospice unit. Oral communication is a very common internal communication media, particularly among nursing staff. While oral communication is an effective media of information exchange for the internal staff it is problematic for the external clinicians providing care to the patient as contextual details about a patient may be discussed orally but not recorded in the chart. Patient data have to be recorded in the chart for legal reasons but the data are often at a higher level than what is discussed on the unit. One physician described the written data as too linear and lacking richness of detail. The same physician also described how making the data electronic will not necessarily solve the problem but rather it is the attitude around the charting that needs to change. Data need to be charted so that they can facilitate asynchronous communication. Essentially data need to be rich enough to tell the whole story when the author of the story is not around.

2.1.2.2. Clinical Unit - Workflow

The workload on a clinical unit can vary greatly depending on the patients on the unit. That variation can be particularly significant on a palliative care unit because as patients get closer to death there is greater workload and stress on the staff. Workload considerations are important when determining strategies for patient care such as medications. Some medications require more frequent administration and that can be challenging depending on the status of the patients on the unit. An incident was observed where a physician wanted to order a medication for their patient that required frequent administration during a day when the hospice had three patients who were going to die within the next couple of days. The nursing staff attempted to negotiate a
different medication that would achieve the same effect but require fewer doses, in order to make their workload more manageable.

Workflow also has an impact on the communication processes that take place on the hospice unit. The most important team meeting that takes place at the hospice is the interdisciplinary rounds that take place each morning. The staff on the unit described it as a valuable experience for collaborating about a patient case. Many of the physicians described in interviews how they sometimes feel excluded from the patient care process because they are not formally invited to the interdisciplinary rounds. However the physicians also described attendance at team meetings as challenging because most of them have offices or other clinics to attend to and thus it is not practical from a workload perspective to go to the hospice for a ten minute discussion of a patient case.

2.1.2.3. Clinical Unit - Charting

It is common in team based environments to have charting done by multiple care providers, owing to the complexity of patient care, and different contributions made by the multiple providers who provide patient care. As part of the nursing care model at the hospice nurses, personal support workers, physicians and volunteers all record patient data. The perspectives of the different care providers are a key part of understanding the overall picture of the patient. However a challenge that arises from that overall picture is that patient data may be in multiple documents and all the data have to be pieced together to obtain the entire picture of the patient. For example volunteers are part of the patient care team and have their own book for recording interdisciplinary notes. Volunteers spend a lot of time with the patients and are a good source of psychosocial data about a patient. The challenge of reconciling multiple data source sources is particularly significant for external physicians as they are not on the unit as frequently and thus it is difficult for them to know what individual pieces of data are needed to obtain the entire picture of their patient. In interviews physicians described how they want to be able to come into the hospice and get an overall understanding of how their patient is doing without having to read through the entire chart or track down the many people who did the charting.

Another issue related to charting is what we refer to as moments of “translation” or “deferral.” Moments of translation are where nurses would edit a document such as a prescription that was written by a physician and were quite common as most of the physicians were used to writing prescriptions in hospital based settings whereas the hospice obtains their prescriptions from a community pharmacy. The community pharmacy requires very detailed drug information including the concentration, dose, and route. In hospital pharmacies the drug name was often all that was needed as the pharmacy would dispense the drug according to protocol. Moments of deferral are were a physician would write two prescriptions and give the nurse leeway on how the medication should be administered. In deferring, the physician recognizes the nurse is the most knowledgeable about the patient’s situation and gives the nurse flexibility for administering the medication.

2.1.3. Individual Context

One of the key challenges in a team based model is that the macro level team is contextualized by a number of micro level individual care providers. It is essential that the different individual perspectives be understood and ideally reconciled as part of the bringing people together under a team based model. Practically speaking, the individual level is what builds the team model from the bottom up. Many of the difficulties
described above in the organizational and clinical unit context stemmed from clashes of different individual contexts. Without understanding the individual perspectives and the history and reasons for those perspectives, it is difficult to understand how to reconcile individual perspectives into a care delivery model that supports teams. For example the nursing model emphasizes a holistic approach to care as opposed to a systematic fix-it approach that is more common in the medical model. During observations of an interdisciplinary team meeting a medical resident was continually asking medically oriented questions while the nursing team was looking at the patient case in a more holistic framework as per the nursing model. It would be easy to criticize the resident for not thinking within the nursing model but those different thought processes originate at the individual level owing to different training and clinical backgrounds. The resident is drawing upon what was learned in medical school which teaches a traditional medical model.

3. Health Information System Design to Support the Nursing Care Model

As described earlier the hospice is currently paper based but would like to automate some of their care delivery by implementing different types of HIS. We now look at how those contexts would be impacted by automation through different types of HIS.

3.1. Electronic Health Record (EHR)

One of the challenges identified was the need for data sharing of patients data to family physicians located outside of the hospice. An EHR would enhance data sharing by allowing family physicians access to data from their own office. That would make it easier for family physicians to monitor their patients, for example symptoms assessment or medications. However an EHR is a snapshot of a patient’s data that typically includes diagnostic, test results, medications and demographic data. Much of the detailed data required for care delivery such as palliative care is not contained in a typical EHR. For example, the patient described in Section 2.1.1 who was denied admission to the hospice because of acute interventions would not have been prevented by an EHR because reason or justification for therapies is not a standard field in EHRs. Another issue with an EHR in collaborative settings is that it would need to be accessible by multiple providers and locations. Thus an EHR that is only accessible through a hospital IS would not be practical. Rather it needs to be accessible through secured Internet access that is available across different settings.

Further, during some of the interviews it was suggested that having data in an electronic form is not as important as the attitude and way clinicians use the data. In complex care such as palliative care it is necessary to record specific data elements as well as the rationale behind the data elements. For example, physicians come to the hospice to see their patients at various times during the day. The nurse or other staff who had done the patient’s charting may not be around and thus the physician is left with the patient’s data without the context behind the data. If a medication or treatment was changed from what the physician intended the data may not provide an explanation for why it was changed. Those are the types of contextual data that are needed to facilitate asynchronous communication and understanding about a patient case.
3.2. Electronic Order Entry

Electronic order entry would enhance communication practices as much of the nurse’s time is spent pulling information about orders. For example medication order entry would be facilitated by having an online order entry system that is accessible by pharmacists. That would reduce the communication overload on nurses by eliminating the faxing and follow up confirmation about prescriptions. The hospice currently only deals with one pharmacy so it would not be very difficult to set up a secure pharmacy order entry system. A nurse would enter a prescription and then be able to track its status such as whether it was received, processed or shipped.

However an order entry system would require cooperation from the physicians as two of the clinical unit contexts we described were moments of “translation” and “deferral.” If a physician directly enters an order into a system those moments of translation or deferral would be lost and it would likely result in the pharmacy having to make a phone call to either the hospice or the physician to clarify the order. In that case the gains in efficiency from automated order entry would be negated because of the need to clarify the order. Further, a physician may not be physically on the care unit when they process an electronic order. Thus they would not have an understanding of the current workload of the unit and they would not be able to take workload into consideration when they place their order.

3.3. Other Informatics Tools

Electronic care plans would be useful for facilitating team based care because it would provide a means of agreeing upon a strategy for patient care and mapping out that strategy for all the different providers. The care plans could have alerts to inform the family physicians of changes in patients’ status to help the physicians monitor their patients. Video or web conferencing would improve the linkages between the internal and external communication structures as it would enable external physicians to virtually attend interdisciplinary meetings. Many of the details about a patient’s case are discussed in the daily rounds meetings described in the clinical unit context. However because a physicians’ time is limited they would need to have specific time periods set for when they would need to participate in the team meeting.

4. Discussion

Informatics based applications can improve aspects of nursing centered care delivery. However there is a need for evaluation about how such applications will impact care delivery. We will discuss educational, systems design and research implications of this study.

Educational implications include the need for greater cross-discipline teaching. As more care is provided in collaborative settings, we need to educate clinicians about collaborative care delivery and cross-discipline communication. Some of the individual contexts within team based care such as physicians or residents focusing on medical questions that stray from the holistic perspective of the nursing model are not faults of the individual clinicians but rather reflect deeper system issues. Similarly the use of oral communication is embedded in the nursing culture and that culture will not change
just because of the implementation of a HIS. Rather, we need to improve interdisciplinary education to create a culture of interdisciplinary practice.

For systems design implications we have illustrated the value of qualitative interpretative methodologies. To obtain the level of detail needed for HIS design to support complex care delivery we must understand the specific intricacies of how care is delivered. Talking to clinicians about what they do in practice and how an HIS could support practice is not enough. HIS designers need to observe and experience care delivery in the front lines. A key finding from this study is that we should not assume that the because patient data are made electronic that it will solve all communication problems. Electronic data will solve information problems such as organizing data in one place or providing better access to the data, but it will not necessarily improve communication practices. If a paper chart lacks the contextual richness about why a decision was made then making that data electronic will not make the data any more meaningful. As we described in Section 3.1 it is the attitude and usage of the data that needs to change rather than how we design the HIS that provides the data.

This study also extended the use of the CIM by illustrating its value in understanding the organizational, clinical and individual contexts prior to designing and implementing HIS. In complex organizational settings where HIS are used, such as the nursing based model presented in this paper, it is crucial to understand the contexts prior to designing the HIS. Models such as the CIM provide a structure for understanding different clinical needs and the complex systems where HIS are used. For example, the nature of care provided in this study requires very specific data with respect to the patient’s situation such as the context of why they might be receiving a certain medication. That data are too specific for what is contained in most EHR systems. Thus EHR systems may need to be custom-designed to support very specific types of care delivery. As more healthcare delivery is provided through complex models such as nursing models and other interdisciplinary approaches, there will be an increased need to understand the contextual factors associated with those models and how they will impact the uptake and usage of HIS. Berg states we need to evaluate HIS to prevent failure [9] and thus we need to understand different contexts of HIS use prior to developing and implementing HIS in those contexts. The approach presented in this paper provides a means of understanding different contexts of HIS usage in a complex team setting.

References


Understanding the Impact on Intensive Care Staff Workflow Due to the Introduction of a Critical Care Information System: A Mixed Methods Research Methodology

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Abstract. The Intensive Care Unit (ICU) is a complex and dynamic tertiary care environment that requires health care providers to balance many competing tasks and responsibilities. Inefficient and interruption-driven workflow is believed to increase the likelihood of medical errors and, therefore, present a serious risk to patients in the ICU. The introduction of a Critical Care Information System (CCIS), is purported to result in fewer medical errors and better patient care by streamlining workflow. Little objective research, however, has investigated these assertions. This paper reports on the design of a research methodology to explore the impact of a CCIS on the workflow of Respiratory Therapists, Pediatric Intensivists, Nurses, and Unit Clerks in a Pediatric ICU (PICU) and a General Systems ICU (GSICU) in Northern Canada.

Keywords. research methodology, mixed methods, workflow, EMR, critical care information system, workflow interruptions, ICU

1. Introduction

The Canadian health care system is expected to consume 42% of total provincial and territorial government revenues by 2020[1]. Additionally, our population is aging and its health needs are becoming more complex. By 2020, 32% of our population will be over 55, as opposed to 22% in 2001[1]. Consequently, policy-makers are desperate to find solutions to the increasing burden on an already financially burdened system. Furthermore, despite outstanding clinical and basic science research conducted in Canada, a major weakness of the system is its inability to effectively, efficiently and
rapidly translate that research knowledge into improved quality of care, better patient outcomes and reduced costs. It is thought that these benefits might be realized through use of Electronic Medical Record (EMR) systems. Unfortunately, very little is known about whether or not the introduction and use of this technology actually results in improved quality of care, better patient outcomes and reduced costs.

2. Rationale and Hypothesis

It is believed that the use of a specialised EMR, such as a Critical Care Information System (CCIS), will increase the time available for direct patient care and, consequently, will improve outcomes. Scientifically investigating the impact of a new technology on patient outcomes, however, is complex and difficult to undertake. A mixed-method, multi-staged, longitudinal study design is needed. Such a study can be adapted in response to changes in culture and environment over time while remaining scientifically rigorous.

We have developed a research design based on the agile research paradigm[2], the CHEATS evaluation approach[3], and the ward-based workflow assessment tools [4] developed by us previously. We are undertaking this study to test the following null hypothesis: The introduction of an EMR (in this specific case, the CCIS) in intensive care will not result in any changes in direct patient care, patient outcomes or staff retention.

3. Context

In order to test the hypothesis, it is necessary to know staff activities before and after the introduction and use of a new system. As instant access to patient records is believed to be key to improving patient care, we must first measure the amount of time spent retrieving records as opposed to providing direct patient care. Unfortunately, the available evidence regarding health care providers’ work has concentrated on the hours they work as opposed to what they actually do [4]. Also, available evidence on workflow revealed that intensive care workflow is considered by those providing intensive care to be very different from workflow in more general ward settings. Discussions with intensive care physicians and nurses led to the suggestion that, while interruptions to workflow are usually considered an increased safety risk in general ward settings[5], they are considered to be part of the “way they work” in an intensive care setting. As a result, we decided to study interruptions as well as workflow.

4. Methodology

The study is being undertaken at one intensive care unit (ICU) and one Paediatric ICU (PICU) in Northern Canada. It utilizes a mixed method (qualitative and quantitative), pre- and post-intervention quasi-experimental research design. Two approaches are being conducted in parallel in order to test the null hypothesis. The first is both qualitative and quantitative (quantitative data will be gathered by means of
observation). The second approach is purely quantitative; we will analyze patient outcomes and staff retention rates throughout the course of the study.

4.1. Approach One

Preliminary Focus Group: Starting from the foundation of Brixey’s work in the US that categorized interruptions in Emergency Departments[5-10], and that of Westbrook in Australia investigating workflow and interruptions on surgical, respiratory and geriatric hospital units[4,11,12], we developed a comprehensive scheme of categories for workflow and interruptions. A 90 minute focus group was then run with 10 key ICU and PICU staff members. Drawing on the expert advice of our clinical collaborator, focus group participants were selectively and purposefully sampled using a combination of expert and snowball sampling methods designed to ensure the capture of “information-rich cases” from each professional group being studied (Physician, Nurse, Respiratory Therapist, and Ward Clerk). During the focus group, participants were asked to discuss the definition and significance of workflow categories and interruptions in their practice. Focus group content was transcribed and the data analyzed by two members of our research team using framework analysis. Based on the results of this analysis, we then modified the categories identified by Brixey[6] and Westbrook[11] for use in our observation/time and motion study.

Observation/time and Motion Study: A pilot period of observation was undertaken in June and July, 2008, to validate software (adapted from Westbrook[4,11,12]) for the Personal Digital Assistants (PDAs), which were to record the frequencies and types of workflow activities and interruptions at the PICU site. Each ICU professional (physician/clinical fellow, nurse, respiratory therapist, or ward clerk) was observed for multiple periods covering weekdays, weekends, daytime and night-time as well as shift-changes. This schedule was strategically designed to test and validate the fundamental concepts and tools necessary for investigating the conceptualization, experience and management of interruptions in intensive care. We are currently analyzing the data gathered during this pilot phase and ensuring that we have established inter-rater reliability between the researchers collecting the data. Once this is complete PDAs will be used to collect quantitative observational data at baseline (at least three months prior to “go-live” for the CCIS) and at three time points post “go-live” ( “go-live” plus 3 months, 12 months and 24 months). During each observation period each role will need to be observed 20 times to include each combination of time of day and time of week. As a result there will be a total of 120 hours of observation for each phase and for each site (GSICU and PICU). To accommodate this, we have planned for the observations to be undertaken within a four to six week period. This observation schedule has been strategically designed to capture mid-shift and shift-change activities during both daytime and night-time shifts, and to cover four different professional perspectives in the ICU.

Knowledge Translation and Outreach: After each period of observation, we will conduct a “lessons learned” session. These sessions will be attended by the local research team; and our international collaborators during their planned visits to Edmonton. Additionally, members of the Benefits Realization and Evaluation Team, the CCIS Project Management team and all the clinical stakeholders from both the general systems adult ICU and the paediatric ICU will be invited to participate. These sessions will be interactive and are intended to: 1) provide quick feedback to all our stakeholders, without waiting for the release of formal publications, and 2) provide an
opportunity for the wider stakeholder group to give input and direction for the next stage of the study.

*Adaptation:* We refine the research strategy for Approach One. This study requires an iterative approach for a number of reasons. First, our study will investigate and document a phenomenon that has rarely been studied. Second, we will do so using the most complex and comprehensive research design applied to the study of workflow and interruptions to date. Third, our investigation will track changes in the actual experience of interruptions throughout the entire change management process: before, during, and after the implementation of a new information technology.

4.2. Approach Two

*Staff Recruitment and Retention:* Intensive care units are desperately short of trained staff and are also experiencing extremely high staff turnover [13,14]. It is believed that the introduction and use of EMRs (CCIS) in the intensive care environment will help to address this issue by raising staff satisfaction [15] and leveraging personnel [13]. Therefore, we will be monitoring staff recruitment and retention during the lifespan of the study.

*Patient Outcomes:* We will track patient length of stay and mortality over the lifetime of the study. While it will be difficult to demonstrate causality between the implementation of the CCIS and any changes to these outcome statistics, any significant changes need to be explored further. The implementation of information technology in health care settings can have unintended consequences, which include changes in workflow, communication patterns and practices [16].

5. Limitations

There are two major limitations to this study. While we can investigate whether workflow, interruptions, patient outcomes and staff retention change subsequent to the CCIS implementation, we cannot definitively state that any changes observed are fully caused by the implementation and use of the CCIS alone. If, however, the changes observed are negative, that is, patient outcomes deteriorate, we are obliged to determine whether or not this is directly caused by the CCIS and to immediately make the necessary changes to the implementation plan for the rest of the region.

Secondly, the generalizability of the study is difficult to determine. We believe that we have done everything we can to ensure that our methods are valid, scientifically rigorous and reproducible. Given, however, that every implementation of an EMR is different due to software customization, generalizability is a property that is difficult to ensure. We continue to work to address these limitations as we undertake this research for the first time.

6. Outcomes

Few issues are more important to health care system managers and policy-makers than patient safety and quality of care. Managers and policy-makers, moreover, must strive to act in a fiscally responsible manner. They face the unique and formidable challenge
of providing safe, high quality services while drawing on a limited - and in the case of intensive care - very specialized pool of human and financial resources. In Canada, this challenge is compounded by its well-documented shortage of health care workers and its aging population. Understanding workflow and interruptions, therefore, will be extremely beneficial to long-term managerial and policy decision-making in the ICU.

Medical errors – which may be directly caused by interruptions - are extremely costly and can result in patient death, disability, and prolonged hospital stays [17]. Interruptions, which have been associated with increased fatigue and decreased job satisfaction in the ICU [18], may also contribute to staff turnover. The relationships among these phenomena and to patient care outcomes in the ICU have not yet been analyzed.

Studying interruptions implies documenting and analyzing clinical workflow in the ICU. While understanding workflow is essential for the efficient allocation of resources, there is mounting evidence to suggest that this is especially true during the implementation of a new information technology [19]. Researchers have increasingly shown that changes in workflow due to new technologies may be more important in terms of financial, care quality, and patient safety outcomes than the type of technology that is implemented, itself [16]. Experts in this field have also determined that attention to clinical processes is “key” to the safe and successful implementation of these technologies[20]. Essentially, what this research has shown is that patient safety and care quality cannot be separated from clinical workflow when new technologies are introduced in healthcare setting. To make truly informed decisions about using information technology in healthcare, policy makers and managers at all levels and in all jurisdictions need to understand clinical workflow.

7. Conclusion

In conclusion, the research methodology proposed here is complex, and costly to undertake, but should ultimately produce a foundation for future research in an area which has received little attention to date. That is, what impact does an information system actually have on patient outcomes?

References


Implementing an Interdisciplinary Electronic Documentation System at Two Pilot Units within an Acute Care Setting

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Abstract. An electronic interdisciplinary clinical documentation system that includes assessments and some clinical interventions was designed and implemented on two pilot units. This paper describes the procedures for designing the screens, implementing the system, and integrating the electronic documentation system with the workflow of nursing staff. The results of this pilot project are outlined and implications for future efforts are examined.

Keywords. electronic documentation, workflow evaluation, patient care information system

1. Introduction

An electronic interdisciplinary clinical documentation system that included assessment and some clinical interventions was implemented on two acute care clinical units within a research teaching hospital. The units were identified through an assessment process. Various members of the interdisciplinary team across three hospitals within the region were engaged in the design process. The system was then implemented on two pilot clinical units using a phased approach, starting with nursing. The implementation process included education, user support during the transition period, and sustainment support to address systems issues. A review of staff workflow pre and post implementation was conducted and practice and system workflow improvements were implemented. The electronic clinical documentation system was refined based on user feedback during the first six months post implementation. Five to six months after the last changes have been made, an evaluation will be conducted of the new system to assess the impact of the system on staff workflow, quality of documentation, and satisfaction with the electronic system and the devices.

This project was initiated as part of the organization’s ongoing effort to migrate to a full Electronic Health Record (EHR). The organization had already invested in an electronic patient care information system (GE Centricity) that provides admission, discharge and transfer transactions, lab, radiology and cardiology order entry and results reporting, and pharmacy order processing. The next step was to begin implementation of modules for clinical documentation. The purpose of the project was to enable care-providers to document their clinical activities electronically rather than on paper forms, to standardize charting practices and procedures within units and across the multiple sites within the health region, and to maximize work process/flow efficiencies that could be achieved using this new technology. For the purpose of this
initiative, clinical documentation included assessments, some interventions, and medication charting. All other documentation remains on paper. The medication charting component has not yet been implemented and a description of that aspect of the project is not included in this paper.

2. Methods

The GE Centricity patient care information system provides flexibility for each organization to tailor screens to match their needs. Therefore, an organization must develop the screens that are to be used by their health care providers. While the system was to be implemented on two pilot units in the same hospital, it would eventually be used by several hospitals within the health region. This was a challenge: the design of the system had to meet the clinical and workflow requirements of the two pilot sites and of multiple other clinical settings. A broad network of users was engaged in the design process. Principles for effective decision-making were established at the beginning of the process. These included:

1. Concern for patient care and service must be foremost in all decisions.
2. The design must enhance inter-professional collaboration and relationships.
3. The design must support safe and effective work practices.
4. The initiative will create documentation standards based on best practices.
5. The system must provide maximum leverage and customization of information for both individual and corporate requirements.
6. The system must be user-friendly.
7. The design must support the “Five Rights of Information Management”:
   - right location (just where you need it),
   - right time (just when you need it),
   - right items (just what you need),
   - right context (just in the situation where it is relevant) and
   - right format (in an easy-to-use approach).

To support the second principle, the planning team determined that the information system must reflect an inter-professional approach. While some units within the region were already using an inter-professional approach for documentation on paper, most units were still using a discipline-specific approach that employed discipline-specialized forms filed in separately tabbed sections of the chart. While this often provided easy access to information within a discipline, members of an interdisciplinary team often did not review the documentation of their colleagues. This made it difficult to identify a single care plan for the patient.

Working groups were formed to design the various assessment and intervention screens. Because multiple documentation approaches were used in the various disciplines, units and hospitals, the working groups were faced with the challenge of standardization. One group elicited feedback for a system design that, while consuming no greater user time investment, permitted basic and complex assessments and easy navigation. The drafts were reviewed by working groups and shared in organization-wide forums and hospital information sessions. Standardized assessments and interventions were then built into the patient care information system. Over a period of fourteen months, 54 assessments/interventions were built, which supported the
elimination of 42 paper documents used by various health care providers, not including physicians.

The system underwent three types of testing to ensure quality and functionality. Functional testing was done by the project team, working group members, and volunteers once the screens were drafted. Testers entered case scenarios as test data. All issues and requirements for changes were logged and the screens retested after changes were made. As well, volunteer staff, who had used an electronic clinical documentation system in another organization, were asked to identify opportunities to improve the workflow of the information system. The final test was conducted by nurses on several units. Four volunteer pilot units (three surgical units and one acute medical unit) were asked to participate in a parallel test. For a given day, two nurses on each unit were asked to complete both paper and electronic documentation about patient care that the nurses had provided. Each nurse was given only half of their usual patient assignment to allow for the additional workload and time needed for the unfamiliar documentation system. Participants received a one day orientation to the new system and project staff were available for additional support on the day of the parallel testing. As a result of feedback from the testers and the staff, assessments were modified or completely revised. Categories and positioning of documentation tabs were also changed.

While consultation on the design of the system was broad, implementation was phased. The unit managers were asked to volunteer their units as pilots. An assessment was then completed by the project team on the volunteers using the following criteria:

- The unit can absorb the process/workflow change and has a willingness to participate in the project.
- The unit has a history of successfully implementing initiatives (particularly those related to clinical documentation).
- The unit has clinical documentation practices that reflect an inter-professional perspective.
- The unit has broad clinical documentation practices that can be generalized to other units.
- The unit has a history of early adoption of informatics technology.

As a result of the assessment, two units were identified. One was an elective reconstructive orthopedic surgical unit and the other was a short-stay surgical unit. The short-stay unit had 10 acute medical beds that supported admissions from an Urgent Care Centre within the hospital. The two units supported elective surgical procedures on patients deemed to have a lower surgical risk. This hospital had been a leader in implementing electronic order entry and, of all the acute settings within the health region, the staff had used the highest level of computerization. The care of several diagnostic or procedural grouping were standardized and outlined in clinical pathways. The teams had worked hard over the years to use an inter-professional, standardized approach to care and the length of stay for certain subsets of patients were the shortest in the region.

The new clinical documentation system was implemented on these two pilot clinical units with mainly nursing staff. While the design of the system was inter-professional in nature, the screens required for detailed allied health assessment were in the process of being built and tested. On the pilot units, care was standardized around the plans outlined on the clinical pathways and care providers usually documented directly on the pathway. However, the clinical pathways were not yet built within the
electronic documentation system as they were part of the next phase of the project. As a result, non-nursing health care providers continued to document on paper for the pilot and only nurses were included in the first phase of implementation. All health care providers were given read-only access to the clinical documentation system.

In preparation for the “go-live” day, health care providers on the pilot units were asked to complete an assessment of their knowledge related to using computers approximately 6 months prior to implementation. Each was asked to rank themself as “competent”, having “moderate” skills, having “basic” skills, or as being a “non-user.” Most staff categorized themselves as competent or moderately skilled users (85%) while the remaining staff indicated they had basic or little knowledge. Those individuals with basic skills were scheduled for a one hour, one-on-one sessions with a project team member. The team member reviewed the basics of computer use and demonstrated linkages to web-based training exercises. Individuals who had basic knowledge of computers were provided with a 20-minute guided tour of the web-based exercises. These web-based exercises were available on the intranet and were mostly links to existing programs provided by non-organizational resources and made available to general audiences. They were self-study modules that could be completed by staff at their convenience. Access to on-site computer labs was possible if computers on the unit or at home computers could not be used.

Three weeks before the go-live date, nurses were assigned to a one-day education session within a computer lab. Student nurses were also invited to attend. Project staff used several educational strategies to conduct these sessions. The sessions consisted of “chalk and talk” lessons, demonstrations, and on-line educational modules within a classroom setting. To ensure that staff did not forget their skills, the sessions were held a short time before the actual go-live date. A few staff required additional educational time to support their learning of the new skills and sessions were provided upon request.

Wireless mobile workstations were provided for nurses to enter information and for allied health and physician staff to access information. Computers mounted on mobile workstations could be moved from the corridor to the bedside. Infection control guidelines were established in consultation with the Infection Control team and were taught to nurses during their education sessions. Nurses were encouraged to engage in point-of-care documentation and to avoid the use of “cheat sheets” as a way to decrease duplicate charting. Mobile workstations were plugged into hallway wall sockets when not in use.

On the go-live date, the documentation of all new admissions and patients who were expected to be in hospital for another 36 hours, was entered in the new system. Patients who would be discharged within 48 hours remained on paper until their time of discharge. Project staff were available 24/7 on the units over a five week period to provide just-in-time user support. The ratio of project staff to nursing staff was 1:3 for the first few days and after, 1:4. Finally, one project staff member was assigned per unit.

The go-live implementation plan included the provision of supernumerary nurses. These nurses were to provide workload support so that unit nurses could be confident that their patients were receiving care while they were taking additional time to enter documentation in the new system. The budget was allocated and a staffing clerk was assigned to schedule the supernumerary staff for at least every shift during the first week. However, even before the go-live date, the unit had difficulty finding staff to replace their short-call leaves (sick time, etc.). There had been frequent shifts in the
past where nurses experienced workload challenges due to staffing at below baseline levels. While the unit was successful in finding supernumerary staff for a few shifts during the first week, this was not the norm. For some shifts, nurses were learning the new system and working shifts where sick calls could not be replaced. As a result, the staff was subjected to much stress.

3. Outcomes

Several issues arose immediately after the go-live date. The electronic clinical documentation system provided nurses with the opportunity to complete point-of-care documentation. This approach should have decreased the frequency of duplicate charting and should have provided information to all members of the health care team in a timely manner. However, nurses reported that their documentation time increased, leaving them less time for patient care. Therefore, they reverted to paper and later entered the data into the computer. This procedure did not minimize duplication and did not provide information in a timelier manner. While some of the additional time was due to the learning curve, it was also due to their previous documentation patterns. One unit documented directly on the clinical pathway mainly using checks and brief notations. Even the simple process of logging into the system and navigating the screens took more time than their existing processes.

The use of the mobile workstations presented other challenges. Nurses found the mobile workstations heavy and cumbersome. Moving the workstations to the bedside was time-consuming; the machine had to be unplugged, moved from the hallway, and then nurse had to log in. Consequently, nurses often left the workstations in the hallway. This decreased the amount of point-of-care documentation. Moreover, remembering to plug a computer into the wall to charge its battery proved to be a challenge during busy shifts. As a result, some nurses left the computers plugged-in, thereby further decreasing the opportunity for point-of-care documentation. Additionally, some staff expressed concerns that the computer depersonalized their care to their patients. They were distressed when they believed that they were spending more time with a computer than their patient.

In general, staff agreed that electronic documentation was the way of the future. They no longer had to search for charts and anyone on the unit could view the patient record from any workstation. There were adequate number of workstations provided and many of staff were excited about the potential of the system, as more components were added, to improve their work. First, however, the current challenges had to be addressed promptly.

The project team engaged a working group of staff members and the unit leadership team to make a review of workflow processes using a “lean” management approach. The group identified several assessments as being particularly labour-intensive. These included medical admissions, intake and output, vital signs, neurovascular assessment, vascular access and tubes/drains. Over several working sessions, the group mapped their existing workflow processes and designed preferred workflow patterns. They reviewed the workflow within the software and identified how the screen designs affected their work patterns. Several screens underwent significant redesign and others received minor adjustments. The group would review various drafts in relation to the workflow patterns, engage their colleagues in the discussions on the drafts, and make final revisions to the screens.
Once a screen was finalized, the group determined an implementation strategy for introducing the new screens. Educational sessions were organized when the changes were significant. A bulletin and pre-shift communication was used for minor adjustments. Regular unit huddles were used to communicate the changes and to identify additional opportunities for improvement. On three occasions, one-to-one sessions with all nurses were scheduled to review the changes and to ensure consistent use. Six months after the go-live date, the major issues identified by the staff had been reviewed by the working group, screens appropriately revised, and the changes implemented. The outcome of these changes will be evaluated early in the new year.

4. Conclusions

An assessment was conducted of the implementation strategy and recommendations for future implementations were developed. Three main areas for future planning were identified. First, it is critical that there be additional nursing staff to provide workload relief during system implementation so that users have time to learn the system. Several months after implementation, new staff and staff absent during the implementation appeared to experience a smoother transition to electronic documentation in their clinical practice. These nurses were given orientation shifts in which they were paired with an experienced nurse who assumed primary patient care responsibility.

For future implementations, it is suggested that nurses be provided with the opportunity to learn in a clinical setting; they should not have primary responsibility for patient care at the same time. Second, the type of devices used should be tested in a live setting before implementation. Although use of the mobile workstations was simulated in advance, problems with them were identified only after the go-live date. If it is not possible to test the devices in a clinical setting, then other equipment options should be examined post-implementation. A period of time should be set aside by the project team to review and resolve device issues with clinician input. Third, it is required that existing workflow processes related to paper documentation be reviewed and new processes be planned. It can not be over-emphasized that it is important to work with staff to anticipate and design the workflow changes needed to integrate the new electronic documentation system with daily clinical practice. Balancing the need to support flexibility in working styles with the standardization of documentation practices is an ongoing area of study. Further assessments of the experience of nurses using the electronic clinical documentation system will be done using surveys and user groups. This ongoing feedback will assist the project team to continue to refine the implementation plan.

In summary, this was an initiative using technology to standardize documentation and to maximize workflow efficiencies. There is a tendency to focus on the design and construction of an electronic clinical documentation system. However, technology is not helpful in maximizing workflow efficiencies if it does not support improved workflow processes for those individuals using the tools. The project team must work with clinical teams to examine existing workflow patterns and to adapt the new technology to gain workflow efficiency.
Practical Considerations for the Implementation of Health Outcome Measures

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Abstract. The collection of health outcomes information is important for effective management of the health care system. The Health Outcomes for Better Information and Care (HOBIC) program is implementing a set of nurse-sensitive health outcome measures across the province of Ontario. This paper examines some of the opportunities and challenges of implementing measures across multiple organizations and multiple sectors of the health care system.

Keywords. health outcomes, outcome measurement, program implementation

Introduction

HOBIC was initiated in 1999 based on recommendations from the nursing task force report “Good Nursing, Good Health: An Investment for the 21st Century” [1]. This program was established to develop, validate and implement a set of nurse-sensitive patient outcome measures across all sectors of the health care system in Ontario. Nurse sensitive outcomes are those which “are relevant, based on nurses’ scope and domain of practice, and for which there is empirical evidence linking nursing inputs and interventions to the outcomes” [2]. Recently, the scope of HOBIC has broadened to include three other health professions: pharmacists, physiotherapists and occupational therapists.

To date only the nursing-specific measures are tested and are being deployed. The twenty-seven measures are grouped into one of four broad categories: activities of daily living (ADLs), readiness for discharge, adequacy of symptom management and patient safety. Four sectors were chosen to be part of the initial implementation and a pilot study was conducted to ensure that these measures were valid and reliable [3]. The sectors chosen for the initial phase of implementation were: acute medical-surgical care (AC), complex continuing care (CCC), long-term care (LTC) and home care.

Participation in HOBIC is not mandatory and organizations which volunteer to participate in HOBIC must meet a small set of minimum requirements. Acute care organizations must have an existing electronic documentation system and the infrastructure to support electronic documentation at the point of care. Long-term care homes and CCC units must already be participating in the Ontario RAI-MDS initiative and a majority of staff must be actively collecting the RAI-MDS measures electronically.
This paper examines some of the challenges of implementing a multi-faceted initiative like HOBIC. Three aspects of the implementation are examined: assessing the organizational capacity to implement, the leveraging of existing standards, and the use of HOBIC measures to support outcome oriented care. Throughout the text a comparison between acute care hospitals and long-term care homes is used to highlight some of the core differences between the various sectors.

1. Assessing Organizational Capacity for Implementation

Conceptually the process of implementing HOBIC is relatively simple: organizations update their documentation system to include the HOBIC measures; staff members are trained on how to properly collect the new measurements; and an interface is built to transmit this data to a centralized database. Coordinators work to identify, enlist and support organizations through this process from start to finish.

The first step of identifying facilities capable of implementing HOBIC has proven to be one of the most frustrating. This is especially true of the acute care sector where most organizations operate independently of one another and have relatively no formal linkage when it comes to clinical documentation. Regional coordinators are required to contact each site individually because publicly available sources of information, such as the OHA e-health adoption survey, do not provide sufficient detail to assess the presence of electronic documentation in the facility. Coordinators must rely on busy hospital IT or nursing administrators to provide them with the information for implementation assessment.

In contrast, the alignment of HOBIC with the RAI-MDS implementation in LTC homes has made identification of potential sites in this sector significantly easier. The RAI-MDS team has been able to identify active sites and has informed representatives that a HOBIC coordinator may be contacting them. Based on this notification, some LTC home administrators took the initiative to contact the HOBIC program directly in order to receive further information. The presence of this communication channel has helped to simplify much of the early information-gathering work.

2. Leveraging Existing Standards

LTC homes also have a distinct advantage when it comes to leveraging the existing IT infrastructure for the HOBIC implementation. This advantage is largely attributable to the widespread adoption of hosted software products rather than the traditional local installations. The use of hosted solutions, which may likely be influenced by lower acquisition costs, has benefited HOBIC. Vendors have worked directly with the HOBIC program to modify their products and to design a single interface for transmitting data to the central repository. Once made, the modifications have remained inactive until a LTC home or CCC unit is approved for participation in HOBIC.

Savings have been realized because only a few software applications have required customization costs. Consequently, HOBIC has been able to fund much needed wireless infrastructure in LTC homes. Implementation of wireless connections allows health providers to document directly at the point of care, thereby reducing duplication and increasing compliance.
In acute care no vendor-hosted clinical documentation products have been identified to date. In addition, changes made to a vendor product were typically not transferable between organizations. The main reason that an implementation is unique to a particular hospital is due to a lack of clinical documentation standards. Furthermore, because no province-wide electronic documentation initiatives currently exist in this sector, adoption of electronic documentation software remains low. For example, in eastern Ontario only 1 out of 16 possible facilities in the Champlain local health integration network (LHIN) was identified as having electronic nursing documentation.

On a more positive note, the presence of multi-site hospitals, such as Quinte Health Care and technology alliances such as the North Eastern Ontario Network (NEON) have allowed some facilities to leverage multiple deployments from a single build. Some LHINs have also used HOBIC as a starting point for standardization of documentation across the region. The Central East LHIN is a successful example of how HOBIC has helped to highlight the need for development of a standardized admission and discharge documentation process[4].

3. Supporting Outcome Oriented Nursing Care

With over 75 implementations complete or underway, some focus is now being placed on analysis and reporting. Nursing leaders believe that collection and reporting of the HOBIC measures will help shift “nursing care from a task orientation to an outcomes focus” [5]. It is believed that the collection and subsequent use of these measures will enable nurses and other care providers to make decisions based on what is assessed rather than what is assumed to work. Care providers will be able to take their own assessment results and compare their findings with other similar facilities and patient populations.

In order to access HOBIC, information organizations can choose to implement reports within their existing clinical application or log into a secure portal provided by the HOBIC program. The five existing portal reports allows each organization to examine its results and perform internal comparisons among units. Benchmarking reports, where information is examined across organizations, are still in the early stages of planning.

Making this information useful for clinicians on a daily basis still remains difficult regardless of the sector. Ideally HOBIC would like to see tighter integration between a provider facing clinical applications and the information available in the HOBIC database. Use of web services or other methods of retrieving information could be considered if vendors were to build this capability into their products. Ultimately our desire is to see clinicians incorporate this information into their care planning and decision-making processes. The ideal way of achieving this objective would be to make access to the information convenient and timely.

4. Summary

Experience from HOBIC has shown that implementation of a large scale multi-faceted project can be successful especially if existing work can be built upon. When earlier work does not exist, planners should take time to consider the wider implications of
rolling out the initiative. Small decisions may have unintended positive or negative consequences for those projects which follow.

Collecting outcomes data is only the first step towards providing better patient care. This information must be used from bedside to boardroom to ensure that patients receive the highest quality care. Timely and convenient access to information is a key to making this a reality.

References


Where is Nursing in the Electronic Health Care Record?

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Abstract. The authors explore the possibilities for documenting professional nursing practice in an electronic health record. Recognizing that there are a variety of approaches to electronic documentation, the intent of this discussion is to generate a general rather than a particular approach to this issue. Nurses themselves must determine the ways in which professional nursing care will be captured in the electronic systems used in their facilities. Questions that arise from nursing include: How can nurses balance generalized care and protocol management with the need for documentation of each individual's nursing needs and particular experiences? How can the goals of nursing care be incorporated into the record? How can nursing actions/interventions be clearly communicated to all members of the health care team? In what ways can an electronic record document collaboration with the client to determine individualized outcomes of care and treatment? In considering these questions a number of issues arise: the selection of standardized languages to be used in the records, the title of the record, the tension between coding and text, the accessibility and transferability of the record, the ability to retrieve data on nursing outcomes through data mining techniques, ownership of the record, and privacy/security of the information stored. Although the paper will make no attempt to answer these questions it will draw on relevant journal articles to provide a context for this pivotal change in that way we account for health care practice.

Keywords. EHR, health and well-being, standardized language, health outcomes

Introduction

Nurses cannot underestimate the importance that a shift from paper-based to electronic documentation will mean for the professional practice of nurses and the provision of client care. Electronic record systems provide an opportunity to forge links between professional nursing practice, the practice of other health professionals, and the health and well being of our clients. On the one hand, one can already imagine the impact that ready access to health information about a client, over the span of a life, as well as access to all that is known about health and disease worldwide would have on decision making for both clients and the health care providers who support them. On the other hand, this seems a pivotal moment in our history to ensure that the uniqueness of human health experience, the important differences between and among individuals, is not systematically left out of the database. While the evidence of generalizable knowledge undoubtedly informs professional decision making, access to knowledge that expands understanding of an experience of health and illness is what alleviates suffering and lessens the impact of illness experiences. For example, knowing the
trajectory of an illness not only from a statistical perspective, but also understanding what it is like to live with a particular experience. This raises the question, “how can nurses balance generalized care and protocol management with the need for documentation of each individual’s health experiences?”

One cannot overlook the possibility that electronic record systems obscure disciplinary practice as it may become more difficult to record and review professional nursing assessments, nursing actions, and nursing’s contributions to client care. In this paper we will discuss the opportunities that electronic systems promise through improved access to information and communication between health care providers, clients and their families. In addition, the authors explore challenges electronic health systems present for the professional practice of nurses. There is no doubt that the shift from paper to electronic documentation will improve access to individualized histories and to what is currently known about disease and treatment. What is less certain is what knowledge will be included or excluded in such a database and how particular knowledge of individuals’ health will make its way into such records.

1. Background

Since the 1970s, many nurses and their nursing organizations have been engaged in the development of standard terminologies for describing and documenting nursing practice. While much of nursing’s work has always been described and documented in health care records, the independent role of professional nursing is largely omitted in systems that are based on International Classification of Disease (ICD) and medical coding of conditions. For example if a nurse is caring for a pre-operative client, the nursing actions related to medication administration, diet and recording of vital signs are included in the record. But nursing actions taken to support an anxious client, to teach a family member, or provide a quiet and supportive environment would be unnoticed. Nurses recognize that much of what they might consider to be the essence of nursing – the interpersonal, relational aspects of caring practices – is undocumented, unnoticed and undervalued. Thus, taking the stance that that which is unnamed is unnoticed, nurses began a movement to define, describe, and give language to that which they observe, judge, act upon, and evaluate as part of professional nursing practice.

The concepts of independent nursing versus collaborative nursing gained favor in the early stages of development of nursing languages [1]. Collaborative nursing referred to those actions taken by nurses as a result of collaboration with another professional, i.e., administering medications as an action based on an MDs order or enacting physiotherapy treatments prescribed by a physiotherapist. Independent nursing referred to that part of nursing practice for which a nurse is licensed to address independently, i.e., providing an environment minimizing risks for infection or falls or providing for physical and emotional comfort. The former of these were and currently are recorded in systems using medical coding. It is the latter nursing actions that were identified as those that required a means for description and documentation beyond the medical documentation systems. Thus, the discipline embarked on a journey of over three decades to identify nursing’s disciplinary phenomena of concern and to provide a means for nurses worldwide to give voice and bring visibility to nursing practice.
2. Standardization of Language

Over this 30-year period, there have been considerable advances in nursing terminology development, but at the same time, there has been less than full agreement among nurses on what is nursing’s phenomenon of concern, or the need/desirability for nursing languages. The current adoption of electronic health care records creates a need for immediate decisions regarding what will be included or excluded in new record systems. Nurses at local, regional and national/international levels must be acquainted with the debates within the discipline and the options for moving forward. Nurses must make informed choices and no longer have the luxury of time to continue debates or discussions.

There are several primary nursing language systems in use worldwide. These are the International Classification of Nursing Practice (ICNP®) [2] and the NANDA-I [3], Nursing Interventions Classification (NIC) [4], Nursing Outcomes Classification (NOC) terminologies [3,5]. What these systems have in common is the use of ‘nursing diagnoses’ or statements that identify the nurses’ phenomena of concern, a listing of nursing actions taken to address the nursing concerns and a listing of expected outcomes of nursing practice. These systems and lists have become exceedingly complex over the years. For example, the nursing diagnoses include conditions of actual problems or concerns, as well as conditions of risk for problems, and opportunity to enhance healthy states. The systems include axes that identify the client as an individual, family, group or community; the focus of care; the means of carrying out nursing actions, and the expected timelines for resolution of the condition. Over half of the identified nursing diagnoses describe conditions of a psychosocial, spiritual or educational nature (such as conditions of anxiety, fear, powerlessness, hopelessness, lack of knowledge) and the physiological and environmental conditions are very clearly represented as well. Detailed information on these nursing terminologies is widely available and not a part of this paper. However, the authors understand that many nurses in practice and some in the position of having to implement electronic record systems have little acquaintance with the details of these language systems; therefore we present an overview of issues nurses need to be prepared to address.

Nursing literature reports several benefits of documentation using standard terminologies. Use of a standard language makes nursing visible in local, national and international data sets permitting use of retrievable nursing information to influence quality of care and relevant nursing policy [6]. It allows for theory-based care and supports comparisons of nursing data across locations [7]. Standard documentation enhances nurse-to-nurse communication [8], as the terms provide a means by which nursing’s concerns can be entered into record and become part of a legal documentation of nursing assessments, judgments and actions. Documentation through electronic means is quicker and more efficient than narrative charting and avoids the common problems of illegibility and interruptions that occur when nurses and others need data that is not easily retrieved from lengthy paper records [9].

Literature also suggests that nurses have real concerns that nursing work is too complex to be accurately recorded through the ‘short-hand’ phrases or labels that these standard languages provide. Thus, research is ongoing to evaluate the degree to which nursing activities can be documented through existing systems and to determine if and when narrative charting can/should be used to supplement the standard terms [10]. One recent study evaluated the degree to which a standard vocabulary, the Nursing Data Dictionary (NDD) derived from the ICNP® could describe actual nursing activities and
found that 75% of nurses’ data entry events were accomplished using the NDD and that less than 4% used free text only, and 20.4% used a combination. Evaluation of the actual charting showed that over 80% of the free text entries could be found in the NDD and only 1% of expressions used for supplementary language purposes (for example, adding a conjunction) were not covered in the NDD [11]. Thus, it appears that nurses, when experienced and comfortable with the electronic systems, can use them for the vast majority of their documentation.

An alternative view suggests that the transition to electronic records is an opportunity to enlarge our current capacity to capture/document professional nursing practice informed by disciplinary goals of nursing. In this scenario, documentation with electronic records moves beyond the limitations of diagnosis from either a medical or nursing perspective. Rather than work exclusively from diagnosis, an alternative view suggests professional practice guided by goals specific to the individual experience of health and well-being. Although NANDA and other standardized languages argue that they are able to address deficits beyond the physical realm, the holistic view that underpins nursing practice is undermined by language that fragments the human experience of health. In other words, the human health experience could be viewed and thus documented through a nursing lens in which the person is understood as a unified whole rather than a compilation of deficits.

Rankin [12] argues that the contemporary emphasis on health management technologies in a form of “computerized aggregates of patient data” (p. 57) is not improving care in Canadian hospitals. On the contrary, the hospitals’ business-like efficiency practices that privilege electronic databases with its standardized languages, while meeting the hospitals’ goals of resource management and allocation may obscure and distort “the actual experiences of nurses and patients” [12] (p. 58). These experiences, which are more accurately described as the process of nurse-client relationship and that arguably constitute the core of nursing, are nonetheless not included in electronic health records. Similarly, MacKinnon and McIntyre [13] (p. 70) observed in a research study that nurses in the hospital setting often have to attend to the institutional priority of “nursing the chart” (or the electronic health care record) at the expense of the time needed to come to know the client and to establish a therapeutic relationship - central to the client’s health and wellbeing. The concern is that the use of electronic health records privileges the source of knowledge about the client as being other than the client himself or herself. To summarize, the danger here is a creation of a standardized account of nursing practice that supersedes an individualized account of a client or family from their perspective [12], with the latter being completely omitted from the electronic health record.

Compelling arguments have been put forward that the electronic health record could facilitate research and evaluation of nursing outcomes that could be easily retrievable, and would support institutional priorities. Some would argue that understanding nursing outcomes raises the profile of the care that nurses provide and its contribution to the health of clients. While this can be shown to be an effective measure of particular nursing interventions and justify the provision of staff to provide these interventions, it limits the practice of nursing to the performance of skills with measurable outcomes. In situations where outcomes can be linked to nurses independent functions, a case can be made to support utilization of electronic and retrievable documentation. This claim that the electronic health record will provide a cumulative database to assist with staffing and other institutional priorities is an excellent one. The risk is that limiting the conceptualizing of professional nursing
practice to measurable interventions leaves out what many would identify as the central goals of nursing practice.

One initiative in which nurses are already involved is the Nursing and Health Outcomes Project (NHOP), now renamed the Health Outcomes for Better Information and Care (HOBIC). Electronic systems are designed to collect and analyze information on staffing indicators and health outcome measures. It is suggested that this type of information can assist nurses and other health care professionals in the course of their daily work to plan care and evaluate its effectiveness. It is further suggested that data from electronic systems can support decision-making about resource use and assist researchers to better understand the impact of nursing and other health disciplines on patient care and health outcomes. Although it may be the case that standardized collection of patient health outcomes, staffing and quality of work-life information can benefit health care providers and indirectly the health of the people they care for, as we move ahead in developing electronic health care records these benefits remain secondary to individualized health care concerns of clients and their families. Similarly, while the use of standardized nursing language such as NANDA has the potential to position nursing alongside medicine in the electronic records, the discipline of nursing and the health of individuals might be better served by modeling, for all of the disciplines in the electronic record, what it means to make the person’s experience central to their health care.

References

Section 8

Research and Development Initiatives
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Genotypic Approaches to Therapy in Children (GATC): Using Information Technology to Improve Drug Safety

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Abstract. Adverse drug reactions (ADRs) are a major cause of morbidity and mortality in children. Current models of ADR surveillance have repeatedly demonstrated little pragmatic value to practicing clinicians. ADR reporting rates in the US and Canada suggest that only 5% of ADRs are reported. The Genotypic Approaches to Therapy in Children (GATC) network was established to identify and solve drug safety problems in paediatrics. We hypothesized that genetic polymorphisms underlie a significant portion of concentration-dependent ADRs in children. Our objective was to establish an ADR active surveillance network in paediatric hospitals across Canada. Surveillance clinicians evaluate clinical information from ADR cases and drug-matched controls, and collected DNA samples from all patients. The surveillance network will enable the identification of predictive genomic-markers for ADRs. With this knowledge, children at risk can be identified before therapy is initiated and enable personalized adjustments to therapy based on genetic make-up.

Keywords. adverse drug reaction, drug safety, surveillance, paediatrics, genomics

Introduction

An adverse drug reaction (ADR) is an unintended and noxious response to a drug that occurs under normal conditions of use. ADRs are a major cause of morbidity and mortality, accounting for up to 7% of all hospital admissions and may rank as the fifth leading cause of death in the western world [1,2]. Children are particularly at risk, with estimates suggesting that almost 30% of paediatric hospitalizations result in severe ADRs [3,4]. In addition, ADRs result in an estimated 25,000 to 54,000 pediatric
deaths each year in the United States and a further 2,500 to 5,400 children die each year in Canada [1,5].

Current models for detecting ADRs have proven inadequate. By the time a drug comes to market, an average of only 1000 people have taken it and only the most common side effects will be detected [6]. Post-marketing surveillance systems, such as Health Canada’s Med Effect Program, rely heavily upon health professionals and laypeople to voluntarily report ADRs. Yet, estimates suggest that fewer than 5% of ADRs are actually reported [7,8], and that up to 50% of existing reports lack basic information such as dose, frequency of administration and temporal relationships between the drug and the ADR [9]. Such a paucity of useful ADR data is arguably of limited value to practising clinicians and insufficient to improve patient safety.

Clearly a new model for ADR surveillance is required, particularly for populations at risk, such as children. For meaningful paediatric safety decisions to be achieved, comprehensive ADR data must be collected and evaluated on a national scale. This can be achieved by establishing a national “active” ADR surveillance network, centered in paediatric institutions and staffed by trained ADR surveillance personnel. To support such a network of widely dispersed clinicians, and to establish a databank of high-quality information, creative use of information technology is required. To our knowledge there is no such network.

This new model for ADR surveillance may also enable the development of meaningful ADR prevention strategies, by researching the causes of ADRs. Factors such as developmental changes between birth and adolescence, gender, drug-drug interactions and disease state play an important role in ADRs, however, it is becoming increasingly clear that much variability in drug response is inherited [10-12]. Indeed, it is estimated that genetic factors may contribute to 50% of ADRs [13] and account for 20–95% of drug response variability [14]. A surveillance network that includes the collection of genetic data, along with clinical data, could enable the identification of predictive genomic-markers for ADRs. With this knowledge, children at risk can be identified before therapy is initiated and enable personalized adjustments to therapy based on genetic make-up.

1. Objectives

1. To establish a national, active ADR surveillance network in paediatric hospitals across Canada.
2. To develop a national database for reporting and recording ADRs.
3. To identify genomic markers predictive of ADRs and to incorporating these markers into a diagnostic tool.

2. Method

The Genotype-Specific Approaches to Therapy in Childhood (GATC) ADR network was established in 2005. It is a national network of trained ADR surveillance clinicians in 10 Canadian paediatric hospitals, serving >75% of Canadian children (see Figure 1). Surveillance personnel are dedicated exclusively to the identification and reporting of ADRs in children. Surveillance clinicians receive ADR referrals from doctors,
pharmacists, nurses and members of the general public. Informed consent is obtained from the child and/or family member, and a DNA sample collected from saliva, a mouth swab or a blood sample. In each case, patient data relating to the ADR is also collected from medical records and stored in the database including: demographic information, ethnicity, medical history, medication history, relevant laboratory findings, a description of the adverse reaction, the temporal relationship to drug therapy, and clinical outcomes. Patients of the same age who took the same drug, but did not suffer an ADR (drug-matched controls), are also identified and recruited.

Each GATC ADR surveillance clinician has a password protected study laptop stored within a locked office. Personal identifying information is housed locally and accessible only by the site surveillance clinician and the site investigator. Study participants are assigned a unique GATC ID code.

Anonymous clinical data is collected and stored in a custom password-protected database housed in the study laptop at each site and transferred via an encrypted virtual private network (VPN) to the central server at the University of British Columbia. The database enables storage and transfer functions to occur within each hospital’s information technology network, mobile data collection at the bedside, and uploading of records to the server.

The database was constructed to operate in a stand-alone mode to allow local data collection prior to transfer via a secure connection to the network server. Once data is uploaded, the server disconnects, returning the user to their respective hospital network. Each hospital opened the appropriate ports to enable secure VPN traffic in and out of their individual networks. This allows a two-way communication between the server and the remote sites for secure transfer of information, for transfer of large volumes of data, uploading updates or upgrades, and remote technical support.

The ADR master clinical database is password protected and stores GATC study data from all sites. No identifying information, with the exception of date of birth (to allow the computer to accurately calculate age at time of the ADR), is transferred to the server computer. Authorized GATC staff has access to the ADR database server, and existing data in the server cannot be updated without their approval. Clinical data for the study will be held for 25 years and then destroyed. Upon study completion, the study laptops will be returned to the principal study site for re-formatting of all hard drives. DNA samples are shipped to the Centre for Molecular Medicine and Therapeutics (CMMT) in Vancouver for storage and genetic analysis. GATC developed a panel of single nucleotide polymorphism (SNP) markers designed to identify genetic polymorphisms of more than 220 key genes. These include genes that encode for drug metabolising enzymes, transporters, drug receptors, ion channels and disease-specific genes related to the mechanism of ADRs. The genomic data is documented and coded with a study ID and housed in the password-protected genotype database located at CMMT.

3. Results

In three years, GATC network clinicians have identified and enrolled 1836 ADR cases and 13188 drug-matched controls from 10 paediatric health care centres across Canada (see Figure 2). Preliminary analyses have identified three immediate high priority ADRs; anthracycline-induced cardiotoxicity, cisplatin-induced hearing loss, and
codeine-induced opiate intoxication in breastfed infants. The surveillance clinicians have been directed to recruit for these ADRs.

4. Discussion

The lessons learned in establishing the network reflect the importance of high-quality and careful input of data, pragmatic challenges of linking locally collected data to a national database, and the need for evolution in design of drug safety active surveillance for targeted collection of specific ADRs.

The quantity and quality of ADR reports is crucial. Our network focuses its efforts on increasing the quantity of cases and controls in areas of immediate interest, as well as ensuring quality reporting through complete information gathering for each ADR case or control recruited. An employee network that is funded to meet this directive can accomplish this more effectively than a voluntary surveillance model.

The database has evolved in several versions. Changes have allowed more efficient and accurate data capture and include the addition of linking functions between sections, drop-down menus, automatic confirmation of accurate date entry functions, and a standardized entry of clinical test results (e.g., echocardiogram and audiogram reports).

The pragmatic challenges of linking locally-collected data to a national database is confounded by site-specific ethical and privacy policies, site-specific safety software, the lack of local information technology support, the incompatibility of local PC based systems (9 out of 10 sites) with the Mac-based laptops and the lack of computer knowledge of the individual surveillance clinicians.

Due to the central structure and an employee network, the network can be quickly directed to target specific drugs, ADRs or classes of drugs. The network has the ability to produce data within a short time period.
5. Conclusion

GATC has demonstrated a model of effective ADR reporting and active, targeted ADR surveillance coupled with genomic analyses allowing development of innovative and pragmatic ADR risk management strategies for clinicians based upon a child’s genotype. GATC’s national database has been developed and modified to meet the need of the surveillance clinicians as well as to ensure anonymous, standardized, complete and accurate collection of necessary clinical data.

References


Overcoming the Absence of Tone and Non-Verbal Elements of Communication in Text-Based Cybercounselling

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Abstract. Understanding is critical to productive interactions, good communication and therapeutic change. Clients may understand the meanings of words a professional uses but not what the professional intends. If both the client and the professional simply assume that the other will understand their intention because the words are understood, the meanings of the words may come into dispute. This, in turn, leads to failed communication and negative therapeutic outcomes. To counter this, we have developed and used the Presence Techniques in text-based cybercounselling for more than a decade. This paper describes these online counselling techniques and explores their use and effectiveness.

Keywords. cybercounselling, cybertherapy, online counselling, online therapy, Presence Techniques

Introduction

The authors, who are the founders of Worldwide Therapy Online Inc., the world’s first online clinical practice, began work in the field of cybercounselling in 1995. At the time their work was the first such effort to use e-mail to connect with clients who required mental health services. Since then, the use of e-mail for the delivery of counselling and therapeutic services has become the most prevalent type of web-based intervention [1].

From the start it was clear that overcoming the absence of tone of voice and the non-verbal elements of communication would be critical in engaging clients therapeutically and engendering change. Early case studies [2,3] indicated that the modality held promise. Since that time we have refined our original, and created new, text-based therapeutic techniques that allow us and other therapists and counsellors whom we trained to overcome the absence of tone of voice and non-verbal elements. These techniques are referred to as Presence Techniques.

These techniques now form the foundation of our cybercounselling work. We have developed in-depth training focused on the techniques [4] and used them in our clinical work with online clients throughout Canada and around the world. They have proven to be essential in the therapeutic process.
1. The Therapeutic Alliance

The initial development of the Presence Techniques was as much a response to the fundamental need in counselling to establish the therapeutic alliance as it was to address the lack of tone of voice and non-verbal elements in our text-based work. The therapeutic alliance is the open, respectful and collaborative bond between counsellors and clients [5]. Research into the counselling process clearly indicates that the therapeutic alliance is a critical factor when it comes to effective counselling [6,7]. If online counsellors are able to form a therapeutic alliance with their clients the approach holds promise.

Cook and Doyle [8] compared the ratings of the therapeutic alliance from 15 online therapy clients with ratings from clients who engaged in face-to-face counselling. The online clients completed at least three sessions of online counselling. The researchers found that clients participated more in the distance modes and reported a therapeutic alliance equivalent to the face-to-face ratings.

Prado and Meyer [9] found similar results in their study at the University of Sao Paulo. In this work, done exclusively with asynchronous e-mail counselling, counsellors were able to establish a solid therapeutic alliance.

Finally, Cohen and Kerr [10] found that clients provided similar ratings between online and face-to-face counselling regarding the counsellor’s expertness, attractiveness, and trustworthiness. This is relevant given the absence of visual and non-verbal information in the online modality and the concern that online clients might rate these aspects of counsellors poorly. In addition, clients were asked to rate the depth, smoothness, positivity, and arousal of the counselling sessions as measured by the Session Evaluation Questionnaire [11]. Clients rated the level of arousal higher in the face-to-face modality but there were no other significant differences between groups.

2. The Presence Techniques

2.1. Emotional Bracketing

Consider a client whose boyfriend has many of the qualities of her father. Recognising this, a counsellor might ask her if she has noticed that her boyfriend and her father have many similarities. The words are simple and the question is easy. The client may even have an answer.

In a face-to-face interaction, one’s tone conveys that this is a typical question in counselling and that there is no underlying meaning. But in text this is not so clear. Although the client may understand what the words mean, it is not at all assured that she will understand what the counsellor means. The client may detect a subtext like “this suggests you are abnormal” or “I’m wondering if you were abused.”

To ensure that clients understand the meaning, we use a technique called Emotional Bracketing. Emotional Bracketing employs the use of square brackets wherein we write about inner non-observable thoughts and feelings.

The following example comes from an exchange with an alcoholic client. Such clients often hear criticism of them and their behaviour even when no criticism is intended. In our experience with online modality, it is critical that we are clear with such clients about the emotion and meaning behind our statements. The client’s name is John:
“It is very important [feeling concerned, somewhat worried] that you reply to this e-mail [feeling pushy but needing to hear from you] as soon as you receive it John. This will be the third time that I have written in the last week [concerned that you may have relapsed]. Please reply.”

What is critical in this exchange is that we have conveyed to the client that it is concern and worry rather than anger or frustration, which has led us to write what we have. This example also illustrates another important use of Emotional Bracketing. It allows the counsellor to say something that may be difficult or challenging and then use the brackets to tone it down. Counselling regularly involves different degrees of confrontation.

When face-to-face, the counsellor can read the client’s reactions and modify their language and tone, or ask the client about their reaction should there appear to be a misunderstanding. In text-based work, we do not have this luxury. Therefore, it is critical that our meaning is clear within our messages and replies.

Emotional Bracketing is also valuable in the early stages of counselling when establishing the foundations of the therapeutic alliance. The technique allows us to show the client warmth, understanding and compassion in ways that are unique to this process. This also helps to underline the fact that this is a different kind of e-mail communication; just as we engage in certain kinds of dialogue face-to-face that make it clear that counselling is a different kind of conversation.

Clinicians new to cybercounselling sometimes make the mistake of using the square brackets of Emotional Bracketing to provide simple information. Parentheses should be used for this purpose. Rather, Emotional Bracketing is used just as tone and body language are: to enhance meaning.

2.2. Descriptive Immediacy

A second Presence Technique that we use to overcome the absence of tone of voice and non-verbal elements of communication in our text-based work is Descriptive Immediacy. This technique provides the client with information about the counsellor’s observable, non-verbal behaviour toward the client.

It is our belief that clients need an experience, not an explanation. It is typical to work with clients who have heard explanations of what is wrong with them from everyone - from their parents to their teachers to the bartender. Descriptive Immediacy is used to intensify the client’s experience of engaging with a counsellor by bring the client and the counsellor into the presence of one another in the text; to give them an experience. Here is an example of a session in which the client is dealing with fear:

“When you said at the beginning that you were scared, I let out a big sigh. I found myself nodding my head as you talked about your fear. And yet as you kept describing it, I started to see that you have a handle on the fear. When you were done, I sat back and smiled and thought ‘he knows what to do’. And I really think you do.”

The technique can also be used with brackets, as this example illustrates:

“Wow! [smiling with wide eyes and a thrilled look on my face] Tina, you showed real courage in the game today. [imagining myself offering you a handshake] Congratulations!”
In each case the goal is to intensify the experience of engagement. The technique also aids us in establishing the therapeutic alliance.

Counsellors new to the process sometimes make the mistake of using this technique to ascribe behaviours to the client. Saying to a client “my face is full of admiration for you” is an acceptable use of the technique. However, “you smile and nod your head in reply” is not.

2.3. Descriptive Imagery

Descriptive Imagery is related to Descriptive Immediacy. In our initial work we did not distinguish between the two but as we and others have used the techniques it has become clear that they are distinct techniques.

Descriptive Imagery is the use of descriptive language to help the client create a mental picture that is relevant to the therapeutic environment. Descriptions of the counsellor’s office, the weather and the community context are some typical images that may be relevant. For example, we might write:

“My office is warm and quiet and there are a number of comfortable chairs that you may choose from. On one wall is a bookcase with textbooks. The window looks out onto the garden and a babbling brook in the distance.”

Descriptive Imagery is used to ground the clients in the virtual presence of the counsellor and to aid them in experiencing a deepened reality of their interactions.

2.4. Time Presence

Time Presence is a final technique that also fulfils the purpose of bringing the client into the counsellor’s presence and of providing them with a therapeutic experience.

Time Presence involves writing as tough the interaction between client and therapist is in the present. So a counsellor might write something like “A moment ago when you said you were angry I thought...” or “Last session when we were discussing...” In logical terms, the statements do not make sense but, when integrated into the cybercounselling process, they aid the client in engaging in the here-and-now of the sessions.

3. Client Comments and Outcomes

Therapy Online’s therapists are trained in the use of Presence Techniques and employ these techniques as a regular part of treatment. Anecdotal reports from clients who were treated entirely online confirm the value of the approach. One client notes that “I found this process to be beneficial.” Another states that “My counsellor’s Wittiness and sense of humour was a big factor in opening up to a complete stranger. She offered great suggestions that I have implemented in my relationship with my husband and children and I am very grateful.”

Recent research [12] by the authors comparing face-to-face and online counselling with clients from the same referral source indicates that there are no significant differences in outcome measures. It seems likely that that the Presence Techniques play an important role in the lack of difference in outcome comes between the two modalities.
4. Conclusion

The Internet and e-mail communication are ubiquitous. We have no doubt that cybercounselling will continue to grow and soon become as unsurprising as online shopping or banking. However, establishing a solid relationship in the form of the therapeutic alliance is a challenge of tremendous importance to successful counselling.

The Presence Techniques have been created to address this issue by providing ways for counsellors (and clients) to communicate essential non-verbal and tone-of-voice information that is not be contained in the words used to describe a problem, ask a question, or explain a therapeutic task.

More specific research needs to be done looking at the use of individual techniques and their value in the overall success of online work. Presence Techniques are a part of successful cybercounselling as indicated by anecdotal evidence from clients and counsellors, and outcome research comparing face-to-face and online modalities.

References

A Randomized Clinical Trial of Clinical Decision Support in a Rural Community Health Network Serving Lower Income Individuals: Study Design and Baseline Characteristics

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Abstract. Lower income individuals in the US frequently experience difficulties in obtaining access to needed health care services. We describe a randomized clinical trial that seeks to improve the quality of, and access to healthcare services for medically underserved populations in five rural counties of North Carolina. We propose to achieve these improvements by implementing system-to-system integration via a telehealth network with an asynchronous clinical decision support system for health care providers.

Keywords. clinical trial, computers, rural health, community network, Medicaid

Introduction

Lower income individuals in the US frequently experience difficulties in obtaining access to needed medical services [1]. These difficulties have led to a disproportionate reliance upon emergency rooms as a primary source for their non-urgent medical care [2-4]. While Medicaid programs utilizing a Health Maintenance Organization (HMO) model have proven successful in providing appropriate care for urban populations, there is limited availability of such programs in rural areas [5-9].

Recently, our group demonstrated that the use of a clinical decision support system (CDSS) that sends asynchronous electronic mail alerts to care managers was resulted in a significant reduction in the use of inappropriate emergency room care for Medicaid patients in Durham County, North Carolina. However, it is not known whether this urban CDSS model can be transferred to rural communities.
1. Objectives

The purpose of the present project is to improve the quality of, and access to healthcare services for medically underserved populations in five rural counties (Person, Granville, Vance, Warren, and Franklin) in the Northern Piedmont region of North Carolina who are participating in a Medicaid care management program. Our project’s four objectives are as follows:

1. Improve the overall quality of health care through increased use of preventive and chronic disease services.
2. Improve healthcare outcomes for chronic disease within under-served populations.
3. Improve access to appropriate health care by managing the over- and under-utilization of key health care services.
4. Reduce the costs of inappropriate health care.

2. Hypothesis

We propose to achieve our study objectives by implementing system-to-system integration via a telehealth network with an asynchronous CDSS for health care providers. These capabilities will allow care managers to receive timely notification of sentinel health events occurring for medical patients within the five-county target area.

3. Study Design

This section describes how the proposed information interventions will be used to manage health care services for a rural Medicaid population served by a regional, community-based Medicaid care management network known as the 5-County Community Care Partners (CCP) Network.

3.1. Study Setting

CCP was formed in 2004 as a Medicaid care management organization with administrative oversight from Duke University Health System. The telehealth network that supports CCP includes three community hospitals with emergency departments, two federally qualified health centers, four rural health clinics, 16 primary care practices, four county health departments, five county social service departments, and the CCP care management organization that serves all five counties.

The five county Northern Piedmont region of central North Carolina has a total population of approximately 200,000 individuals (more than 40% are of minority race and 15% live below the poverty level) [10]. All five counties are classified as medically underserved areas. The CCP network serves approximately 20,000 patients, most of whom are African Americans. Within this population, emergency department use is five times the US average for patients with diabetes and ten times the national average for patients with asthma [11,12]. Similarly, hospital use is 30% higher for patients with diabetes and 200% higher for those with asthma [12,13].
3.2. Information Intervention Description

Communication and collaboration between CCP care team members is facilitated by a regional health information exchange and data repository. This system collects patient information through documentation from care managers, automated data transfer interfaces with network organizations, and monthly data feeds from the North Carolina Medicaid office. The CDSS component evaluates patient information on a daily basis using a series of rules-based knowledge modules to identify instances of inappropriate patient care (e.g., patients with low severity emergency department visits who could be seen in an outpatient clinic, or patients who missed well-child visits). As these situations occur, the CDSS sends email notices to care managers regarding these problematic events to allow for appropriate follow-up medical care.

3.3. Intervention Components

The Community-Oriented Approach to Coordinated Healthcare (COACH) system was developed in 1999 to support Medicaid case managers in Durham County, North Carolina. The implementation of COACH allows case managers to record and share information about their clients [14]. This project will build upon the COACH telehealth network and the System for Evidence-Based Advice through Simultaneous Transaction with an Intelligent Agent across a Network (SEBASTIAN) CDSS [15]. It will also implement interfaces between other health information systems serving the CCP target area and COACH.

The COACH database includes administrative (demographic, service use, encounter tracking, provider associations, audit trails, and billing data), care management (health risk assessment, utilization risk assessment, services required, environmental factors, socio-economic data, home assessment, special needs, and care management plans), clinical (problems/procedures, medications, allergies, laboratory results, and disease-specific care plans), and communications (messages, referrals, notices of new information, and health trigger) information. When Duke University Health System assumed administrative responsibility for the original four county Medicaid population in 2004, COACH was made available to case managers in these counties and an interface with each county hospital was developed to facilitate the identification of sentinel events via SEBASTIAN [15]. In 2007, a fifth county was added, creating the current CCP network.

3.4. Intervention Conditions

We have pre-specified sentinel conditions that collectively define this study’s information interventions. These conditions have been ranked according to their importance for the target health care population (Table 1).

During the clinical trial, notices will be generated for all patients who meet these pre-defined criteria. While notices for patients in the intervention group will be forwarded to care managers, notices for patients in the control group will be withheld and retained for subsequent analysis.
4. Study Methods

4.1. Patient Inclusion Criteria

All Medicaid beneficiaries enrolled in CCP who weren’t the subject of a notice and who have one or more years of continuous enrollment in CCP are eligible for this study. The continuous enrollment requirement is needed so that Healthcare Effectiveness Data and Information Set (HEDIS) indicators can be calculated.

4.2. Comparison Groups

When the present study began, approximately 150 patients treated at one of the CCP hospitals had already been the subject of alerts generated via SEBASTIAN. To avoid contamination, these patients were excluded from the study and the remaining CCP patients were randomly assigned by family unit to have notices sent to their care providers (intervention) or to have notices withheld (control). Patients enrolled in CCP after the initial treatment assignments will be randomized to the information intervention or control groups at the start of each subsequent phase of the study.

4.3. Endpoints

Endpoints are associated with each of the study’s four objectives.

1. Improve quality of health care: We will evaluate HEDIS indicators for preventive services (cancer screening, immunizations, and chlamydia screening) and chronic diseases (diabetes and asthma)

### Table 1. Alert description.

<table>
<thead>
<tr>
<th>Alert Rank</th>
<th>Intervention</th>
<th>Alert Conditions and Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>Timely intervention by case managers</td>
<td>Outpatient care: emergency department encounters for fever and pregnancy; child birth requiring a postpartum visit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emergency department and inpatient encounters for patients with chronic diseases: asthma and diabetes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Over-utilized emergency departments: low severity encounters and more than three encounters within a 90-day period</td>
</tr>
<tr>
<td>High</td>
<td>Intervention by case managers to change patient behavior</td>
<td>Patients who miss more than two outpatient appointments in a 60-day period</td>
</tr>
<tr>
<td>Medium</td>
<td>Preventive services</td>
<td>Patients with asthma: action plan, staging, or maintenance medication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patients with diabetes: tests for HgbA1c, LDL cholesterol, total cholesterol, urine microalbumin, ophthalmologic examination, or influenza vaccine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Preventive: well-child visits, Chlamydia testing, mammography, and Pap testing</td>
</tr>
</tbody>
</table>
2. **Improve health outcomes**: We will evaluate hemoglobin A1c levels in patients with diabetes, and rates of emergency department and hospital use for the entire population, and separately for patients with diabetes and asthma.

3. **Improve access to and appropriateness of health care**: We will evaluate HEDIS indicators for health care access (well-child visits and post-partum care) and appropriateness of care (rates of emergency department and hospital use for chronic disease patients and for non-critical conditions).

4. **Reduce costs of inappropriate care**: We will evaluate the costs of care for ambulatory care-sensitive conditions in terms of their impact upon costs for emergency, inpatient, and outpatient care.

**4.4. Data Sources**

Information used to evaluate study endpoints will come from two data sources: claims data for North Carolina Medicaid beneficiaries in the five county target area and routine chart audits for patients with diabetes and asthma. COACH currently receives monthly enrollment and claims data imports from the agency administering Medicaid in North Carolina. Information in the claims records includes: International Classification of Diseases, Ninth Revision (ICD-9) diagnosis and procedure codes, Current Procedure Terminology (CPT) procedure codes, and payment amounts for emergency department, inpatient, outpatient, durable medical equipment, and pharmaceutical services. We will use Medicaid claims data to determine HEDIS measures, utilization rates (emergency department and inpatient), and medical costs of care. Chart audits are conducted twice a year for patients with diabetes and asthma. These audits will supply hemoglobin A1c and low-density lipoprotein (LDL) cholesterol level data.

**4.5. Analysis Plan**

Generalized estimating equations with a working correlation matrix to account for clustering within families will be used to estimate study outcomes and make comparisons between treatment groups. The primary comparisons will be performed for all patients randomized to information intervention vs. control. Secondary analyses will be performed for the subset of patients (both interventions and controls) who generated one or more information interventions and for those who did not generate interventions. The purpose of these secondary analyses is to determine whether the treatment effect seen in the entire population is isolated to those patients actually generating an information intervention. Subgroup analyses will be performed by family size (large vs. small), sex (male vs. female), and race (African American vs. other).

**5. Baseline Characteristics Description**

On September 1, 2007, 9324 individuals with 12 months of continuous enrollment in the CCP program were randomized by household in a 1:1 ratio to have their care managers receive the CDSS intervention or to receive the standard of care. The subjects were evenly matched within treatment groups (Table 2). Within the study population, more than 50% were less than 16 years of age, 55% were females, and 64% were African-Americans. The prevalence of diabetes was approximately 2% and the
prevalence of asthma was 8%. In the year before randomization, total emergency department (ED) use was approximately 0.3 visits, low severity ED use 0.1 visits, and three ED visits within a 90 day period was 0.05 visits per enrollee (Table 3). Patients in both treatment groups had similar event rates and medical costs.

Table 2. Alert baseline characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>P-value (1 df)#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuously enrolled</td>
<td>4667</td>
<td>4657</td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>n(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age &lt;2 years</td>
<td>522 (11.2)</td>
<td>481 (10.3)</td>
<td>0.18</td>
</tr>
<tr>
<td>3-6 years</td>
<td>625 (13.4)</td>
<td>611 (13.1)</td>
<td>0.70</td>
</tr>
<tr>
<td>7-15 years</td>
<td>1290 (27.6)</td>
<td>1284 (27.6)</td>
<td>0.94</td>
</tr>
<tr>
<td>16-30 years</td>
<td>747 (16.0)</td>
<td>735 (15.8)</td>
<td>0.77</td>
</tr>
<tr>
<td>&gt;30 years</td>
<td>907 (19.4)</td>
<td>964 (20.7)</td>
<td>0.13</td>
</tr>
<tr>
<td>Black race</td>
<td>2998 (64.2)</td>
<td>2990 (64.2)</td>
<td>0.97</td>
</tr>
<tr>
<td>Male sex</td>
<td>2087 (44.7)</td>
<td>2032 (43.6)</td>
<td>0.29</td>
</tr>
<tr>
<td>History of diabetes</td>
<td>237 (2.2)</td>
<td>271 (2.8)</td>
<td>0.19</td>
</tr>
<tr>
<td>History of asthma</td>
<td>493 (8.4)</td>
<td>501 (8.8)</td>
<td>0.57</td>
</tr>
<tr>
<td>Asthmatic with age&gt;18</td>
<td>126 (2.7)</td>
<td>166 (3.56)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*p-values based on 1 degree-of-freedom Chi-square tests
*p-value based on the Kruskal-Wallis test

Table 3: Prior year clinical events and outcomes.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 Events/patient</th>
<th>Group 2 Events/patient</th>
<th>P-value (1 df)#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency department</td>
<td>0.33</td>
<td>0.35</td>
<td>0.36</td>
</tr>
<tr>
<td>Low-severity ED</td>
<td>0.11</td>
<td>0.11</td>
<td>0.98</td>
</tr>
<tr>
<td>Count of 3 or more ED visits within 90 days</td>
<td>0.03</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Outpatient visits</td>
<td>11.35</td>
<td>11.59</td>
<td>0.71</td>
</tr>
<tr>
<td>Cost / patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total costs ($)</td>
<td>1713.82</td>
<td>1814.90</td>
<td>0.37</td>
</tr>
<tr>
<td>ED costs ($)</td>
<td>146.53</td>
<td>201.53</td>
<td>0.11</td>
</tr>
<tr>
<td>Outpatient costs ($)</td>
<td>1492.96</td>
<td>1526.32</td>
<td>0.73</td>
</tr>
<tr>
<td>Office visit costs ($)</td>
<td>558.49</td>
<td>540.68</td>
<td>0.43</td>
</tr>
</tbody>
</table>

6. Discussion

Lower income and rural populations present unique quality and access challenges for those providing medical care. We believe that the use of a regional health information exchange network and asynchronous CDSS will result in improvements in the quality and costs of medical care for our study population. If this is the case, this standards-
based information solution has the potential to be ported to other regions serving similar populations.

References

Section 9

Service Administration, Management and Self-Management
Patient Self-management and Chronic Illness: Evaluating Outcomes and Impacts of Information Technology

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**Abstract.** Chronic illness is increasing in Australia and throughout the world. It is proving to be a large burden upon health systems. In response, a number of approaches are being tried including the introduction of self-management programmes to assist people in improving their health outcomes. There are also claims that the introduction of information and communications technology (ICT) tools can improve the management of these chronic conditions.

This paper investigates the influence of ICT on the health outcomes and experiences of patients with chronic obstructive pulmonary disease (COPD) participating in a mentored self-management programme. It utilises a combined quantitative and qualitative methodology and introduces the use of triad interviews to provide a broader evaluation of the experiences of individuals within a controlled trial. Two sub-groups of participants within the controlled trial were examined, both received mentoring but one sub-group was also supported with access to an ICT symptom monitoring tool. This research highlights the need for more holistic perspectives on patients and towards the use of a variety of methodological approaches in designing and evaluating e-health projects. Critically, this research highlights the need to expand our understanding of participant’s outcomes beyond conventional clinical or cohort based measures.

**Keywords.** evaluation, chronic disease self-management

**Introduction**

With the increasing incidence of chronic illness and the subsequent burden upon health systems worldwide, there are moves towards patient-centred care and in particular self-management programmes. Recent studies suggest that encouraging people with a chronic disease to take a more active role in managing their own condition can be as effective as introducing new medications [1-3]. To date the evaluation of such programmes has focussed primarily in two areas: firstly the impact of self-management upon health outcomes and secondly, the impact upon health resource usage. The dominant evaluation methodology used within health research remains the random controlled trial and so this technique is commonly used to evaluate the impact of self-management programmes. However, there are some problems associated with limiting our evaluation to the quantitative techniques utilised in controlled trials [4-6].

Information and communication technologies (ICTs) have also been identified as having the potential to improve health care although the number of studies assessing the impact on patient outcomes and experiences remains limited. Similarly within the
health informatics discipline random controlled trials, in conjunction with other traditional quantitative ICT evaluation methods, have been adopted as the dominant methodology for evaluating the impact of ICTs in healthcare [7]. However, there are some limitations to restricting evaluation processes to these quantitative measures and particularly in relation to patient-centred health care. By such restriction the individual patient experience cannot be examined and deeper insights into the effects of both the self-management programme and the ICT may be missed [8].

This paper investigates the influence of ICT on the health outcomes and experiences of patients with chronic obstructive pulmonary disease (COPD) participating in a mentored self-management programme. It examines a subset of intervention participants within a controlled trial of a mentored self-management programme, with an optional ICT tool for self-monitoring, for people suffering moderate to severe COPD. The aim of the controlled trial was to improve and optimise the quality of life for people with COPD and to slow the progression of their disease by initiating early treatment of exacerbations, thus avoiding unplanned hospital admissions and presentations to emergency departments. This programme presented the ICT researchers with an opportunity to deepen the evaluation to examine the way in which the non-mandatory use of an ICT tool may impact upon experiences within a controlled trial as well as examining the impact upon health outcomes. To undertake this investigation the following methodology was developed.

1. Methods

The overarching controlled trial, the Pathways Home for Respiratory Illness project aimed to assist participants with chronic obstructive pulmonary disease (COPD) to achieve increased levels of self-management and self-efficacy by self-managing their condition through the use of technology supported self-monitoring techniques coupled with interactions with case mentors. The case mentors provided telephone based support for the participants’ development of self-efficacy for self-management through the development and maintenance of goals and action plans.

Within the controlled trial, participants were introduced to the concept of self-monitoring through the use of a personalised symptom diary. The diary was available for use in paper format or as an online form. The diary was completed daily and the participants had access to a longitudinal record of their entries. Those using the online system could view their longitudinal record online at any time. The participants who chose to use the paper diary completed the diary daily and posted it in to the research officer each week. The paper diary was then entered onto the system and the longitudinal record printed out and posted back. Thus the case mentors could also view the diary records and use these during the self-management sessions. Because of the need to conform to the trial protocols, the ICT tool was very limited in scope and was simply used to record the same data that was recorded within the paper diary.

A subset of participants was selected from the controlled trial intervention group. This subset consisted of two subgroups, each with six participants: those who had used the ICT tool (IT group) and those who had not (Non-IT group). A two stage evaluation was undertaken to explore the differences in outcomes and experiences of the participants within each group.

The first stage of the evaluation examined the project outcomes using the standardised tests Stanford Self-Efficacy for Managing Chronic Disease 6 Item Scale
(SF36v2) and the Hospital Anxiety and Depression Scale (HADS) in relation to the two sub-groups. These data were collected at baseline then quarterly for twelve months. Using these traditional outcome measures and comparative principles, any statistically significant differences between the two groups are assumed to be the result of the influence of the ICT tool. The analysis undertaken used the mathematically derived standard measure, effect size, enabling comparison of change between or within groups [9,10].

The second stage of the investigation used recorded qualitative interviews to explore the experiences of the participants from these sub-groups to examine how the use of the ICT tool had influenced their experiences within the project. Individual semi-structured interviews were conducted with the “care triad”. This involved the trial participant, their mentor and the research assistant who visited them quarterly and conducted all the surveys and clinical measures. (Previous researchers have utilised this concept of triad or dyad interviews but with each member present at the same interview [11-13]. Alternatively conversations between the healthcare practitioner and the patient have been recorded and these formed the basis of the interview transcript [14,15].) These triad interviews then formed the basis for the qualitative analysis. Interviews were transcribed and then thematic coding was used to analyse the data [16]. The coded interview data was compared across and within the groups to establish similarities and differences between and within the groups.

2. Results

In terms of demographic statistics, there were more females than males who chose to adopt the ICT tool. The mean age of the IT cases was 9 years lower than in the non-IT cases. The marital status of the groups differed in that the IT cases were not single and 33% were divorced. The IT cases had a slightly higher education level.

In all the self-reported measures the non-IT cases demonstrated greater improvement than the IT cases (see Table 1). In all measures except the HADS depression score there was an improvement for each group. However, for the IT cases there was actually an increase in the depression level.

<table>
<thead>
<tr>
<th></th>
<th>Enrolment</th>
<th>12 Months</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IT Cases</td>
<td>Non-IT Cases</td>
<td>IT Cases</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Stanford</td>
<td>4.89</td>
<td>±2.72</td>
<td>5.22</td>
</tr>
<tr>
<td>PCS</td>
<td>27.82</td>
<td>±3.80</td>
<td>32.85</td>
</tr>
<tr>
<td>MCS</td>
<td>39.45</td>
<td>±8.46</td>
<td>38.64</td>
</tr>
<tr>
<td>HADS Anxiety</td>
<td>11.33</td>
<td>±2.88</td>
<td>10.67</td>
</tr>
<tr>
<td>HADS Depression</td>
<td>5.17</td>
<td>±2.93</td>
<td>7.33</td>
</tr>
</tbody>
</table>
The triad interview data provides many insights into what influences people with COPD to decide to use an IT tool and how this affects their experience within a controlled trial. Some interview results are as follows:

- Participant’s attitudes toward computers and technology in general were found to be of mild impact on whether people used the IT tool.
- A participant’s self-image was a strong indicator of their adoption of the ICT tool.
- Participants who associated using a computer with intelligence or thought they were too old were prone not to choose to use ICT tool.
- Negative previous computer experience did not prevent adoption of the ICT tool.
- The mentors’ computer attitude and experience was not demonstrated to have any effect upon the uptake or use of the ICT tool.
- The impact of the introduction of computers and the use of the ICT tool was varied but quite pronounced.
- The impacts reported were not limited to direct project-related impacts.
- All IT cases except one reported psychosocial benefits in terms of the computer being company or a distraction.
- The actual use of the ICT tool differed between participants. Some reported benefits while others did not.
- Once participants had commenced using computers they became comfortable with the idea of using it for other purposes.

3. Discussion

The analysis of results reveals that traditional approaches would clearly and unequivocally classify the ICT tool as not having a positive effect, indeed indications of a negative effect could be considered. The value of complementing these conventional measures with more individualistic methods is revealed through the qualitative research. Significantly this highlights:

- the complexity of use experience,
- disease knowledge, and
- capacity for behavioural change.

Thus, individuals who may, from a statistical standpoint, have been overlooked actually have a highly varied set of reactions to the introduction of the ICT tool. These reactions result from the inter-relationships among many individual factors, which include severity of disease, self-image, family context, confidence, social support and disease understanding. During the twelve month project there were many different experiences. For example, one participant with severe disease who lived alone, from their own perspective, transformed their life through the use of solitaire, email and changed family status. This did lead to an upward trend in symptoms for some time even though this trend was not statistically significant. The participant continued to use the ICT tool for the duration of the project and found some benefit from it in terms of managing their disease. The participant also considered that the tool made a difference to them in terms of their quality of life.

Another participant, who adopted the ICT tool, did not manage to use the ICT tool or the computer at all. This participant had moderately severe COPD and was the
primary care provider for her husband who suffered from severe COPD. Her husband was extremely unsupportive of her participation in the project and refused to allow access to further training in the use of the ICT tool. Interestingly, this participant had a good understanding of the project and improved her self-efficacy for self-management through her participation in the project.

Thus through the use of a combined methodology and the introduction of the concept of triad interviews this research enabled us to explore more fully the experiences of people participating in a controlled trial and enhanced our ability to evaluate the effects of the introduction of an ICT tool.

4. Conclusion

This paper has presented detailed insights into the complex interactions that are revealed from the analysis of data resulting from a controlled trial. It identifies a set of factors that have an impact both positively and negatively on the outcomes and experiences of participants. This research highlights the need to consider a wider perspective and alternative methodologies when designing and evaluating e-health projects. It also indicates a need to expand our view of participant outcomes to a broader perspective of individual outcomes.

References


Toyota A3 Report: A Tool for Process Improvement in Healthcare

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Abstract. It is proposed that the A3 problem solving process be used by hospital staff to improve its healthcare workflow. A hypothetical case study is given to demonstrate the applicability and benefits of the methodology. The research results show that A3 is a useful tool for healthcare organizations seeking to continuously improve their healthcare service quality.

Keywords. workflow improvement, Toyota A3

Introduction

According to Statistics Canada, long patient wait time is the number one barrier for those Canadians who have difficulty accessing care. In addition, Statistics Canada reports that a high proportion of patients have unacceptable wait times [1]. Much research indicates the wait times are mainly caused by inefficient workflow design that contains many wasteful processes [2]. Therefore, a more efficient method, which focuses on reducing the waste in order to improve overall patient value, is urgently needed for reducing wait times and improving the quality of Canadian healthcare.

The Toyota Motor Corporation is rarely surpassed by other companies in its corporate-wide continuous improvement process. Toyota is possibly best known for its highly efficient production system that is named “lean manufacturing”, also known as “lean”. “Lean” is the set of tools (A3 reports, Value Stream Mapping, 5S, etc.) that assist in the identification and elimination of waste. As waste is eliminated, product quality improves and production time and costs are reduced. Beyond auto production, many other manufacturers and service industries have looked to Toyota for organizational insight that can be adapted to their own industry.

The manufacturing environment is totally different from the hospital environment. Would adoption of Toyota’s production system by the healthcare sector be more fruitful than other efforts? This research aims to apply “lean” thinking to improve healthcare workflow. Although many of Toyota’s tools and practices have been studied, analyzed and copied, this research focuses only on one tool – the A3 problem solving report. Toyota uses this tool to systematically guide problem-solvers through a rigorous process, to document the key outcomes of that process, and to promote improvements. This tool is used so pervasively that it forms a keystone in Toyota’s world-famous continuous improvement program.
1. The A3 Problem Solving Report

The A3 problem solving is a way to look with “new eyes” at a specific problem identified by direct observation or experience. It offers a structure that always begins by defining the issue from the customer’s perspective. The A3 report provides a framework in which to think and document specific problems and solutions [3]. The template of an A3 report includes the following components (see Figure 1):

- **Theme**
  The theme, which is clearly stated, describes the problem. The theme should focus on the problem and not advocate a particular solution.

- **Background**
  Background information is added to clarify the statement of the theme or to establish the significance of the theme.

- **Current Condition**
  Current condition, which is the most important section in the A3 report, depicts how the system currently works. “Storm bursts” are used to highlight the problems, quantify the extent of the problem (e.g., percent defects, hours of downtime, etc.), and display this information graphically or numerically. The data used to develop the diagram are collected through direct observation to prevent deviation from general or hypothetical concepts.

- **Root Cause Analysis (RCA)**
  It is hoped that the likelihood of problem recurrence will be minimized by directing remedial measures at the root cause. However, it is recognized that total prevention of recurrence by means of a single intervention is not always
possible. The RCA is an analysis structured to ascertain the root causes for the problems. The “5 why’s” method is a common technique for RCA. The final "Why?" in the analysis of each storm cloud/problem generates an implementation plan checklist. To visually view the process of the “5-why’s”, a Cause-and-Effect Diagram or a Fishbone Diagram is often helpful.

- **Target Condition**
The target condition is a hypothesis that proposes a means to eliminate the waste and to improve the process as to more closely match an ideal. A pictorial representation of the visualized new process, which uses iconic symbols, is based on the understanding of the root causes (the current state) and the countermeasures needed to address them.

- **Countermeasures**
Countermeasures describe what is needed to change the current condition to the target condition.

- **Implementation Plan**
The implementation plan describes those actions that must be performed in order to realize the target condition. The implementation plan includes three parts: the steps, the timing of the steps, and the responsible party.

- **Follow-up Plan**
The follow-up plan indicates when to measure and how to measure the improvements or results. Reasonable targets are established beforehand and the results of the new processes are measured against the specified targets to assess the magnitude of the improvement.

2 Case Study

In this section we apply the A3 problem-solving process described in the previous section to a hypothetical case. A bottleneck in a post anesthesia care unit (PACU) has been chosen as the case [4,5].

- **Theme and Background:**
Post-anaesthesia recovery is a continuous process that can not be considered complete until the patient returns to their preoperative physiological state. One-to-one care is necessary immediately following surgery because this is when complications are most likely to occur. There is a bottleneck in the recovery room. Patients are spending on average 95 minutes there before being transferred back to the ward. Patients receiving spinal anesthesia should be fully awake within 30 to 40 minutes. However, there is a large time delay from the time the patient is awake to the time they are transferred to the ward.

- **Current Condition:**
The recovery room nurse is frequently taken away from the primary duty of patient care because she or he needs to obtain an X-ray, find a surgeon to read an X-ray, retrieve supplies, or order the transfer of a patient to a ward. Sometimes, the nurse needs to leave the patient and go to a PACU station to answer or make phone calls.

- **Root Cause Analysis [5]:**
**Problem 1:** The nurse must leave a patient to retrieve an X-ray from a view box and bring it to the surgeon for interpretation. Why? X-ray is placed on view box outside of patient care area. Why? – to alert clinical staff that an X-ray has been taken. Why? - so the X-ray can be read.

**Problem 2:** The nurse must bring an X-ray to surgeon. Why? – the surgeon is not aware when X-ray is ready. Why? – the surgeon can not come to the PACU to read the X-ray.

**Problem 3:** The nurse makes frequent trips to supply room. Why? – patient care supplies are needed. Why? – not all supplies are kept at the bedside and the PACU was designed with a distant supply room.

**Problem 4:** The nurse makes and receives frequent telephone calls. Why? – there is a need for verbal communication at patient hand-over. Why? – there is no other synchronous method to convey information. Why? – there is a lack of portable (or bedside), hands-free communication devices.

**Problem 5:** There is a delay in giving a patient report at hand-over. Why? – the PACU nurse is waiting on telephone hold. Why? - because the ward nurse is not available. Why? - the ward nurse is busy in ward. Why? – the nurse must have verbal communication with the ward nurse at hand-over. Why? - there is a lack of appropriate synchronous communication devices.

**Problem 6:** There is unnecessary (duplicate) charting. Why? – there is an inefficient paper charting system. Why? – there is no automated information capture from patient monitoring devices and the EMR.

**Problem 7:** There is congested traffic flow at the PACU. Why? – the PACU has an inefficient layout.

- **Target Condition**
  The objective target is to bring greater value to the patient by making efficient and effective use of resources. For example, it is desirable that a) the amount of time the nurse is out of the PACU be minimized; b) there be few disruptions in the care process; c) there be little non-productive time and; d) communication be streamlined to support an efficient and effective workflow.

- **Countermeasures:**
  1. Implement a PACS system so that the surgeon can view an X-ray remotely after receiving a pager notification when the X-ray is ready and implement a CPOE system to enter an order for the patient to be discharged from the PACU.
  2. Redesign the PACU layout in order to minimize unnecessary staff movement and to streamline workflow.
  3. Introduce Blackberries in the PACU so that all PACU staff can use wireless email during their shift.
  4. Implement an EMR system to reduce the need for synchronous verbal communication.

- Implementation Plan (see Table 1)
- Follow-up Plan (see Table 2)
Table 2. A follow-up plan for the hypothetical PACU case study.

<table>
<thead>
<tr>
<th>Target</th>
<th>When</th>
<th>How</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACU length of stay less than 45 minutes</td>
<td>06/15/08</td>
<td>Nurses spend more time at the bedside.</td>
</tr>
<tr>
<td>40% increase in direct bedside care</td>
<td>07/01/08</td>
<td>Less time is spent charting.</td>
</tr>
<tr>
<td>35% decrease in wait time for surgery</td>
<td>07/01/08</td>
<td>Nurses spend more time at the bedside.</td>
</tr>
<tr>
<td>35% decrease in wait time for surgery</td>
<td>06/18/08</td>
<td>Frequently used supplies are kept at the bedside.</td>
</tr>
<tr>
<td>35% decrease in wait time for surgery</td>
<td>10/01/08</td>
<td>Traffic flow is improved.</td>
</tr>
<tr>
<td>35% decrease in wait time for surgery</td>
<td>06/15/08</td>
<td>By remote viewing, time for X-ray interpretation is decreased.</td>
</tr>
<tr>
<td>35% decrease in wait time for surgery</td>
<td>02/01/09</td>
<td>The need for synchronous voice communication is decreased.</td>
</tr>
<tr>
<td>35% decrease in wait time for surgery</td>
<td>07/01/09</td>
<td>Hand-over efficiency is improved.</td>
</tr>
<tr>
<td>35% decrease in wait time for surgery</td>
<td>07/01/09</td>
<td>Charting takes less time.</td>
</tr>
</tbody>
</table>

3. Strengths and Limitations of Using the Tool

The A3 tool has been successfully applied to a number of problems in a healthcare setting. The tool has many strengths.

- An efficient tool – Unlike most other approaches, the A3 report documents the actual work by observing it at first hand, which results in high accuracy and process efficiency.
- Easy to learn – A3 reports do not require long hours of specialized training. They can be drafted without a computer, using pencil and paper.
- Reduce meeting time – The A3 process is best done by a group of two to five people representing the affected parties. Staff validates and participates in the A3 process without leaving the workplace. This greatly reduces the time and number of meetings required.
- Promote knowledge sharing – When the A3 report is kept in a three-ring binder, auditors or regulatory groups, senior leaders, and staff from other departments can review activities. This promotes cross-departmental sharing of process changes and generates even more problem-solving ideas.
- Satisfied frontline workers – The A3 is easy to learn and easy to teach. Frontline workers can use it to remove the frustrations of their daily work created by weak and unsupportive processes.
Although the A3 tool can be a powerful tool for promoting fast and effective workflow improvement, it is not a magic wand. Implementing the tool requires a conscious effort, and numerous obstacles must be overcome [2].

- Need to cooperate with other tools – The A3 tool allows us to identify specific activities that we can change to improve quality and reduce waste. However, it cannot help us stand above and observe details of interruptions and delays in a process. Other tools, such as Value Stream Mapping (VSM), need to be used with it to make process reengineering a success.
- Simply problem solving – The problem solving team is usually simply making the time or cost to problem solve, i.e., the amount of time and budget needed to reduce errors and waste in the process is uncertain.
- No theoretical basis – Since there is no theoretical basis for constructing an A3 report, a different QI improving group could construct different A3 reports for identical problem situations, possibly producing a different implement plan. In addition, the statements for an A3 report are arbitrary because they are based on subjective opinions. They are characterized as ambiguous and have multiplicity of meaning.

4. Conclusion

The A3 problem solving report has been successfully adopted by manufacturers and service industries to systematically guide problem-solvers through a rigorous process, document the key outcomes of that process, and promote improvements. From a previous case study, the A3 report appears to be an objective tool that promotes communication, and integrates the specialized knowledge of individuals from different functional departments to work toward a common purpose in improving healthcare processes. However, the methodology has some weaknesses. For example, the A3 report needs to cooperate with other tools to eliminate workflow waste. It also simplifies the problem solving without a theoretical basis.

The A3 allows us to identify specific activities that we can change to reduce waste and improve quality. However, it does not tell us which activity is the most important for satisfying the requirements of patients. Further research needs to cooperate with other methodologies (e.g., House of Quality) to address this problem.

References

Mobile ICT Support for the Continuum of Care

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Abstract. The Wireless Wearable Physiological Monitor (WWPM) is designed to provide unobtrusive, regular, remote physiological monitoring of clients within their home environment. Its goal is to provide enough health support functions to enable its user to remain at home while being under a limited form of medical supervision. The WWPM solution will reduce the care burden on families and friends while providing a level of continuous care for the ill or elderly. The WWPM solution is a combination of non-invasive sensors that monitor a person’s physiological data and a two-way communication system that allows the physiological data to be sent to a central computer application. The central application can interpret the data received and automatically prompt the client to take appropriate action or alert a care provider who can intervene with the needed support. The central application is intended for use by care providers within the traditional continuum, that is, as a component in a patient’s health management or care plan. It is this combination of data, professional care and communication that will produce the medical and behavioral outcomes necessary for individuals to manage their health outside of traditional health service institutions.

Keywords. Wireless Wearable Physiological Monitor (WWPM), ICT, continuum of care, unobtrusive monitoring, home care

Introduction

Canada is a country of over 32 million people spread across almost 10 million square kilometers but a majority of population resides in urban centres. Seniors constitute one of the fastest growing groups in Canadian society. By 2041, about 23% of the population will be over 65, up from 12% in 1995. This growth in a population that requires more health care attention will only aggravate chronic health care shortages in the human resource and financial areas [1].

The WWPM project was conceived at the University of Alberta (UofA) in 2001 and the WWPM consortium was organized in 2002 with participating members including: the UofA, Capital Health, Alberta Research Council, TR-Labs, Seiko Instruments (SII) and MI Labs. Funding was provided by the Western Economic Diversification, Advanced Education and Technology (formerly Alberta Innovation and Science), and Alberta Health and Wellness.

The WWPM consortium brings together sensor technology, data, professional health care and communication infrastructure to develop a comprehensive approach to allow clients with chronic diseases to manage their health and wellness outside the
walls of traditional health care institutions. By making the individual more self-sufficient and proactive in managing their own chronic disease or maintain their wellness, the WWPM technology will reduce the need for costly treatment alternatives such as prescription drugs, doctors' visits, or hospital stays and delay admissions to continuing care such as assisted living or long-term care facilities.

Canada Health Infoway Inc. contracted Praxia Information Intelligence and Hay Group Health Care Consulting (Praxia/Hay) to develop a business case for the Telehealth program focused on home Telehealth in 2006. According to their report, continuity of care is particularly important for people with chronic illnesses, such as diabetes, asthma, congestive heart failure, and depression. Because they often see a wide range of health care providers in a variety of settings, navigating through different parts of the health system can be a challenge. The timely and accurate assessment of a patient’s condition translates into better, safer and more efficient care as the patient journeys through the health care system.

One approach to helping individuals maintain their independence and keep themselves as healthy as possible through prevention, early detection, and management of chronic conditions. New delivery mechanisms are also emphasizing care in the home as an alternative to acute care and a complement to primary care. Care in the home provides health services to individuals in their place of residence to restore health, often following an acute episode, and is also intended to maintain health status by enhancing self-management to increase independence and avoid re-admission. The empowerment of being able to self-manage a chronic illness that would otherwise erode quality of life is priceless [2].

In this paper, we summarize data from two separate clinical trials. These data were collected by senior researchers at the UofA who were not associated with the WWPM project [3,4]. Phase I: This phase was to test the WWPM system for validity and reliability in the sample population (Volunteers and Home Care Clients) Phase II: The pilot study conducted of 2004, was extended to clinical populations in Alberta Health Service Capital Health region and enhanced by including blood glucose monitoring, and messaging functions. These steps allowed the project to proceed from technical innovation to the production of a commercially viable technology that allows remote physiological monitoring of clients in their homes.

1. Phase I: WWPM System Pilot Study (Volunteer and Home Care Clients)

The primary purpose of this pilot study was to determine the acceptability (e.g., user friendliness, convenience, etc.) of the WWPM system in a sample of healthy adult Volunteers and Home Care Clients within the Capital Health region in Alberta. The pilot study was a prospective study using structured interviews as the primary data collection technique.

1.1. Sample Population and the Method

- Volunteers were recruited from the Faculty of Rehabilitation Medicine and TELUS Corporation using email, posters, and personal contact. The WWPM pulse monitoring devices were dispensed from a central location in the Faculty of Rehabilitation Medicine for University volunteers and at the downtown
business office of TELUS Corporation for TELUS Volunteers. WWPM staff provided a description of the system and obtained informed consent. Volunteers were then provided with the pulse monitoring devices. The Healthy volunteers wore the WWPM Pulse Monitor for 24 hours. All participants completed a structured interview, administered by an independent Research Assistant (either face-to-face or by telephone) within 24 hours of the end of their participation.

- Home Care Clients were recruited through Capital Health Home Care Nurses. Following referral into the project, the clients were contacted by WWPM staff and a home appointment was scheduled for WWPM system delivery. During the home visit, WWPM staff provided Home Care clients with a description of the Pulse Monitor System and the 1 X modem and obtained informed consent. All clients agreed to participate in the study.

- The equipment was installed by the WWPM Technician, and all Home Care Clients wore the Pulse Monitor for five days. Prior to installation, the WWPM devices were pre-programmed so that all Home Care clients received a message at 14:10 hours (It is time to have a rest). Within 24 hours of receiving the device, all Home Care Clients were contacted by an independent Research Assistant to determine if they had problems or questions related to the WWPM system. At the conclusion of the five day trial, the equipment was retrieved by the WWPM Technician, and all participants completed a structured, face to face interview by the same Research Assistant.

1.2. Results

A pilot study of the Wireless Wearable Physiological Monitoring (WWPM) System, as a pulse monitor, was conducted in 2004. The pilot study, which involved 47 healthy adult volunteers and 41 Capital Health Home Care Clients, concluded that end-users in both groups “were positive in terms of the acceptability and user-friendliness of the device.”

The participants were asked a number of questions related to the WWPM System. The answers, from both the Volunteer and Home Care Clients, were consistent across samples. The questions related to the:

- user-friendliness of the WWPM pulse sensor,
- clarity of the display, and
- comfortableness of the pulse sensor.

The majority of Volunteers and Home Care clients indicated that the WWPM system is user friendly. However, a greater percentage of Home Care clients were more likely to agree/strongly agree that the system was user-friendly than were the younger Volunteers ($X^2 = 6.80, p < .05$). The reason for this difference is unclear. Ratings of the time and pulse displays were high from both the Volunteers and Home Care clients. There was a significant difference in ratings between the two samples in terms of comfortableness of the sensor. A greater number of Home Care Clients indicated that the pulse watch was comfortable to wear all day long compared to those in the Volunteer sample ($X^2 = 12.15, p < .01$). The difference in ratings may indicate a positive response bias in the Home Care sample. Notwithstanding the differences, common constructive feedback on the device centered on the bulkiness of the pulse sensor (making the device too conspicuous), the nature of the strap material (e.g.,
plastic making them perspire), and the required tightness of the strap to maintain contact with the skin, especially for women with small wrists [3]

2. Phase II: Clinical trial with home care clients in Alberta Health Service Capital Health

The purpose of this study was to examine the function of the WWPM System for exchanging messages between home care clients and health professionals, and for remote monitoring of pulse and blood glucose levels. A secondary purpose was to examine the capacity of the WWPM system to detect changes in pulse in: a) community residing elderly clients during light exercise; and b) community residing healthy older adults while performing an activity of daily living.

2.1. Sample Population and Methods

- Home Care clients: A total of 101 clients were recruited. Three withdrew and 98 completed the study. Of those who remained in the study, 47 clients used the WWPM for pulse monitoring and to receive messages, and 51 diabetic clients used the WWPM blood glucose monitoring. Clients who did not understand simple instructions due to language barriers or cognitive impairment were excluded from the study.

- Community-residing elderly client exercise groups: Two groups of elderly outpatients participated in the WWPM study. One group of 7 participated in an exercise group in the Capital Care Group Norwood CHOICE program and another group of 18 participated in two exercise activity groups with the START program located at the Glenrose Rehabilitation Hospital.

- Healthy older adults: A group of 27 healthy older adults used the WWPM to measure their pulse at rest, during a self-selected activity of daily living, and at rest again post activity. The data of one participant was removed because the watch did not detect or record any pulse readings during the post activity rest period. This resulted in a final group of 26 healthy older adults.

- Health Professionals: 20 health professionals in Capital Health Home Care participated in the study by returning questionnaires that described their experiences and feedback about the WWPM System.

- Community Care Access: 8 health professionals from Community Care Access participated in the study by returning questionnaires that provided feedback on the WWPM System.

WWPM system: The core system contains three components: the Central Server System (CSS) - a hardware and software solution; the Wireless Station (WS); and the Wearable Pulse Sensor (WPS). The CSS allows a care plan to be created for any individual that has a WS and a WPS. The CSS also has programs for storing, interpreting and visualizing physiological and client response data. Finally, the CSS includes a state-of-the-art security system to ensure that the client’s data is kept secure and private at all times; and that only authorized personnel can access the relevant data. The security mechanisms were designed to conform to American and Canadian privacy legislation standards.
The WS serves as a hub in the physical location where the client needs to be monitored (typically the home). The WS provides a wireless Personal Area Network (PAN) connection to the WPS which, in turn, can be connected to the Internet over a variety of interfaces and. The WPS captures a client's physiological data, such as pulse rate, on a pre-defined schedule, or as requested by the client, and transmits the data to the WS. The data is sent to the CSS for monitoring by a health care provider. The WPS can also alert clients when other measurements, such as blood glucose levels, should be taken. The WPS, via the WS, provides two-way communication that allows a client to receive instructions (e.g., take your medication) or send requests or concerns to a call centre as required, such as when they are not feeling well, or require medical attention. The system design allows for significant flexibility in the configuration of the components, based on the needs of various care providers and their clients [5].

2.2. Results

This trial followed up on some of the recommendations made in the pilot study, specifically, meaningful messages were used, and blood-glucose monitoring was incorporated as an additional modality to pulse among Home Care clients. The capacity of the system to detect changes in pulse from rest to activity to rest again, was also examined using two groups of community clients accessing outpatient health services and a group of healthy older adults. (Table1)

- **Acceptability and comfort of the WWPM watch** - Although the majority of Home Care and healthy participants agreed that the watch was easy to put on and take off, fewer thought it would be comfortable to wear all the time. Suggestions for improvement include a smaller watch, more comfortable strap, louder sound and easier to read text message with better contrast and larger font.
- **WWPM as a pulse monitoring** - The instrument was able to detect pulse in most participants, however, in some cases; it did not always provide pulse readings during the entire time participants were monitored. The fit of the watch may have been a factor. Movement was another factor because the instrument was not designed with a motion cancellation capability. In all cases, the technology was able to transmit pulse data wirelessly to a server either during home visits with individual clients, or with up to 10 clients simultaneously participating in an exercise class.
- **WWPM for blood glucose monitoring** - Overall, the Home Care participants and health professionals who used the WWPM for blood glucose monitoring thought that the system worked well. The wireless feature of this technology is unique and this was the first evaluation of its application with the WWPM.
- **WWPM as a messaging system** - Participants and health professionals thought that the concept was a good one for reminding clients to take medication and check their blood-glucose levels. The call button feature was disabled early in the trial; therefore, future research on this feature should address the practical issues. Suggestions from participants and health professionals include louder buzzer for older adults, most of whom have a degree of hearing impairment and may not be in the same room as the device.
Table 1. Home Care participants’ opinions about the WWPM (non-diabetic and diabetic groups combined).

<table>
<thead>
<tr>
<th>Items in Interview (number of respondents)</th>
<th>Agree or Strongly Agree n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watch easy to put on (89)</td>
<td>70 (79.6)</td>
</tr>
<tr>
<td>Watch easy to take off (91)</td>
<td>83 (91.2)</td>
</tr>
<tr>
<td>Watch comfortable to wear all day (98)</td>
<td>61 (62.2)</td>
</tr>
<tr>
<td>I was able to hear the beep (60)</td>
<td>22 (36.7)</td>
</tr>
<tr>
<td>Display easy to see (98)</td>
<td>86 (87.8)</td>
</tr>
<tr>
<td>Text messages were easy to read (65)</td>
<td>44 (66.7)</td>
</tr>
<tr>
<td>Text messages were helpful (62)</td>
<td>47 (75.8)</td>
</tr>
<tr>
<td>“Yes” and “No” buttons were easy to use (86)</td>
<td>74 (86.1)</td>
</tr>
<tr>
<td>Important to have pulse monitored regularly (98)</td>
<td>37 (37.8)</td>
</tr>
<tr>
<td>Would keep watch if possible (97)</td>
<td>49 (50.5)</td>
</tr>
<tr>
<td>Wireless station was easy to use (93)</td>
<td>70 (75.3)</td>
</tr>
<tr>
<td>I was able to hear the voice message (59)</td>
<td>51 (86.5)</td>
</tr>
<tr>
<td>Wireless station had a pleasant reminder (81)</td>
<td>71 (87.7)</td>
</tr>
<tr>
<td>Voice messages were useful (79)</td>
<td>58 (73.4)</td>
</tr>
<tr>
<td>Wireless station did not interfere with décor of house (98)</td>
<td>80 (81.6)</td>
</tr>
<tr>
<td>Would keep wireless station if possible (98)</td>
<td>47 (47.9)</td>
</tr>
<tr>
<td>Glucose monitor was easy to use (50)</td>
<td>45 (90)</td>
</tr>
<tr>
<td>Useful to send glucose readings to home care staff (51)</td>
<td>30 (58.8)</td>
</tr>
<tr>
<td>Would keep glucose monitor if possible (48)</td>
<td>20 (41.7)</td>
</tr>
<tr>
<td>Glucose monitor used with wireless station was different from personal monitor (yes) (50)</td>
<td>40 (80)</td>
</tr>
<tr>
<td>Prefer to use own glucose monitor with wireless station (no) (36)</td>
<td>22 (61.1)</td>
</tr>
<tr>
<td>Feel more independent with continued use of system (95)</td>
<td>41 (43.2)</td>
</tr>
<tr>
<td>Feel safer with system (97)</td>
<td>61 (62.9)</td>
</tr>
<tr>
<td>Greater peace of mind being monitored? (87)</td>
<td>53 (60.9)</td>
</tr>
<tr>
<td>Would you pay a monthly fee for this service? (yes) (88)</td>
<td>58 (65.9)</td>
</tr>
<tr>
<td>If yes, what amount would you pay for this device and service? (55)</td>
<td></td>
</tr>
<tr>
<td>$50</td>
<td>9 (16.4)</td>
</tr>
<tr>
<td>$40</td>
<td>4 (7.3)</td>
</tr>
<tr>
<td>$25</td>
<td>26 (47.3)</td>
</tr>
<tr>
<td>$10</td>
<td>16 (29.1)</td>
</tr>
<tr>
<td>Another organization should pay for this service (yes) (84)</td>
<td>61 (72.6)</td>
</tr>
<tr>
<td>Would buy/rent and pay for service (10)</td>
<td>5 (50.0)</td>
</tr>
<tr>
<td>Would buy equipment if service free (10)</td>
<td>6 (60.0)</td>
</tr>
<tr>
<td>Would rent equipment if service free (10)</td>
<td>7 (70.0)</td>
</tr>
<tr>
<td>Would pay for service if equipment free (10)</td>
<td>7 (70.0)</td>
</tr>
</tbody>
</table>

- User-interface - Health professionals ranged in their ability to learn to use the WWPM software. The main issue was related to integration of the WWPM software with current on-screen displays used by the CCA staff. Future development of the WWPM should take into consideration how its software integrates with existing software [4].

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1 The maximum number of respondents was 98. The number of participants who responded to an item on the interview question may be low and, therefore, not be representative of the entire group of participants, in this case, home care clients.
3. Discussion

There is a surge of interest in using wireless wearable physiological sensors or biosensors in health care; military; fitness; tracking children; etc.

We have shown that it is possible to integrate clinical home care and wireless networking as a new way of collecting physiological data. Unobtrusive, wearable sensors will certainly allow us to collect large volume of data, and mine the data for new information over time. We may find significant individual differences in how patients' bodies respond to medications, to medical treatment, to the emotions of others, to food they eat, and to their environment. A new generation of wireless wearable physiological sensors may fundamentally change the future of health care.

According to the Canada Infoway, Home Telehealth Business case report, a combination of infrastructure and services are necessary for telehomecare support:
1. **Client** – condition-specific hardware and services required to support the management and monitoring of their conditions in each of the populations being considered.
2. **Central Systems** – Applications used by clinicians in the management of multiple clients through a centralized monitoring service and mobile clinical staff providing local support to these clients.
3. **Communications Network** – Hardware, software, network and communications infrastructure necessary to deliver services as well as the operational support to maintain the integrity of the system.
4. **Provider Devices & Care team Activities** – Hardware required to support the delivery of care to clients enrolled in the telehomecare service, as well as to support client-to-provider and provider-to-provider information sharing [2].

The WWPM provides these four elements. It has been shown to be valid and reliable, and received positive feedback from clinicians and Capital Health clients.

This project was transferred, in 2008, from the UoA to Redengine Health, a company created as a result of this research, under the leadership of Mr. Tom Ogaranko, President. Redengine Health will continue developing and testing a commercial version of the technology in various regions in Alberta, throughout Canada and Asia in 2009.

References

An EHR-Based Paradigm Shift in the Operation of Mental Health and Addiction Services

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Abstract. This paper responds to a commonly expressed belief, or perhaps hope, that full implementation of the electronic health record (EHR) will promote a “paradigm shift” in the delivery of health services, enhancing both service system efficiency and effectiveness in ways that would not have otherwise been possible. A model is proposed that defines stages in the development of the EHR in terms of two sets of functional components: 1) information management tools used to support the delivery of care; and 2) decision support tools that use information drawn from the EHR to promote functional integration among the components of complex service systems. “Paradigm shift” is defined operationally within this framework in terms of evolution of the EHR through these stages. The concept of “clinical interoperability” (anchored in a semantically interoperable EHR) is elaborated upon and presented as the sine qua non for a distinctive form of paradigm change that centres on support for care delivery within any given location in the system, and on EHR-based support for client movement through the system. The Vancouver Island Health Authority/Infoway Bridges, now deployed across the full array of hospital and community-based mental health and addiction services, is an example of an EHR that leverages the semantically interoperable components of an EHR to support a paradigm shift in clinical interoperability for the mental health and addictions service system.

Keywords. EHR, framework, information management, decision support, clinical interoperability

Introduction

The Bridges initiative in the Vancouver Island Health Authority (VIHA) is organized around an electronic health record (EHR)-based clinical/business intelligence solution that has been operational within Mental Health and Addiction Services (MHAS) since March, 2008. This initiative was undertaken as a partnership between VIHA, Canada Health Infoway (Innovation and Adoption Program), and Strata Health Solutions Inc. The solution builds on the Cerner EHR platform in VIHA and has been deployed across the full array of MHAS-operated services, in hospital and community sectors.

The Bridges implementation consists of four tightly-coupled elements. 1) The entire solution builds on a foundation of the clinicians’ knowledge, abstracted and registered in the EHR system through the use of structured clinical documentation tools. 2) The documentation tools supply data drivers for service system navigation and decision-support functionality. The decision support tool employs a matching logic that maps profiles of scores on the documentation tools into the array of MHAS services.
3) The solution also distributes a condensed view of clinical information from the EHR to referral recipients. The objective is to ensure timely and appropriate decisions regarding service access, and to secure a foundation for continuous care spanning encounters and sectors within the service system. 4) data from the clinical documentation and service system navigation tools flow into the VIHA data warehouse to support the construction of an outcome-based business intelligence solution that is populated with information about client clinical/functional status, service requirements and treatment outcomes along with data regarding system capacity to meet client needs. As longitudinal data accumulates, this information will be used to construct risk-adjusted clinical outcome measures expressed directly as change in status over time. This information, in turn, will be used to populate an outcome-adjusted demand estimation framework.

1. What Is Meant by the Term “Paradigm Shift”? 

Any reference to “paradigm shift” is appealing, at least implicitly, to the notion elaborated by Thomas Kuhn in his seminal work, *The Structure of Scientific Revolutions* [1]. Kuhn defines a paradigmatic way of thinking as a set of ideas accompanied by a set of assumptions or condition, in terms of which a body of thinking would be considered reasonable or rational. As disconfirming observations accumulate, the dominant paradigm is thrown into crisis. A new paradigm emerges when key underlying assumptions are challenged, and replaced with new ideas that support a theory that accounts for all observations.

There are two ways in which a paradigm shift could be said to occur:

- The first involves a change in the underlying rules or assumptions that govern a system of thought or action. In the case of health information management, granting clients write access to their health record would constitute such a shift.

- The second is a developmental shift, in the sense that cognitive-developmental psychologists such as Piaget [2] use the term to describe the stage-sequential aspects of the development of intelligence. This is a two-phase process: The first phase entails the emergence of functionally distinct and specialized subsystems of thought or activity. The second phase involves hierarchical integration (functional subordination and regulation) of lower-order subsystems within a higher-order set of mechanisms or processes. What is distinctive of this type of “paradigm change” is that the operational characteristics of subsystems are preserved, but they are brought together operationally into a functionally integrated whole that displays characteristics that are not fully evident in any of the component parts. Assembling a frame, handle bars, two wheels, a drive train, a seat and brakes to form a bicycle would be an example.

The model proposed in this paper characterizes EHR-based paradigm shift within the health service system in terms of a stage-sequential development process, marked by specification of discrete domains of EHR functionality, followed by the construction of tools that bring together previously disconnected elements into a whole that displays novel characteristics.
2. A Model for Characterizing Paradigm Change within the EHR

The model proposed in this paper defines stages in terms of four characteristics:

1. Representation of clinicians’ knowledge as discrete data (versus free text) – this is necessary for the clinicians’ knowledge to supply data drivers for decision-support functionality. The assumption here is that current applications associated with structured clinical vocabularies such as SNOMED CT are not yet able to abstract sufficient semantic content from clinicians’ free text narratives to eliminate the need for structured clinical documentation tools to supply data drivers for decision support functionality in the EHR.

2. Representation of functions performed by clinical services or programs as discrete data.

3. Pull (clinician-initiated) versus push-based (technology-initiated) information access.

4. Decision support functionality – this may consist of basic functions such as alerts warnings or reminders; or it may entail more complex functions such as intelligent service system navigation tools.

Table 1 depicts the first two stages in the model. Stage 1 leverages off of the benefits associated with consolidation of clinical information from disparate sources into a single clinical data repository, even if clinicians continue to document as free text. Stage 2 leverages off of the functionality enabled by order entry and the codification of standards and care paths into the EHR. Some of the key benefits include medication error trapping and chronic disease management support for individual clients and caseloads.

Table 2 depicts Stages 3a and 3b. These stages are elaborated when standards-based tools are put in place to enhance the EHR’s knowledge of clients and the system that provides for their needs. Stage 3a focuses on benefits associated with synoptic reporting, where standards-based tools are used to capture key portions of the clinicians’ knowledge according to a structured documentation protocol. Stage 3b focuses on benefits associated with the creation of searchable service registries.

The principle shortcoming of stages 3a and 3b arises when the standards-based language used to describe clients (Stage 3a) does not map tightly onto the language used to classify services (Stage 3b). Until that mapping is established, there will be strict limits to the realization of a potential inherent in the EHR to provide intelligent support for client navigation through a service system. This may not be a needed capacity for all areas of healthcare, but it is very relevant for the complex network of clinical services for mental health and addictions populations and it is equally relevant for the complex network of services for seniors.

The hallmark characteristic of a Stage 4 implementation (see Table 3) is the convergence of the standards-based languages used to describe clients (in a Stage 3a configuration) and providers or services (in a Stage 3b configuration). When both are described using the same set of standards-based constructs (i.e., when the semantic core of Stage 3a functionality and 3b functionality are mapped onto one another), it becomes possible to elaborate a matching logic that connects profiles of scores on standards-based documentation tools to inventories of services whose inclusion/exclusion criteria have been expressed using the same set of standards.

Explicit formulation of such a client-service matching logic enables the implementation of intelligent service system navigation tools. Such a configuration
would provide enhanced support for continuity of care as clients move through the system and it would also enhance functional integration of the components of an array of different clinical services.

Table 1. EHR implementations with limited registration of the clinicians’ knowledge as discrete data.

<table>
<thead>
<tr>
<th>Stage 1 – Clinical Data Warehouse</th>
<th>Functions</th>
<th>Information Management</th>
</tr>
</thead>
</table>
|                                  | Automating workflow and consolidation of clinical information from multiple sources | - Clinical data repositories populated with two types of data:  
  - Discrete data limited to another machine’s knowledge of the client (e.g., lab results)  
  - Clinicians’ knowledge of client, rendered as free text (e.g., transcribed dictations)  
  - Passive access to information – it is available to be viewed by clinicians who search for it in the EHR  
  - Messaging – Inbox functionality, with limits on intelligent messaging set by limited capture of clinical information as discrete data.  
  - Clinical interoperability – dependent on clinician searching out pertinent clinical information |
|                                  | Navigation, Referral | Scheduling, appointments capitalizing on access to remotely located appointment books |
|                                  | Benefits |  - Single point of access to information from multiple providers and locations  
  - Efficiency – e.g., streamlined sharing of information  
  - Eliminate redundancy, e.g., duplicate lab tests |
|                                  | Examples | EHR implementation with ADT functionality, laboratory results, Picture Archiving and Communication Systems (PACS), transcribed documents, progress notes |

<table>
<thead>
<tr>
<th>Stage 2 – Coding Orders and Diagnoses; Clinical Alerts; Chronic Disease Management Solutions</th>
<th>Functions</th>
<th>Aligning practice with codified standards</th>
</tr>
</thead>
</table>
| Information Management |  - Clinician knowledge represented partially as text, partially as discrete data in the form of orders  
  - Potential to reconcile codified indicators of clinical practice (e.g., orders) with established standards, e.g., Computerized Prescriber/Physician Order Entry (CPOE)  
  - Information push keyed to information registered as discrete data  
  - Reminders  
  - Intelligent Inbox functionality (e.g., out-of-range lab values) |
| Navigation, Referral | Scheduling, appointments – as in Stage 1. |
| Benefits |  - Error trapping – aligning practice with established and codified standards  
  - Foundation elements for chronic disease management solutions |
| Examples | Computerized Prescriber Order Entry (CPOE) with error trapping; Chronic disease management solutions that monitor order completion and indicators of clinical status to enhance care management for clients and caseloads |

3. Stage 5 Clinical Interoperability – A Paradigm Change in Health Service Delivery

Here, we work from the definition of paradigm shift as a developmental change involving the functional integration of discrete components into a higher-order entity. By integrating Stage 3a and 3b functionality through the use of tools that leverage off of a standards-based client-service matching logic, a paradigm shift would have taken
place at the level of semantic interoperability. What remains is to link those tools to changes in service delivery processes – that would constitute a paradigm change in the delivery of care, in which semantic interoperability of information systems gives rise to what might be termed “clinical interoperability” among diverse elements of a service system (see Table 4).

Table 2. EHR implementations with standards-based coding of clinically pertinent contents.

<table>
<thead>
<tr>
<th>Stage 3a – Synoptic Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Functions</td>
</tr>
<tr>
<td>• Decision support driven by the clinicians’ knowledge captured with structured, standards-based documentation tools</td>
</tr>
<tr>
<td>• Clinically contextualized alerts</td>
</tr>
<tr>
<td>• Indexing of clinical information supports searches for clinically relevant information</td>
</tr>
<tr>
<td>• Data for comprehensive electronic medical summaries</td>
</tr>
<tr>
<td>• Data required to support the creation of clinically robust business intelligence solutions</td>
</tr>
<tr>
<td>Information Management</td>
</tr>
<tr>
<td>Documentation organized around clinical minimum data sets:</td>
</tr>
<tr>
<td>• Standardized nomenclature to capture clinicians’ knowledge</td>
</tr>
<tr>
<td>• Scope of documented content is specified</td>
</tr>
<tr>
<td>Navigation, Referral</td>
</tr>
<tr>
<td>Scheduling, appointments as in Stage 1, though better ad hoc support for transitions of care as a function of streamlined access to a consistent body of documentation</td>
</tr>
<tr>
<td>Benefits</td>
</tr>
<tr>
<td>• Efficiency – reduce/eliminate transcription</td>
</tr>
<tr>
<td>• Scope of documentation conforms to best practice standards</td>
</tr>
<tr>
<td>• Enhanced ability to search for information on the basis of clinical relevance</td>
</tr>
<tr>
<td>• Information foundation laid to support continuity of care</td>
</tr>
<tr>
<td>• One component put in place intelligent access/referral decision support functionality</td>
</tr>
<tr>
<td>Examples</td>
</tr>
<tr>
<td>Web Surgical Medical Records System, Alberta</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 3b – Resource Registries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Functions</td>
</tr>
<tr>
<td>Searchable resource directories</td>
</tr>
<tr>
<td>Information Management</td>
</tr>
<tr>
<td>• Resource directories classified in terms of service provider type, clinical focus or intervention type (e.g., alcohol treatment), function (e.g., post-withdrawal stabilization), or mode (e.g., hospital-based inpatient)</td>
</tr>
<tr>
<td>• Information required to make final decision around service appropriateness is likely to be rendered as free text</td>
</tr>
<tr>
<td>Navigation, Referral</td>
</tr>
<tr>
<td>• Clinician-initiated search of resource directory using key terms</td>
</tr>
<tr>
<td>• Clinicians must navigate down through layers of a service taxonomy and/or search through text-based service descriptions to ascertain goodness-of-fit for client needs</td>
</tr>
<tr>
<td>Benefits</td>
</tr>
<tr>
<td>Enhanced capacity to locate resources</td>
</tr>
<tr>
<td>Examples</td>
</tr>
<tr>
<td>Alliance for Information and Referral Systems, which ties in with the AIRS/222 LA County Taxonomy of Human Services</td>
</tr>
</tbody>
</table>

To achieve clinical interoperability and functional integration of the component parts within a network of clinical services, assuming a Stage 4 implementation has been developed, the following conditions need to be met:

1. Cross-trained clinicians – clinicians must share a core set of understandings around the ways in which different clinical presentations are documented in the semantically interoperable Stage 4 EHR. As essential part of this cross-training involves an understanding of why different services are appropriate/inappropriate for clients fitting different clinical profiles.
2. Consensus around appropriate use of Stage 4 documentation/service system navigation tools – semantic interoperability will not translate into clinical interoperability unless clinicians use the Stage 4 tools in a consistent fashion. To support convergence and consistency in the use of the Stage 4 solution, data can be extracted from the synoptic reporting tools and the service system navigation tools to paint a picture of consistency and appropriateness of use. The Bridges implementation makes use of such approaches to support change management.

For VIHA/MHAS, there are potent internal drivers that are positioned behind the decision to build and implement the Bridges EHR-based documentation and access/referral decision support tools. Within MHAS, a paradigm shift in the direction of clinical interoperability is regarded not as an “elective procedure” but as a piece of work that must be accomplished to enable the service system to address more effectively the needs of some of MHAS highest need/highest risk clients. The need for a paradigm shift is a consequence of the joint interplay of five factors:

1. Client characteristics - The MHAS service system has evolved to meet the needs of many but not all priority subpopulations. The system is particularly challenged to meet the needs of clients with severe substance abuse/addictions issues, or clients with concurrent mental health and addictions issues - populations that are at high risk for homelessness, very high rates of serious health problems, spread of various infectious diseases, and entanglement with the criminal justice system. It is generally estimated that approximately 50% of the clients with severe mental health problems are also affected by a concurrent substance abuse problems.
2. Structure of the MHAS service system – Because no one profession or service location can provide a complete package of services for the more seriously concurrently impaired populations of MHAS clients, MHAS has had to develop a differentiated array of services. The complexity of the system of hospital and community-based services mirrors the clinical complexity of the clients.

3. Dynamic of client movement through the network of services – priority MHAS clients are precisely those that are difficult to stabilize and are prone to frequent crisis-driven moves through the network of services, including medical services. Decisions around where a client needs to be positioned in the system often take place under time constraints, which adds to the challenge of navigating clients through the system.

4. Within the broad array of MHAS services, much of the care provided to clients is directed by clinicians from a variety of disciplines who differ according to their knowledge and skill in the areas of assessment, diagnosis and treatment. Within that pool of providers, maintaining standards around health information management can become an issue unless active steps are taken to promote standards.

5. Status of the health record – a large numbers of different geographically dispersed services will inevitably evolve into a comparably large number of different methods for managing health information. The result is a deeply fragmented health record marked by inconsistencies in content and business process associated with documentation.

Table 4. Clinically interoperable service system supported by a semantically interoperable EHR.

<table>
<thead>
<tr>
<th>Stage 5 – Clinical Interoperability Supported by Semantically Interoperable EHR Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potential Functions</strong></td>
</tr>
<tr>
<td>- Continuity of client care across multiple encounters involving different service types and different clinicians</td>
</tr>
<tr>
<td>- Functional service system integration through system-wide deployment of clinical knowledge management tools and service system navigation tools</td>
</tr>
<tr>
<td><strong>Information Management</strong></td>
</tr>
<tr>
<td>- For groups of clinicians and services: common elements of clinical practice spanning multiple services is mirrored by core contents covered in synoptic reporting tools deployed across the network of services</td>
</tr>
<tr>
<td>- Feedback regarding consistency in use/interpretation of terms composing the clinical minimum data set: referral activities on the sender or receiver side provide an indicator of the extent to which there is a shared understanding of the terms in the minimum data set among a community of clinicians.</td>
</tr>
<tr>
<td><strong>Navigation, Referral</strong></td>
</tr>
<tr>
<td>- Single referral mechanism for an array of service providers</td>
</tr>
<tr>
<td>- Service agreements among providers can be mirrored in configuration of rules around access and referral</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
</tr>
<tr>
<td>- More effective care for complex clients who access multiple services and move frequently throughout the network of services</td>
</tr>
<tr>
<td>- Data sources for clinical business intelligence solution span the full service system</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
</tr>
<tr>
<td>Bridges implementation in VIHA Mental Health &amp; Addiction Services – Synoptic reporting tool linked to access/referral decision support functionality; need/risk/outcome-based evaluation/planning tools</td>
</tr>
</tbody>
</table>
4. VIHA/Infoway Bridges Implementation

The challenges involved in managing health information across a broad array of services and professions are daunting and the issues that must be surmounted to knit together at the component pieces of the MHAS service system into an effectively integrated network are comparably challenging. However, an analysis of the information management requirements for an effectively integrated service network within MHAS points to a parsimonious information management solution strategy consisting of three broad components:

1. A consistent method for abstracting the clinicians’ knowledge of clients at the point of service and registering that knowledge in the EHR.
2. A single method, employed by all MHAS providers and locations, for intelligently managing client flow throughout the complex and changing network of MHAS services.
3. Clinically robust business intelligence infrastructure - MHAS does not hold all of the answers on how to provide an effective service to its most challenging client populations and promising practices are very expensive. A system that better meets needs will emerge through successive iterations, with progress heavily dependent on the ability to guide the process on the basis of information about what strategies are working for which subpopulations. This knowledge lives with the clinicians and, if their knowledge is not abstracted and registered in an analyzable form, the capacity for the MHAS system to learn and evolve from experience will be impacted.

Figure 1 depicts the major elements of the Bridges solution to these sets of requirements:

1. The entire Bridges solution is organized as a synoptic reporting tool, consisting of standards-based data elements and text fields. This reporting tool (the VIHA/MHAS Clinical Profile version 7.0, referred to hereafter in this document as “the CP”) functions as a clinical minimum data set for all MHAS adult services. It is designed around the British Columbia Ministry of Health’s draft Minimum Reporting Requirements (MRR) for Mental Health and Addiction Services, which incorporates the Health of Nation Outcome Scales (HoNOS), a heavily evaluated tool that was developed by the UK’s Royal College of Psychiatrists. In the Bridges CP, the MRR is supplemented strategically with data elements identified by the majority of MHAS clinicians as essential components of an assessment of any MHAS client. The CP (complete with text fields) takes roughly 25 to 35 minutes to complete for new clients. For reassessments that pull forward data from earlier CP’s, the tool takes five to 10 minutes to complete.
2. Complete inventory of VIHA/MHAS delivered or contracted services (approximately 292 service entities), each with a standard description that is viewable via point-and-click functionality in the solution.
3. Matching logic – the MHAS services are grouped into 45 categories on the basis of homogeneity of inclusion/exclusion criteria. The matching logic for the Bridges solution consists of the inclusion/exclusion criteria for each service category, expressed in terms of profiles of scores on the CP items. 31 CP items are sufficient to specify the matching logic for all 45 categories of service.
4. Access/referral decision support – Strata Health Solution’s PathWays access/referral tool is overlaid on the MHAS Client/Service Matching Logic in order to inform clinicians regarding goodness-of-fit between the clinical profiles of their clients and the inclusion/exclusion criteria of services.

5. Clinical information push – to ensure that referral decisions are appropriately informed, the PathWays tool pushes the appropriate information to the referral recipient, based on the information the referral sender has sent to PathWays to drive the access/referral decision support functionality.

6. Single access mechanism – the CP is used by all MHAS services to convey the information required by referral recipients, and PathWays is the single referral mechanism used by all services to manage client referrals.

7. Messaging - PathWays manages communication between referral sender and referral recipient so that the referral sender has an up-to-date picture of any actions that have been taken by the recipient on behalf of a referred client.

8. Business intelligence infrastructure – all data from the CP concerning client demographics and clinical status are sent to the VIHA data warehouse. As well, all information about referral activity from PathWays flows into the data warehouse. This information, together with other data that resides in the warehouse, provides a clinically rich foundation for evaluation, planning and performance monitoring.

5. Does Implementation of Bridges Entail a Paradigm Shift?

This question is reframed by asking whether the Bridges implementation involves changes that can be characterized in terms of the model of stages in the development of EHR functionality. Deploying the CP in the Cerner enterprise EHR environment can be interpreted as a Stage 3a implementation. Creation of a service registry and
classification of those services is characteristic of Stage 3b functionality. The implementation of access/referral tools that are anchored in a unified structured clinical vocabulary that is employed to describe both clients and services is definitive of a Stage 4 implementation. Full uptake of these tools by all providers in all programs could be reasonably interpreted as a paradigm shift to clinical interoperability anchored in semantically interoperable documentation and service system navigation tools.

When the Bridges tools were deployed in March, 2008, MHAS entered into the process of transitioning to Stage 5 clinical interoperability. There has been little resistance to the implementation of the access/referral tools. However, the final challenges centre on those clinicians and disciplines that remain committed to pure text-based documentation methodologies, most notably psychiatrists working in the system (though this issue is by no means restricted to that discipline).

Clinician reluctance to adopt standards-based documentation practices may relate, at least in part, to the fact that benefits associated with such documentation methodologies may have not been presented in a cogent fashion. Clinicians have little or no basis for envisioning the work that their knowledge could accomplish in an EHR environment if their knowledge were registered as discrete data. Hence, they have little concrete incentive for engaging in substantial changes in documentation practice. The stage sequential model laid out in this paper helps to clarify the limitations associated with text-based documentation in the EHR environment and it is intended to treat systematically the question of what benefits might accrue with a more thoroughgoing shift to synoptic reporting methodologies. It is hoped that this type of information will contribute to the dialogue around physician engagement with the EHR by clarifying some of the ways in which their considerable knowledge of client needs, risks, and outcomes can do work on behalf of clients and the service system that could never be accomplished with purely text-based documentation.

References

Potential Return on Investment (RoI) on web-based Diabetes Education in UK

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Abstract. The incidence of diabetes mellitus is growing in the UK. As most diabetes care is performed by the patients themselves, structured education is one way to encourage their responsible participation in delivering effective care. Continuous e-learning by Internet has proven to be a useful method of diabetes education. “Return on Investment” (RoI) can be used as an indicator of the cost-benefit of web-based education. RoI is the ratio of money gained or lost on an investment relative to the amount of money invested. This report uses system dynamics modeling to predict the flow of patients in the educational system and the cost of their care. The analysis compared traditional and web-based education. Separate models were developed for each educational method and simulated until 2020 in one year intervals. The population of diabetic patients was adjusted at each cycle according to anticipated incidence and mortality rates. The population of educated diabetic patients was based on the educational capacity and literacy limits of each method. A report by the National Health Service (NHS) was used to calculate the cost of care by considering the cost difference between uneducated and educated patients. By 2020 with an annual rate of inflation of 3%, the annual cost of care is projected to increase to £3.67 billion for the traditional model as compared to £3.39 billion for the web-based model. RoI is estimated to be a ratio of 32.33. Investment in web-based diabetes education is not only a health benefit but also a reduction in care cost.

Keywords. return on investment, diabetes, web-based education, e-learning

Introduction

Diabetes mellitus is a growing chronic disease characterized by high level of blood glucose which is caused by the inadequate secretion of insulin hormone or a problem in receptors of this hormone on the target cells. Diabetes prevalence in UK is 3.66% and its incidence rate is 0.33%.

Diabetes complications involve different parts of the body like eyes, kidneys, and the nervous and cardio-vascular systems. These complications significantly increase the cost of diabetes care. Due to the high prevalence of complications and costly treatments for them, diabetes care is one of the most budget-consuming parts of the health care in many countries like UK. Any method that can reduce these complications and cost of diabetes care can be very beneficial.

There is good evidence that better control of the blood glucose level near normal range can decrease the risk of these complications. A major part of the care in diabetes is controlling the caloric intake and oral or injection treatment which is performed by

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the patients themselves. As a result, one of the best ways to achieve control on blood glucose level is increasing the patient’s responsibility for better control of their disease. Because of this self-responsibility target, patient education is considered as one of the important components of diabetes care. Structured education of patients has proven to be effective in diabetes management, decreasing the HbA1c level of the patients which is an indicator of middle-term (120 days) control of blood glucose level.

Return on Investment is the ratio of money gained or lost on an investment relative to the amount of money invested. This variable can be utilized as a good indicator of the cost-benefit of methods in education for diabetes.

1. Review of the literature

According to a report from the Department of Health the cost of diabetes care in UK is £5 million per day. Control of diabetes can significantly reduce this cost because the management of complication in diabetes has the highest cost in diabetes care. Wagner et al [1] showed that this cost reduction is 7.5% per each percent reduction in HbA1C. Structured education has shown to be able to reduce 1.6% of HbA1C [2,3].

In a randomized clinical trial in 2007 Ko et al [4] evaluated diabetes education in long-term follow up of the educated patients and concluded that the efficacy of education is not long-lasting and the difference between HbA1c level of the educated patients and the control group will not remain significant after one year. Other research agrees with this finding [5,6]. There were suggestions that continuous reinforcement may prevent this relapse [7]. Bloomgarden et al supported this hypothesis in their study [8].

Educational capacity for diabetes in UK is limited and, considering the reports from Diabetes UK and Healthcare Watchdog, the increase in coverage of structured education between 2005 and 2007 was 1.5% per year. A single course for diabetic patients is insufficient because, as the 2007 report of the Healthcare Watchdog indicates, only 11% of the patients are already educated. Assuming that the number of patients waiting for education remains at a constant level (first-come, first-served) in the traditional model, it would take nearly 60 years for a recently diagnosed diabetic patient to attend an education course. This shows that an alternate method for patient education is needed.

[E]-learning via Internet has been used for many years in different courses as a wide spread and efficient way of education. This system has proven to be useful for diabetes education by many researchers. Facilitating this method of education can be a big step forward in diabetes care. A report from “UK Office of National Statistics” shows that 61% of UK households have access to Internet, so a considerable percentage of diabetes patients can be covered by web-based education.

Literacy could be considered as a barrier for self education via web. In this research coached education by parents are not included because there is no quantitative evidence about this support. Based on this assumption 12.5% of the UK population who are below 10 years old are considered not suitable for this method of education. Also, there are some people who do not like to use high-tech systems for any reason. This group is considered as technology-refusing and, according to a report from a similar web-based education in USA, the percentage of flow toward this level is considered to be 18.72% [9]. Another limiting factor for diabetic patients is the
mortality rate. Based on a diabetes UK report, this rate in diabetes is five times more than normal mortality rate which gives the assumption of 4.1% in UK.

Most of the similar previous projects were retrospective and did not give the financial prospect of future. This article is trying to demonstrate this prospect by modeling of diabetes education.

2. Method

There are many interrelated factors affecting diabetes education and the cost reduction resulting from it which makes it a complicated model. In this study, system dynamics modeling is used to predict the flow of the patients in education system and the cost of care comparing traditional and web-based educational systems.

PowerSim version 2005 was used for developing and simulating the models. Separate models were developed for each educational method and variables affecting these educational systems were included in those models. For a long prospect the models were simulated until 2020. Because most variables affecting this system have an annual basis, the system is calculated with one year interval.

In both models, there is a level object for UK non-diabetic population, which is increased by population increase rate. This population increase is the overall effect of birth rate, mortality rate, immigration and emigration. Patients will be transferred from this level to “Un-educated Diabetic Population” level according to “Diabetes Incidence Rate”. “Diabetes Mortality Rate” is a restricting factor which decreases this level.

This level is affected by different behaviors in developed models. In the traditional education model, patients shift from this level to “Educated Diabetic Population” based on the mentioned education rate, but fall back to the uneducated level after one year according to evidence in a review of literature.

In a web-based education model (Figure 1), initially a group of patients leave this level to “Education Refusing Population” for separating them from the group that intend to receive education, from whom the ones above 10 years old will climb to “Educated Diabetic Population” based on “Internet Availability Rate”. This group will remain at “Educated Diabetic Population” because they can reinforce their knowledge whenever they want to by taking the online course again.

The cost of diabetes care was calculated based on the report from NHS per number of patients considering the difference of cost between uneducated and educated patients.

In both models the total cost of diabetes care was considered as a level which showed the cumulative value of diabetes care in all diabetes patient levels. This level in the traditional model is equal to the cost of care for uneducated patients plus the cost of care for educated patients.

In the web based model, in addition to cost of care for uneducated, educated and technology refusing population, £50 million was estimated as the setup cost for the first year and £1 million for the cost of system maintenance and upgrading for each year.

Because of the long duration of the model simulation (12 years) the inflation rate of 3% was added as a constant value affecting the cost of diabetes care and the cost of web-based diabetes education.
3. Results

Considering the current population of UK which is equal to 61.1 million in 2008 and the population increase rate of 0.9% in our model the UK population would be 66 million in 2020 which gives the similar results used in the model of National Statistics.
Based on the data from the prevalence and incidence of diabetes and its mortality rate, the population of UK diabetic patients will increase dramatically in the duration of this modeling, leading to 3.3 million patients in 2020 which is compatible with the results of diabetes population prevalence model developed by Yorkshire & Humber Public Health Observatory (YHPHO).

Based on the simulation of the developed models, the web-based model is 63.47% higher in educated diabetic population at the end of simulation.

The annual cost of diabetes care in traditional model will increase to £3.67 million in 2020 whereas the web-based model will keep this cost to £3.39 million (Figure 2).

Because of initial price of setup and the low percentage of the educated diabetics in the beginning, the cost of web-based system is higher in the initial two years but, in comparison to traditional model, it will start to reduce significantly from the third year, giving a final difference in cumulative cost to more than £2 billion by 2020.

4. Discussion

Education in diabetes is a very simple method which is very effective. Because of the limitation in requirements for establishing the education system, like lack of enough educators and conflict of the program schedule with patients other programs, it could not be implemented on a required scale. The web-based system would be under development in the first year and will not increase the education rate. Although there is a big investment for the initial setup of this system, it will cover all the investments by the third year.

Return on Investment (RoI) in web-based diabetes education is calculated by cost and benefit of any system (Eq. 1), which will be equal to 3233% in this model.

The average annual cost of diabetes care in the period of study is £2.7 million and considering the results from this model it can be assumed that implementation of web-based education will be equal to one year free diabetes care for UK.

$$\text{RoI} = \left( \frac{\text{Benefit} - \text{Cost}}{\text{Cost}} \right) \times 100 = \left( \frac{2,187,000,000 - 65,000,000}{65,000,000} \right) \times 100 = 3265\%$$  (1)

There might be some factors affecting this model which can not be predicted until the system is fully implemented. Technology adoption rate might be different in UK but we had no evidence on a similar in-house system. Also emerging concepts like web 2.0 is quite revolutionizing this medium which had a significant effect on adopting this channel of communication in other sectors. Many of the points of strength in this model, like increase in collaboration and communication and enriched medium by Rich Internet Application (R.I.A) technology, comply with theories of Technology Mediated Learning (T.M.L.) and can be applicable in diabetes education. Internet coverage rate is growing very fast both in width and depth regarding the availability and bandwidth which can accelerate feasibility of web-based education model.

An important part of this system is support by health care members. The shift toward telemedicine and healthcare-patient communication via electronic media is dependent on the adoption of it by healthcare members. There are good initiatives to encourage this shift.
5. Conclusion

Investment on web-based diabetes education is not a matter of benefit but a requirement to reduce the pressure of diabetes on NHS. A web-based system is more compatible with the life style of the younger generation. These are the people who are considered as computer native. They are more familiar with computer technology in comparison with previous generations and can adopt this technology more easily. Also, this system is expandable by the collaboration of expert patients, which is a major point of interest in recent policies of departments of health.

References


The purpose of this study is to establish a foundation for participatory design between Information Technology (IT) professionals and people with chronic diseases resulting in IT-supported compensation in daily life. The paper presents the methods applied and results from a qualitative study to understand everyday life with diabetes. The participants are 8 families with one or more diabetic member. Our analysis outlines perspectives, activities, locations and information related to daily life with diabetes. On the basis of the analysis a number of artifacts are designed and tested in a living lab environment in Skagen, Denmark. It is concluded that participatory design and the use of the living lab concept yielded a richness of data adequate for iterative design cycles.

Keywords. living lab, diabetes, self-management, chronic disease

Introduction

The goal of the MaXi project is to break down barriers to a patient’s ability to master chronic diseases by means of Information Technology (IT). The project focuses on the intersection of the health professional, the patient, information technology, and society.

The context of the health professional: Innovation has traditionally been the development of support for self care as a one-to-one cooperation between the chronic patient and the hospital: communication of information on diet and exercise, plans, schemes, and guidelines. For the individual healthcare professional, however, this information can be difficult to adapt to daily life in a complex society. IT can potentially improve decisions made by the individual.

The context of the chronic-diseased patients: Patients constitute an enormous non-utilized knowledge resource for increasing quality of life and prolonging their own life expectancy. They have explicit as well as implicit knowledge about their needs but at the same time limited attention is paid to their knowledge, experience, and ideas; especially the ways that their knowledge can be used in innovative ways. At present, patients have a major role only in clinical trials.

The context of technology: Health informatics systems have been primarily developed with a reactive focus, that is, as tools for documentation such as EHR systems and health information management systems. There has been less focus on proactive systems, that is, systems for clinical support of diagnostic processes, and negligible focus on network systems that strengthen coherence among health professionals, chronic patients, and institutions.
The context of society: There has been an increase in the number of patients with chronic diseases; hence there is a common interest in enabling chronic patients to master their own disease as well as raising the level of public attention, cooperation, and support for these citizens. It is a challenge to develop supportive functions that are based on everyday living in a social context. These functions can complement that support given by health professionals who can have no specific knowledge of the social context of their patient.

The aim of the MaXi project is to 1) increase the chronic patient’s ability to master his own illness, 2) transfer the provision of health care from the health professional to society, 3) create new cooperative relations for health care, 4) advance from the technological refinement of well-functioning silos to network-technologies supporting coherent IT support for users.

The specific and exemplary chronic disease chosen for the project was diabetes, and the participants in the study were 8 families with one or more diabetic members.

1. Methods

The methods applied are inherent in the Scandinavian tradition for participatory design and user driven innovation [1]. Eight families where at least one member in the family had diabetes participated in two full cycles of experimental iteration. Each iteration was conducted in three stages: co-operation, contextualization, and conceptualization (see Figure 1).

In the cooperation phase, diabetics were selected for the study. Plans and materials were prepared.

In the contextualization phase, 8 families participated in a home interview, a workshop, and in experiments with technology at a “living lab” that lasted one weekend. Knowledge about central situations for IT-support of diabetics was deconstructed, assigned priorities, discussed, worked with, and staged with technology experiments.

In the conceptualization phase, contextual knowledge was used to construct prototypes for everyday IT-support of diabetics. Diabetics designed their own IT-support tool by sketching ideas on paper, plastic and other materials. Researchers facilitated the process, collected ideas, and distilled user-designs into key concepts for further development.

In the co-operation phase we performed one-hour interviews in the home of the families. During the interviews we used photos of places where families normally go, for example, streets, the sport centre, nature, home, the swimming pool, schools, buses, the supermarket, work, etc., to make the conversation concrete and appropriate for all the family members. The interviews were structured - the participants were asked to select three photos of the places where they most needed information on diabetes-related issues. In turn the family members explained why they had chosen their photos. In this way, each participant was encouraged to reflect on his daily activities with respect to his diabetes.

The photos served to unlock the perceptions of the people interviewed. Family members from 8 to 67 years old participated. Siblings of a diabetic child or children of a diabetic parent could contribute their outlook and ideas. The method was pre-tested with one diabetic family prior to interviews with the 8 participating families.
After the photo interview, all the family members were given 7 postcards with the questions: “Where are you?,” “What would you like to know?,” In addition the diabetic(s) in the family received a Personal Digital Assistant (PDA) telephone with a prepaid phone card for sending text or multimedia messages asking the same questions. Inspired by Gaver [2], the postcards and the PDA served as cultural probes to continue the data collection after the interviews without any time constraints. We invited participants to submit their reflections on the issues discussed during the visit.

At a workshop we discussed with the participants, in a constructive way, the conclusions we had drawn from the home-visit observations – staging situations to which they had assigned priority, discussing those priorities, and cooperating on information central to each situation. Working groups focussed on grocery shopping, household/kitchen activities and cooperation between parents and children.

The prototypes were subsequently implemented and tested in the living lab in a remote fishing/holiday village, Skagen in Denmark, where the 8 families are accommodated – four in each of two consecutive weekends. (Følstad [3] defines a “living lab” as an open innovation platform with the intention to create a (semi)real world environment for collaboration.) The participants in the lab were the 8 families consisting of 30 people, two service providers/shops, researchers from three departments at Aalborg University, IT-consultants from The Danish Technological Institute [4], Edvantage Group [5], and representatives from the Foundation of Skagen Health [6,7].

Methodologically, the objectives were to stage a) future use situations in natural environments in different modes, b) two location-based experiments, and c) one activity-based experiment. The program for the weekend in “Living Lab Skagen 2008” was:

- Friday evening: introduction at Skagen Tourist Office.
- Saturday morning: shopping at the butcher.
- Saturday midday: lunch at family cottages.
- Saturday afternoon: workshop followed by a walk.
- Saturday evening: dinner at a restaurant.
- Sunday morning: design workshop and evaluation.

The two location based experiments were carried out at a butcher’s shop and at a restaurant. Both locations had been selected by the users as difficult places to get information on food content. The experiment was to determine the ease of gaining access to hidden information at the locations, the quality of the information, and the form of e-information at public locations.

Information on selected food items at the butcher’s and on the menu at the restaurant was provided by means of RFID-tags and USB readers displayed on screens installed on location. The shops provided the information and the locality for the experiments. The IT-consultants introduced the technology to the users. The users experimented by buying food items for lunch and ordering dinner. Researchers documented the interactions with photographs and conducted interviews with the users after the experiments.

Another two experiments were carried out on activity-based services by using computerized mock-ups. The mock-up simulated consequences for blood-sugar level in relation to food intake, insulin dosage, and physical activity. A laptop computer was provided to each diabetic. The users were instructed to use the mock-up at lunch before the planned walk and, furthermore, whenever they felt the need. As with the location-
based experiments, the IT-consultants introduced the technology. The researchers conducted interviews and organized a design workshop that concentrated on the quality of the simulation and the quality of the information provided.

The users, in family groups, completed the two days of experiments with a workshop where they designed, with pens, crayons, paper, modelling clay, card board PCs, etc., their future IT-tool.

2. Results From the Family Interviews

We received 72 postcards from the families. Not only were the postcards appropriate for the collection of reflective, additional, and situated data but, as well, they were complementary to the interviews. They gave the participants further opportunity to communicate. Especially teenagers and introvert participants, who had spoken only briefly during the interviews, actively sent postcards.

The data from the family interviews were analyzed to understand how diabetes is dealt with in everyday living and what was important to participants. The coding resulted in a list of six archetypical activities: Calculating, planning, cooperation, remembering, finding and informing (see Figure 2).

3. Results From the Workshop

Key conclusions from the workshops provide perspectives on diabetes: designing for life rather than disease and designing for the everyday core activities necessary for the support of diabetes management. The difference between precise calculations and an approximate simulation was central to the design of experimental artifacts in the living lab. The participants clearly preferred approximate, living lab simulations to precise calculations.
4. Results From the Living Lab

Living Lab Skagen was a living lab constructed in a real-world environment that was not an everyday environment to users, researchers or IT-consultants (see Figure 3). In contrast to interviews, diaries and workshops, users participated 100% in Living Lab Skagen. It was clear that we had entered a laboratory where we were to play at everyday life but not interfere with it.

The number of hours spent in a living lab is not so important. If participants are prepared in advance, focused, and participating seriously, six days will provide much, possibly too much, data.

The social events turned out to be important. Users requested more social events. “Getting to know each other” was equally important as was experimenting and innovating. Users participated because of the experience as well as the opportunity to influence technological development. The living lab should be fun and living lab managers should remember the importance of breaks and games.

As more people cooperate there can be more applications, experiments and living lab simulations. Although the three mock-ups in Living Lab Skagen 2008 provided a large amount of data for further development and experiments, Living Lab Skagen 2009 is planned to have between five to 10 services in order to achieve a larger critical mass.

Figure 2. Core activities performed by diabetics and family members

Figure 3. Left: Users experimenting with local services at the butcher’s. Right: Users designing their diabetes IT-tool of the future.
5. Conclusion

A living lab is an construct that provides a safe zone in which interaction designers, enterprises, and users can experiment which real-life situations. Consequently, designing, operating, supporting and evaluating a living lab calls for an appreciation of the complexity of everyday life situations; indeed, an appreciation of some interactions that are unanticipated such as breakdowns, contradictions and other surprises.

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References

Section 10
Software Assurance and Usability
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Preventing Technology-Induced Errors in Healthcare: The Role of Simulation

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Abstract. We describe a novel approach to the study and prediction of technology-induced error in healthcare. The objective of our approach is to identify and reduce the potential for error so that the benefits of introducing information technology, such as Computerized Physician Order Entry (CPOE) or Electronic Health Records (EHRs), are maximized. The approach involves four phases. In Phase 1, we typically conduct small scale clinical simulations to assess whether or not the use of a new information technology can introduce error. (Human subjects are involved and user-system interactions are recorded.) In Phase 2, we analyze the results from Phase 1 to identify statistically significant relationships between usability issues and the occurrence of error (e.g., medication error). In Phase 3, we enter the results from Phase 2 into computer-based simulation models to explore the potential impact of the technology over time and across user populations. In Phase 4, we conduct naturalistic studies to examine whether or not the predictions made in Phases 2 and 3 apply to the real world. In closing, we discuss how the approach can be used to increase the safety of health information systems.

Keywords. technology-induced error, simulations, health information systems, patient safety, CPOE, EHR, health informatics, biomedical informatics

Introduction

There is growing evidence that the introduction of health information technology can inadvertently result in technology-induced errors. For example, studies [1-5] have shown that poorly designed user interfaces may result in medication errors when using a health information technology. In their previous research Kushniruk et al have also found that user interfaces of electronic health records (EHRs) can have an impact on health care professionals’ reasoning and decision making [6], in some cases leading to sub-optimal performance and the introduction of error [7]. Other studies have found that computerized physician order entry (CPOE) systems may inadvertently facilitate a range of medication errors [2-5]. This paper will describe how simulations can be used to examine the impact of interface design features upon medical errors in healthcare information technology. Two types of simulation are described, namely, clinical simulations (involving observation of human subjects carrying out clinical tasks) and mathematical computer-based simulations used to forecast the impact of interface design features upon medical errors. The paper describes our approach in several
phases. In Phase 1 a clinical simulation can be conducted to establish base rates of error that might result from the introduction of a technology (e.g., EHR or CPOE). Such simulations can involve realistic settings and use of human subjects (e.g., physicians or nurses). Phase 2 involves the analysis of user interactions and the identification of potential errors (including statistical analysis of the relation between usability problems and error rates). In Phase 3 we input the results from our Phase 2 work into computer-based simulation models. This allows us to predict the impact of the introduction of the technology studied into larger populations of users and over time. Finally, in Phase 4 we conduct naturalistic studies to assess if the predicted impact of use of the technology (from the mathematical modeling in Phase 2) holds in real clinical settings. The remainder of this paper outlines the phases of our approach.

1. Methods

Our approach to using simulations to assess the potential of health information technology to inadvertently introduce error (technology-induced error) grew from our earlier work in applying usability testing to the assessment of the impacts of health information technology [8]. Qualitative coding and analysis methods were used in this work. In more recent work we have subsequently taken the output of this work and used it as an input to computer-based mathematical simulations [9,10], as described below.

1.1. Phase 1 – Clinical Simulations

Phase 1 involves conducting realistic clinical simulations of use of health information technologies such as CPOE and EHRs. In our work this typically involves full video recording of user interactions with a system under study, along with audio recording of their verbalizations as they are asked to “think aloud” while doing tasks such as entering medications into a system [8]. We have evolved our approach in carrying out such studies to consist of a low-cost, yet high fidelity method to extending usability testing to recording of subjects (e.g., nurses and doctors) interacting with systems in realistic settings (e.g., a hospital ward or real clinical setting) [1]. In terms of tasks we typically select a range of realistic activities involving the use of the system (e.g., entry of both routine and non-routine medications into a system). In recent work we have successfully used this approach in a study of 10 physicians as they interacted with a hand-held prescription writing application to enter medications. All the screens from the application were video recorded along with audio recordings of the subject’s verbalizations as they carried out the task [1]. The results from Phase 1 formed the input into Phase 2 of our work.

1.2. Phase 2 – Analysis of Usability Problems and Medical Error

In Phase 2 data arising from clinical simulations in Phase 1 are analyzed using qualitative approaches to assess the relationship between aspects of interface design (i.e., usability problems) and medical error rates (e.g., prescribing error rates). From our experience in conducting such analyses it has been found that there may a strong relationship between coded usability problems (related to specific user interface design features) and the likelihood of technology-induced medical error. For example, in a
study of physicians using a hand-held prescribing application all medication errors recorded were associated with at least one usability problem (e.g., inappropriate defaults listed, display visibility problems, etc.) and several categories of usability problems were highly related to the probability of a prescription error being made [1].

1.3. Phase 3 – Computer-based Mathematical Simulation and Modelling

In order to extrapolate from findings in Phase 2 (relating occurrence of medical error to specific usability problems and user interface features) to larger populations and over time, we input the results from Phase 2 as parameters into computer-based models and simulations. For example, in our study of medication errors associated with a hand-held prescription writing application [10], the results from conducting a clinical simulation involving 10 physicians (e.g., the rate of usability problems, the error rate etc.) were input into a simulation program (using Stella® software) where the rate of errors was predicted over time. Several runs of the simulation were conducted to simulate the impact of removing usability problems on the rate of medication errors. Specifically, the base rates for errors associated with specific types of usability problems (from Phase 2) were used as parameters of the systems dynamic mathematical simulation model. Specific user interface features were then examined during simulation runs to assess their impact on error rates. Total expected mistakes (i.e., errors not caught by the user) and slips (i.e., errors caught and corrected by the user) when using hand-held computer applications to enter medication data were also forecasted over time. Other aspects of implementation of systems can also be simulated this way, including the impact of expected learning curves (in use of a system) on error rates, as well as simulation of the impact of widespread dissemination of a system under study in larger populations of healthcare workers.

1.4. Phase 4 – Follow-up Study of Predicted Error Rates in Real-world Settings

In Phase 4 of our approach, predictions made using computer-based simulations in Phase 3 can be validated by conducting naturalistic studies of error in real clinical and healthcare settings. This may involve observational study, ethnographic analysis and chart audits to determine the frequency of medical error in relation to use of the information technology under study. Results from such study may also feed back into refinement of models and simulations in Phase 3 and may also indicate that new laboratory-based clinical simulations (Phase 1) need to be conducted to shed further light on both usability problems and errors associated with use of specific features and functions of health information systems.

2. Experiences To Date

We have applied the approach described above in several projects (some ongoing) where we have initially conducted clinical simulations to collect video recordings of user interactions with health information systems. Applying a video coding scheme we have developed, we have then proceeded to analyze the observational data to identify both usability problems and errors. Our first study in this direction [10] consisted of a reanalysis of data collected from a small scale study of physicians using a prescription writing application [1]. We have since worked (and continue) to develop computer
models that input data from clinical simulations, forming the base parameters of mathematical models. Our work in Phase 2 continues and we are currently working on the design of studies to validate our predictions and forecasts for several health information system applications, including CPOE, in real world settings.

3. Discussion

In this paper we have outlined our approach to the use of both clinical simulations (involving human subjects interacting with systems in realistic contexts) and computer-based mathematical modeling and simulations. Our approach allows for prediction (and subsequent validation) of occurrence of medical errors that are related to usability problems before they occur in real settings and can thus be used for testing systems about to be deployed. This stands in sharp contrast to the majority of the literature to date on errors in using systems such as CPOE and EHR, where data has typically been collected after system implementation (using methods such as interviews and observation in real settings), making analysis of which specific features of systems are associated with error imprecise and subject to human recall bias and error. It is also our contention that it is an ethical and social responsibility of designers and implementers of new health information technologies to apply methods (such as those based on simulation described in this paper) prior to releasing systems to ensure their safety and effectiveness, rather than waiting until after implementation to assess potential for technology-induced error.

References


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Abstract. The relationship between usability and training remains to be explored in health informatics. We examine the training given during the implementation of an institutional electronic medical record system, as well as the usability of the system from the perspective of new users who have been recently trained. We examine in which ways video-based usability testing with new users, who received classroom training one month earlier, can be used to a) indicate needed changes in the training program, and b) provide feedback to improve system customization and deployment. Usability testing methods were found to be an important adjunct to system deployment: they can improve the system implementation as well as suggest strategies for user education.

Keywords. usability testing, usability engineering, electronic medical records, electronic health records, user training, system deployment

Introduction

Implementations of complex healthcare information systems (such as electronic health records) require careful consideration of both system design and customization as well as an understanding of the effective approaches for training new users. Indeed, learnability (i.e., how easy it is for users to learn and master system functions and be able to transfer this learning to real situations) and usability (i.e., a measure of how easy it is to use a system) have a close relationship, with some authors considering usability as one of a number of key components of overall system usability [1-3]. Effective user training will ensure that users are able to have an optimal starting point for working with new information systems. Even if they have not had a chance to master all features, they will have obtained a strong foundation for exploring a new system over time and will likely encounter fewer problems in interacting with systems. However, not all training approaches may be effective in complex areas such as health informatics. Indeed, there may be considerable room for improving training based on feedback that could be obtained from conducting usability tests with health professionals who have recently taken training courses in use of a newly implemented

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system. In this paper we describe a usability evaluation of the implementation of a commercial electronic medical record (EMR) system at Mt. Sinai Medical Center. The EMR was being implemented at Internal Medicine Associates which has 50,000 to 60,000 visits annually, with patients seen by 139 housestaff, and 45 attending physicians from November 28, 2006 to March 19, 2007. Based on our experience, we suggest that there is a close relationship between training and usability. This relationship remains to be explored and warrants further study.

1. Methods

Subjects: Five subjects took part in the usability study. All of the subjects were physicians who had been using the system under study for approximately four weeks after taking part in a classroom training session about its use (none had used the system before taking the training session).

Materials: A commercial EMR was implemented, for which training was supplied (and which was used during the usability testing). In order to carry out the usability study two representative scenarios were designed. The scenarios involved documenting patient history and physical information, entering medications, writing orders, checking alerts, and adding notes and letters (as well as checking the in-box for emails about the patient). The scenarios were presented to subjects as written scripts detailing the patient information and the required tasks (involving the computer system) from arrival of the patient to completion of notes and letters on the patient’s departure.

Procedure: Initially background information was collected describing both the content and topics covered in the group in-class training session for the system. This consisted of a four hour class where examination of the materials indicated coverage of the following topics: 1) logging into the system and system overview, 2) documenting/reviewing standard office visit data, 3) placing orders, and 4) documenting a complex office visit. The usability testing sessions were conducted individually with each of the five subjects four weeks after attending the group in-class training session. During the usability testing sessions (which lasted approximately 40 minutes per subject) the subjects were asked to “think aloud” while they carried out the tasks in two scenarios (described above in the materials section). The audio portion of their think-aloud was recorded using a microphone connected to the computer they were accessing the system on. In addition, all the computer screens were recorded as digital movies using Hypercam© [4]. At the end of each usability testing session, a semi-structured interview was also conducted (and audio-recorded) where subjects were asked: 1) how often they had been using the system since the group training session, 2) how long they had been using the system, and 3) if they had encountered any problems in the session or in using the system in general. The interviews were also audio recorded in their entirety.

Analysis: The analysis of the data consisted of first having all the “think-aloud” and interview data transcribed. Then the digital movies of the user interaction with the system were coded to identify usability issues or problems encountered by subjects as they carried out the requested tasks in the two scenarios. Extending coding described by Kushniruk & Patel [5] and using transana© video annotation software [4], we specifically examined the data to identify areas where users encountered problems in carrying out their tasks and in mapping their terminology and expressions into those allowed in the system (using the system’s coded vocabulary for medical terms,
qualifiers and medications). It should be noted that a study by Aaroson et al suggests a potential relationship between training and implementation, which is where training occurred in this study [6].

2. Results

All subjects completed both test scenarios in an average time of 38 minutes, with little variation in the completion time across subjects. Subjects generally showed a good facility for using the system in carrying out the representative tasks and were overall favorable in their comments about the system, as illustrated by the responses from the subjects below (obtained from the post-task interviews) when asked about their overall satisfaction with the system:

“I do think its really good for on-call, for telephone calls, or whatever, because usually you’d have to find the charts, read the person’s handwriting and here you just look it up and its really helpful for me” (subject 1)

“It’s good, it’s a good system. Like I didn’t realize until today you could add a past medical history onto a problem, that’s easier” (subject 2)

“Generally its pretty good, I like it” (subject 3)

“I love it, I absolutely love it, I hate writing notes and my handwriting is terrible and I find typing much faster, more satisfying “ (subject 4)

“I’m generally very happy with it” (subject 5)

Several specific areas where the usability testing revealed that refinement could be made (which were largely unexpected) were identified and illustrate the use of the approach taken in this paper to providing iterative feedback (based on usability study) to both (1) system customization and to (2) system training. These areas are described below.

2.1. Matching of User Desired Terms to Terms Provided by the System

The most frequently coded issue with use of the system (for the assigned tasks) was finding a matching term in the system (with several coded occurrences of such issues per subject) – all subjects indicated at least one problem with the mapping of terms they had in mind to the completions offered by the EMR system for selecting from (e.g., for entering medications, diagnoses). For example, one subject (subject 4) noted that in entering the family history there appeared to be no match for the entry “lung cancer”, rather they had to enter “cancer” and then qualify it. Other instances of non-matching (i.e., of user entered terms not matching to terms returned by the system in a list to select from) were identified in the transcripts (and coded by the annotation “Problem – No Match”). This occurred on average once per case entered by each of the subjects and in one instance led to the subject not entering information about leg stiffness. One subject (subject 1) discussed this issue during the post task interview, stating the following when asked about problems they had encountered: “If there is something in the fill-in boxes, this doesn’t happen as often, like a diagnosis, or a prescription it can’t find, like something … that doesn’t show or fit in whatever boxes they have here, and
it can’t find it”. This is consistent with earlier findings from [7] where usability testing indicated that matching user desired terminology to coded terms (contained in pick lists within a patient record system) is a major issue during interaction with electronic health records. The implications of this for training in use of EMR are discussed below.

2.2. Use of the System for Patient Charting (i.e., Training in Context of Use)

Although the study did not directly look at the interaction of the subjects with the EMR system in the real setting of system use (i.e., in a clinic during regular workflow or with a patient present during charting) several subjects mentioned, during their post-task interview, potential issues with use of the system when charting during interactions with the patient present. When asked about use of the system, the subjects were overall very positive about the system (as described above) and positive about the system use under certain work conditions, but some subjects indicated they had problems with it one month after training when attempting to use it with the patient present (implications for potential training are described below):

“…very tedious to do while I’m charting patient care but its very good for following and continuity of care so if I’m not actually seeing a patient its great, but if I’m actually trying to see a patient and chart things in it, or even just getting through my clinic day its … cumbersome … It doesn’t help during, its not very useful during the actual, after the visit, cause I don’t even do it when the patient is in the room, I do it afterwards once the patient has left the room to chart it” (subject 1).

This was also noted by a second subject (subject 3) who stated that they had difficulty remembering what patients may be telling them (when using the system with the patient present), particularly if they took the strategy of waiting to start creating a note till later in the interaction (which brings in the issue of training in strategies of system use during patient encounters or more complex workflow).

It is interesting to note that this issue is not specific to this particular EMR but to use of currently available EMRs in general, as noted by Kushniruk et al [8] who found considerable difference in user satisfaction with an EMR system when comparing subjects’ interactions involving a) tasks that involved entering information into the system in isolation of the patient (as in typical system training and usability testing) versus b) tasks that involved entering information in the system while interacting with a patient during a doctor-patient interview. There are a number of implications of this both for system design and customization (which go beyond the scope of this project) but also for need for training in the use of system under different clinical conditions (e.g., entering orders, charting with or without the presence of a patient, and using the system while carrying out workflow involving medical procedures and other physical or mental activities). This could involve training using simulations of workflow and conditions under which the system will be used in real clinical settings.

2.3. System Stability

One of the subjects claimed that the system would occasionally crash while they are in the middle of entering a history (although it should be noted that this potential issue was not recorded during the test sessions). This was something that may be relevant to note for the system implementers to look into (rather than for training) – potentially
using Hypercam© or other screen recording programs to document such incidents in real-life contexts of use.

2.4. Inability to Locate Missing Documentation in Order to Close a Record

Generally, when subjects went to close a note and a required entry was indicated that must be completed before the subject could close the note, this was understood by the users (who then completed the required documentation). However, one of the subjects, when confronted with such a message, was unable (from the information presented by the system) to locate where in the documentation the missing information would need to be completed. Messages must be meaningful for users to locate where problems may be occurring and this is an area for potential targeting for further training/customization.

Other more minor issues/problems were noted in the annotated transcripts, which included error messages popping up several times for some subjects in the entry of height and vital data (e.g., if a number was entered without indicating a metric), occasional problems in the subject not being able to scroll through a list (i.e., the scroll bar not being accessible on the screen) and minor suggestions regarding screen layout.

3. Recommendations and Implications for EMR Training

Based on the current training all subjects were able to successfully complete the scenarios with which they were presented. This included successfully completing all required tasks and doing so in a timely manner. However, the sessions did reveal a number of areas and suggestions for augmenting current training given the nature of the EMR system (and this was fed back to the training team). These include the following:

- Providing training specifically about the terminology that the system accepts and the synonyms that are acceptable to the system. This was a surprising finding. One of the consistent recommendations in the informatics literature has been to have a synonym list for problems [9-11]. This EMR has a third party option for a synonym dictionary which was installed at this site as well as others [12]. The users still had anecdotal difficulty during implementation similar to that found in the study as they were getting too many synonyms back (granularity wasn’t the problem).
- Providing advanced training on strategies regarding use of the system in varied clinical contexts, most specifically, providing practice that could involve the use of a trainer playing a simulated patient (while the physicians learn how to use the system in simulated doctor-patient interactions). This could also include testing of physician (and student) competencies in charting while using an EMR (an area that could be incorporated in health professional student training as well).
- For training of physicians and other health professionals (e.g., nurses) this could be extended to include training in use of the system for different types of workflow.
- Such advanced training could deal with strategies for coping with situations of urgency, complexity or unusual cases of workflow (e.g., when ordering
preventative tests, dealing with error messages and working with incomplete patient information).

Other aspects of the results of this study were fed back to the implementation team. For example it was recommended based on the study that training could include practice in use of the system for different types of workflows and this recommendation was later adopted for nursing.

4. Conclusions

Overall the EMR system was received positively by the subjects tested, who were able to complete the tasks in the scenarios presented to them during usability testing one month after in-class training. The subjects were all using the system in their practice, although the type of their use, frequency of use and strategies for using the system varied. Furthermore the subjects tested demonstrated good knowledge of the main features and functions of the system and were able to carry out the required tasks one month after receiving formal in-class training. Some suggestions for augmenting the training were provided based on the study.

In summary, the approach taken was able to arrive at some interesting and potentially relevant findings and recommendations given a small number of subjects tested one month after training. The result of such usability testing was found to provide useful feedback both for system customization as well as for training. Results of small scale and rapid usability tests can provide useful feedback for improving both system usability (through feedback to system implementers) and potentially system learnability (through feedback to training). The challenge is adapting to the constraints of a commercial system.

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Scenario-based Testing of Health Information Systems (HIS) in Electronic and Hybrid Environments

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Abstract. Researchers have identified sources of technology-induced errors involving health information systems (HIS) across the software development lifecycle. In this paper the authors review approaches to identifying technology-induced error and describe, compare and contrast the advantages and disadvantages of using predictive and post-implementation methodologies to identify technology-induced error. Following this, the authors focus upon clinical simulations using scenario-based testing as a methodology for diagnosing technology-induced errors to assess HIS ability to respond to the stresses and strains of health professionals using such systems in real-world clinical settings.

Keywords. EPR, CPR, EMR, human interfaces, patient safety, technology-induced errors, clinical simulations, scenarios, scenario-based testing

Introduction

Researchers have identified sources of errors involving health information systems (HIS) throughout the software development lifecycle [1,2]. In order to better understand, test for and prevent these phenomena from occurring, researchers have used methodologies from the HIS literature to identify sources of errors so that HIS safety may be improved. In this paper the authors discuss the use of scenario-based testing in clinical simulations. This paper reviews the approaches used in identifying technology-induced error and presents a scenario-based approach to clinical simulations.

1. Methodological Approaches for Evaluating Technology-induced Errors

A number of HIS evaluation methodologies have been used to test HIS for technology-induced or facilitated errors. These methodologies include predictive and post-implementation evaluation approaches.
1.1. Predictive Methodologies

Predictive methodologies identify potential technology-induced medical errors prior to the HIS implementation. Predictive methodologies allow HIS designers, developers and healthcare organizations to predict the types of technology-facilitated errors that may occur prior to HIS implementation. As a result, organizations can prevent technology-induced errors or reduce the likelihood of their occurrence following deployment. Published predictive methodologies include heuristic evaluation [12], clinical simulation [1], and computer based simulation [10].

1.2. Post-Implementation Methodologies

Post-implementation methodologies identify HIS-facilitated medical errors after deployment. Post-implementation approaches help to discover real-world technology-facilitated errors during the post-implementation and operations phases of deployment [3]. Such studies involve the use of case studies [5], naturalistic observation [2], and ethnography [3] to discover errors. They use interviews, observations and retrospective chart analysis (See Figure 1 for the Continuum of Methodologies for Assessing the Safety of HIS).

1.3. Advantages and Disadvantages of Evaluation Methodologies

There are advantages and disadvantages associated with predictive and post-implementation methodologies. For example, post-implementation methodologies examine the impact of HIS after deployment. Therefore, such studies are more costly to undertake as they require intensive observation and analysis of individuals working with the technology in differing organizational contexts (e.g., medicine and surgery) to understand an impact of technology. Also, once the error-facilitating aspects of the technology are identified, there is a need for substantive organizational investment to address them. In some cases this may require the technology be modified or organizational processes be changed. Furthermore, such post-implementation work may require the re-implementation of the technology to reduce or eliminate the likelihood of technology-facilitated errors. Costs associated with reimplementation can be significant. These costs may include expenses associated with modifying the HIS, human resource costs associated with changing organizational policies, and procedures and health care professional re-training costs.

The costs are less for predictive methodologies as technology-induced errors are generally identified prior to implementation. Aspects of the technology that may lead to error are addressed in the design and development phases of the software development
lifecycle. As these evaluations occur prior to the implementation of an HIS, the costs of modifying the HIS are lower and the impact of technology-induced error upon the real-world clinical environments is prevented or reduced. A limitation of this approach is that the evaluator is unable to determine whether or not the error would have occurred in the real-world. Both approaches have advantages and disadvantages associated with their use. A blend of predictive and post-implementation approaches is necessary to identify and eliminate the occurrence of most technology-induced errors.

2. Clinical Simulations, Ecological Validity and Scenario-based Testing

Of the approaches that are predictive in nature, clinical simulations have increased in popularity. There may be a number of reasons for their being an interest in clinical simulations. Clinical simulations are cost effective, and they allow evaluators to capture data using audio and video recording devices that help to identify and understand the “root causes” of technology-induced errors. Analysis of video and audio recordings facilitates the ability of evaluators to identify and understand the causes of such errors [1,13]. Furthermore, clinical simulations allow evaluators to identify technology-induced errors in a laboratory setting rather than the real-world, where the impact of an error is more significant for health professionals and patients.

In order to obtain usable and predictive data from a clinical simulation, it is our belief that careful attention must be paid to clinical simulation design. The primary aim of evaluator creating a clinical simulation should be ecological validity (the extent to which a clinical simulation mimics that which takes place in the real-world) to ensuring the generalizability of the results [14]. To ensure ecological validity evaluators need to use representative settings, subjects and tasks [11].

More importantly, designing clinical simulations for ecological validity should involve identifying scenarios that are representative of those typically encountered by a variety of HIS system users in the real-world. Scenarios should range from the complex to simple, routine to atypical, urgent to non-urgent and/or controlled (i.e., those that follow organizational polices and procedures) to the uncontrolled (i.e., those that do not fit with existing organizational polices and procedures). Simple, routine, non-urgent and controlled scenarios allow one to evaluate the consistency of the interaction between the human, organization and technology. Complex, atypical, urgent and/or uncontrolled scenarios help the evaluator to assess HIS performance and human-organizational-technology interaction under conditions that strain or stress the HIS, in essence, testing the systems performance boundaries. Next, we will define and describe our scenario-based testing for technology-induced errors.

2.1. Defining and Describing Scenario-based Testing

Scenarios are hypothetical events that represent real-world occurrences. In health care such events reflect those that health professionals may encounter in real-world clinical settings. They may be for example, a nurse who is interviewing a patient as part of an assessment in a health clinic, or a health care team that must address the life-critical needs of a patient experiencing a cardiac arrest in an intensive care unit. Scenarios may include multiple settings, health professionals or actors, tasks and/or events. Scenario-based testing allows the evaluator to examine how individuals utilize their environment (human, organizational and technology) to respond to events. In our case, this involves
observing issues that arise when working with a new HIS or constellation of hardware devices. Therefore, scenario-based testing provides insights to how health professionals respond to technology in a given clinical context. In order for the scenario-based testing to be effective it must fulfill three more criteria: 1) it must be motivating to the health professional, i.e., the health profession feels the scenario is cognitively engaging and representative of real-world work, 2) it must be credible, i.e., the health professional has experienced the same or similar type of event(s), and 3) it should represent the range of levels in complexity, routineness, urgency and control, to effectively test the HIS performance. Different test scenarios are described in Table 1.

Next we will describe a process for developing ecologically valid clinical simulations using scenario-based testing. The first step in this procedure requires that the evaluator identify the user-technology level.

2.1.1. Step One: Identifying the User-technology Level

In step one the user-technology level is identified. The evaluator identifies the organizational level at which the scenario will take place for the individual worker, team, department or the health care institution. Is the evaluator interested in a single health professional interacting with a system, a team interacting with a system or a group of individuals that are located across the organization using an HIS? [15]

2.1.2. Step Two: Identifying the User

Here, the type of user who will be asked to participate in the clinical simulation is identified. As well, the users attributes are specified such as clinical experience, domain of expertise, discipline of expertise, years of computer expertise or organizational experience. These attributes influence the outcomes of scenario-based testing and the evaluator must take them into account.

<table>
<thead>
<tr>
<th>Table 1. Different types of scenario-based tests.</th>
</tr>
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<tbody>
<tr>
<td>Simple scenario-based tests should consist of a single event that is played out in a given setting. Complex tests should involve multiple, interwoven and/or interconnected events that may occur in a real-world environment.</td>
</tr>
<tr>
<td>Routine scenario-based tests should consist of events that occur frequently. Non-routine tests focus on less frequent events.</td>
</tr>
<tr>
<td>Urgent scenario-based tests mimic those events that require quick responses to patient health needs. Non-urgent scenarios should be typical of those types of events that are responded to by health professionals as part of their day to day work.</td>
</tr>
<tr>
<td>Controlled scenario-based tests should focus on those events that follow organizational policies and procedures. Uncontrolled tests should follow those that do not follow organizational polices and procedures.</td>
</tr>
</tbody>
</table>

2.1.3. Step Three: Creating Ecologically Valid Hybrid and Electronic Environments

During the third step, the evaluator creates an ecologically valid or “realistic” environment. This involves either simulating the environment in a laboratory setting or conducting the clinical simulation in a real-world environment where the users would typically use software/hardware [11]. Here, the evaluator may choose to observe the impact of a single HIS upon user activities (e.g., physician order entry), a full EHR, or
a hybrid environment in which there may be one or more HIS present or where part of the patient record is electronic and part is paper-based [13]. The evaluator may also use a variety hardware devices to assess their impact on the function of the HIS and upon the users (e.g., physicians, nurses, social workers etc.) [15].

2.1.4. Step Four: Identifying Realistic Situations or Scenarios

The next step in the development of clinical simulations requires identifying realistic scenarios. As shown in Table 1, scenarios, should range from the: 1) simple to the complex, 2) routine to the atypical, 3) non-urgent to the urgent, and 4) controlled to the uncontrolled. Scenarios that are unique and unusual are often those that are characteristic of healthcare and should be used to ensure the HIS responds to a wide range of situations under conditions that would likely stress or strain the system.

Scenarios can have high to low fidelity. Low fidelity simulations generally approximate the real world. For example, a simple study consist of giving a written presentation with a brief description of an event to a physician or nurse and asking him or her to interact with the HIS in response while making a video and/or audio recording. A high fidelity scenario attempts to fully reproduce the real world. For example, a scenario may involve actors playing the role of patients and other staff while a physician or nurse uses the HIS [7].

2.1.5. Step Five: Data Collection

Such evaluations involve the use of audio and video recording devices. Video devices are used to collect data about participant physical interactions with electronic and paper artifacts (e.g., an EHR or a paper patient record). Video recorders such as a Sony Mini-DVD® camcorder can be used to record user interactions with their environment [11]. Audio devices such as tape recorders can also be used document user verbalizations or conversations. Computer screen recording programs, for example, HyperCam® or Camtasia®, can be used to document subject interactions with HIS. Our most recent research [1,11] suggests the integration of audio, video and computer screen recordings allows one to document the interactions between the organizational environment, user and electronic devices (such as laptop computers) during scenario-based testing.

2.1.6. Step Six: Coding Schemes

Data should be coded using theoretically-motivated coding schemes [7,13]. Error theory is applied the coding of audio, video and computer screen recording data. From a methodological perspective, data is coded using both inductive and deductive approaches [1, 13]. Deductive coding uses existing error theories and models and is initially used to code the data. Then, inductive coding leads to the development of new concepts, models and/or theories [7,13].

This approach yields a number of benefits: models derived from empirically validated theories arising from previous research are used and in those situations where an existing theory or model does not explain a phenomena, a theory is extended.
3. Conclusions

Over the past several years researchers and evaluators have developed a number of methodologies that can be used to identify sources of technology-induced errors that apply to HIS throughout the software development, implementation and operations lifecycle. In this paper the authors have reviewed the approaches to identifying technology-induced errors that have been used in the health/biomedical informatics. The authors have described, compared and contrasted the advantages and disadvantages of using predictive and post-implementation methodologies for diagnosing technology-induced error. A blend of methodologies is recommended. Following this, the authors describe in detail one methodology that shows promise in reducing errors: clinical simulations involving the use of scenario-based testing. This methodology shows considerable promise in testing the ability of an HIS to cause technology-induced error and the response of an HIS to the stresses and strains of use by health professionals in clinical settings.

References

Security Evaluation and Assurance of Electronic Health Records

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Abstract. Electronic Health Records (EHRs) maintain information of sensitive nature. Security requirements in this context are typically multilateral, encompassing the viewpoints of multiple stakeholders. Two main research questions arise from a security assurance point of view, namely how to demonstrate the internal correctness of EHRs and how to demonstrate their conformance in relation to multilateral security regulations. The above notions of correctness and conformance directly relate to the general concept of system verification, which asks the question “are we building the system right?” This should not be confused with the concept of system validation, which asks the question “are we building the right system?” Much of the research in the medical informatics community has been concerned with the latter aspect (validation). However, trustworthy security requires assurances that standards are followed and specifications are met. The objective of this paper is to contribute to filling this gap. We give an introduction to fundamentals of security assurance, summarize current assurance standards, and report on experiences with using security assurance methodology applied to the EHR domain, specifically focusing on case studies in the Canadian context.

Keywords. EHR, relative conformance, security assurance, requirements engineering

Introduction

Electronic Health Records (EHRs) maintain information of highly sensitive nature. It has widely been acknowledged that security is a major quality attribute of EHR systems. Security requirements in this context are typically multilateral, encompassing the viewpoints of multiple stakeholders. In the pan-Canadian context, Health Canada Infoway has developed and published a detailed specification of privacy and security requirements and a design of a privacy and security conceptual architecture as part of its EHR infrastructure architecture blueprint [1,2]. In addition, local jurisdictions (e.g., provinces, health authorities, service organizations) have developed their own specific sets of security requirements [3].

Two main research questions arise from a security assurance point of view, namely how to demonstrate the internal correctness and how to demonstrate relative conformance. The aspect of internal correctness equally applies to requirements and design specifications, as well as to actual system implementations. It considers the consistency and completeness of security properties, focusing on a single representation of an EHR. In contrast, the aspect of relative conformance aims to compare different system representations, e.g., a specification against another.
specification or an implementation against a specification. Again, consistency and completeness properties are at the heart of assuring relative conformance, but this time the focus is on sets of different system representations.

The above notions of correctness and conformance directly relate to the general concept of system verification, which asks the question “are we building the system right?” This should not be confused with the concept of system validation, which asks the question “are we building the right system?” Much of the research in the medical informatics community has been concerned with the latter aspect (validation), and it has significantly contributed to the recent emergence of standards and specifications in this domain. However, trusted security requires assurances that gold standards are followed and specifications are met. Creating such assurances for the security of an EHR is generally harder than for many of its other functional or qualitative properties and recent efforts in evaluating correctness and conformance of EHR systems tend to neglect this aspect.

The objective of this paper is to contribute to filling this gap. We give an introduction to the fundamentals of security assurance, summarize current assurance standards, and report on experiences with using security assurance methodology applied to the EHR domain, specifically focusing on case studies in the Canadian context.

1. Security Assurances

The three main objectives of computer security are commonly cited as confidentiality, integrity and availability, also called the CIA properties [4]. Confidentiality demands that no unauthorized party may access sensitive information. Integrity requires that information cannot be altered by unauthorized parties or by technical errors, while availability demands that sensitive services remain available at all times. What is considered secure (allowed) and insecure (not allowed) is typically defined by a security policy, or collection of security policies in complex systems with multilateral stakeholders. It is unrealistic to expect that all security violations can strictly be prevented in a system as complex as a shared EHR. Therefore, security measures may aim on prevention, detection or recovery of security violations.

What are security assurances? The purpose of security assurances is to instill trust in the secure workings of a system. Bishop reminds us that the concept of assurances is well known in health care, e.g., a drug manufacturer’s assurance about the safety of drugs [4]. While assurances cannot provide absolute guarantees about a system or product, they can be generated and combined to increase trust. In the drug example, assurances about clinical trials (FDA, Health Canada) can be combined with assurances based on best practice manufacturing standards and security seals on the packages that contain the drug.

Can we use a similar approach for software-based systems? The answer is yes! While many research challenges remain in computer security and software engineering, recent progress in the field has enabled us to create useful security assurances for software-based systems. Unfortunately, the health care IT sector has been slow to adopt research results in software security assurance. Health care organizations tend to put their trust in “brand names” of IT companies and in their ability to self-regulate, rather than putting in place an unbiased regulatory framework of software system certification and licensing. History has shown that this approach is unreliable [5].
2. Product-Focused Security

Security assurances may be based on various kinds of evidence. Interestingly, the current IT industry neglects the most important, primary evidence, i.e., the software products themselves. Maibaum and Wassyng criticize that current security assurances are largely based on secondary factors, e.g., the software development process, the credentials of the developers, the credentials of the organization operating the software, etc. [5] It is common to rely on the vendor's claim of using “best-practice” process models, e.g., Microsoft's Trustworthy Software Development Life Cycle (SDLC) [6], OWASP's Comprehensive Lightweight Application Security Process (CLASP) [7], or the Software Engineering Institute’s Capability Maturity Model (CMMi) [8].

While such secondary factors are certainly important, they are not sufficiently reliable without considering product-focused assurances. Rational development processes and licensed developers do not necessarily lead to secure products and Parnas & Clements have pointed out that software processes can easily be faked [9].

During recent years, the U.S. Food and Drug Association (FDA) is increasingly confronted with the problem of validating security and safety of eHealth software products. They lack objective criteria for such a validation and, as Maibaum and Wassyng point out, “the FDA evaluators have no deep, common understanding about what evidence to inspect, what attributes to measure, and what values are acceptable” [5]. In Canada, an expert review panel of the pan-Canadian EHR concluded that “… compliance with minimum privacy and security requirements should be subject to accreditation” [10]. Unfortunately, there is not a clear proposal on how to conduct this evaluation and accreditation. Current studies on evaluation frameworks for EHR projects do not consider security [11,12].

In Canada, Health Canada Infoway has founded the Standards Collaborative Working Group 8 “Privacy & IT Security Services” as a forum for discussing and developing EHR security and privacy standards. Interestingly, the archived discussions of this group (http://forums.infoway-inforoute.ca/PSCWG/) do not consider the question of evaluating products for creating security assurances.

3. The Common Criteria – A Possible Solution?

The Common Criteria for IT Security Evaluation (ISO/IEC 15408) is an international standard that attempts to provide answers for some of the questions raised above [13]. Its first version was published in 1996 as a combination of major international standards on security evaluation, including the European ITSEC, the Canadian CTCPEC and the American TCSEC (Orange Book). The current version of the Common Criteria is 3.1 and it is available at [14].

Figure 1 provides an overview of the Common Criteria (CC) security assurance process. Three parties are involved: consumers (customers), developers (vendors) and evaluators (auditors). The process starts by defining a so-called Protection Profile (PP), which details the security requirements for the IT system (called the Target of Evaluation or TOE). The PP may be defined by consumers (for example as part of an RFP), but it may also originate from a developer who seeks security certification for a product or wants to set a security standard. Developers then design and construct the TOE, whose architecture and technical specifications are detailed in a so-called Security Target (ST) specification.
It is important to note that, while there is a *to-one* relationship between a TOE and its ST specification, there is a *to-many* relationship between a PPs and STs. Hence, a PP is not tied to a particular TOE, rather it may be implemented by a set of different TOEs. Likewise, any given TOE may conform to an entire collection of PPs. This scheme is an important enabler for multilateral security. For example, it enables an EHR system to conform to a federal PP (e.g., Infoway’s requirements) and to a provincial PP, e.g., British Columbia’s (BC) PITO requirements. Moreover, PPs and STs may build on each other, by claiming conformance to other PPs and STs, respectively.

Once the TOE has been constructed, conformance to its corresponding ST and claimed PPs is validated by a licensed, independent evaluator, who generates an evaluation report and certifies the TOE, if it passes all criteria.

### 3.1. Criteria and Evaluation Assurance Levels

One of the main features of the CC standard is that it provides a common terminology and definition for security criteria in form of a poly-hierarchy. Two main kinds of criteria exist, namely security functional requirements (SFRs) and security assurance requirements (SARs). SFRs define what security functions a conformant TOE should fulfill (e.g., confidentiality of transmissions), while SARs define how to ensure that the objectives are met (e.g., strength of encryption). SARs are not only product-focused but also pertain to other factors, such as the development process, tools, the fault remediation process, and the operational environment, etc. Further SARs exist to assure that requirements (PPs) and designs (STs) are written correctly and completely (internal correctness).

The CC defines seven Evaluation Assurance Levels (EALs), with EAL 1 providing least assurance and EAL 7 providing maximum assurance. Each EAL packages a specific set of SARs, and an increasing number (and strength) of SARs are included in the higher level EALs. This mechanism allows consumers to specify a desired level of assurance. For example, a government may require at least EAL 4 for an EHR product to be implemented.
4. Applying the CC to EHR Security Assurance

According to the CC Portal [14], a total of 128 PPs and 901 products (STs) have been certified to date. EHRs are currently not among them. Therefore, we have conducted an experiment in the context of a graduate course on security assurance. We wanted to determine (1) whether current Canadian EHR security requirements can be cast into a CC format and (2) whether the CC can be used to align provincial requirements to federal requirements. As data sources, we used Health Canada Infoway’s Privacy and Security Requirements v.1.1 [2] on one hand, and British Columbia’s RFP “Electronic Medical Records Project” [3], on the other.

4.1. Federal EHR PP

Infoway’s requirements document specifies requirements for different system components, including the shared EHR infrastructure (EHRi), any components connecting to the EHRi, and organizations hosting components of the EHRi or components connecting to the EHRi [2]. In our study, we have concentrated only on “components connecting to the EHRi”, since the BC EMR will appear in such a role.

Our first question was whether the polyhierarchy of security criteria provided by the CC (version 3.1) was sufficient to express the requirements specified in our data sources. We found that this was the case for approximately 88% of the requirements in Infoway’s specification. We defined criteria extensions for the remaining requirements, using an extension mechanism specified in the CC standard. The criteria added concerned the notification of users in certain cases of modification to EHR data and specific functions for validating EHR input data.

Most of Infoway’s requirements translated into SFRs rather than SARs. There are no references to quality assurance methods (e.g., software testing, development tools, processes, configuration management etc.) As a result, the translated PP would only be certifiable at a minimum assurance level (EAL 1).

Besides defining security requirements, the CC forces the developer of a PP to clearly denote any assumptions, threats and objectives to mitigate these threats. We found that the federal data source did not clearly articulate these important aspects separately from the actual functional requirements.

4.2. Provincial EMR PP

We were able to express approx. 93% of the BC security and privacy requirements with criteria predefined in CC 3.1. However, the BC requirements were quite specific about patient consent management and various forms of data masking and unlocking. While it was principally possible to represent these requirements using the generic criteria on access control and to add any specific comments with informal “application notes” [2], we felt that the importance of consent management warranted the definition of an extended class of criteria.

Analogous to the federal data source, the provincial requirements translated mostly into SFRs and, thus, the resulting PP would be certifiable only at EAL 1. Again, assumptions, threats and objectives were not listed explicitly but had to be “reverse engineered” from the listed requirements.
4.3. Alignment of Provincial and Federal PPs

One value proposition of the CC approach is that it facilitates the alignment of multilateral security requirements. As the provincial EMR system is supposed to connect with the pan-Canadian (federal) EHR infrastructure, it should theoretically conform to the federal security requirements on “components connecting to the EHRi.” We did not find any such conformance claim in the BC data source.

The CC standard supports two notions of conformance, namely strict conformance and demonstrable conformance. Strict conformance requires that the conformant PP contain all criteria (requirements, assumptions, threats, objectives) of the conforming PP (plus potentially more), while demonstrable conformance can be established by “arguing” equivalence, even if different criteria are used in the two PP.

As expected, the common terminology defined in the CC standard significantly facilitated the alignment of the two requirements sets. In this paper, we report on the conformance of SFRs only, because, as indicated earlier, both data sources did not include explicit representations of assumptions, threats, objectives and security assurance requirements (SARs). Our results show that the provincial PP lacks conformance with the federal PP. We specifically noted 18 Infoway SFRs that were not included in the BC PP.

5. Discussion

While there is a general agreement that security is an important quality factor, for some even a defining characteristic of any EHR [12], the health care IT sector has largely neglected the question of how to create effective security assurances. International standards such as the CC have the potential of playing an important role in filling this void. Our study with two real life sources of EHR requirements indicates the CC’s applicability. It also shows the utility of employing a common security terminology for the alignment and conformance validation of multilateral requirements. While our experiment indicates a lack of conformance between BC’s EMR security requirements (contained in the RFP) and Infoway’s requirements, we do not want to conclude that BC’s EMR systems will be insecure. However, we point out that conformance claims are necessary and should be made in a fashion that can be validated. They are a key element of assuring the security of systems connecting to a shared EHRi. Of course, there is a cost involved in asking EMR vendors to certify their system for security. A US government report indicates that it takes between 10 and 25 months and $150,000 and $350,000 to certify a system’s compliance to EAL 4. However, this cost can be seen to be low compared to the potential damage of a compromised EHR.

References


Abstract. Health information systems (HISs) are typically seen as a mechanism for reducing medical errors. There is, however, evidence to prove that technology may actually be the cause of errors. As a result, it is crucial to fully test any system prior to its implementation. At present, evidence-based evaluation heuristics do not exist for assessing aspects of interface design that lead to medical errors. A three phase study was conducted to develop evidence-based heuristics for evaluating interfaces. Phase 1 consisted of a systematic review of the literature. In Phase 2 a comprehensive list of 33 evaluation heuristics was developed based on the review that could be used to test for potential technology induced errors. Phase 3 involved applying these healthcare specific heuristics to evaluate a HIS.

Keywords. heuristic evaluation, technology induced error, usability engineering, patient safety, evidence-based, heuristic evaluation

Introduction

Each day clinicians make decisions that directly affect patients' lives. According to the Institute of Medicine's report on patient safety, an estimated 44,000 Americans die each year as a result of medical errors [1,2]. In Canada, each year approximately 185,000 hospital admissions are associated with adverse events [3]. Therefore, it is important to take action and develop safeguards to reduce the number of medical errors. To offset these errors, healthcare organizations are investing in health information systems (HISs) such as electronic health records (EHR) and computerized provider order entry (CPOE). These HISs are considered to be effective mechanisms for improving patient safety and practitioner performance [4] because of their ability to improve the legibility of information and integrate decision support functions [5]. Currently, there is an abundance of literature that supports the idea that technology can reduce medical errors and contribute to more effective and efficient patient care. Decisions to implement HISs have been based on this literature. However, Kushniruk et al’s [1] and Koppel et al’s [6] study findings found that HISs may induce medical errors (i.e. technology-induced errors). Other studies have had similar findings. Although the literature may be limited, it is crucial that any potential negative effects of HISs must be considered and methods need to be developed to test HISs prior to their implementation. The purpose of this paper is to outline the development of evidence-based heuristics that can evaluate the safety of interface designs and prevent technology-induced errors prior to HIS implementation.
1. Methods

1.1. Phase 1: Systematic Review

A systematic review was conducted. The search terms “informatics medical errors,” “informatics induced errors,” “technology induced errors,” “technology facilitated errors,” and “CPOE errors” were used to query the Web of Science and Medline. Articles published up to 2005 were selected for review when they described potential harms associated with HIS use. Abstracts from these articles were read and reviewed. If the abstract documented a study where a technology-induced error occurred or explained methods that could be used to test for and/or avoid technology-induced errors then the article was reviewed further. In total, ten articles were identified that matched the above outlined criteria. The articles [1-10] were analyzed further. Data from the articles was organized into a table that captured each article’s purpose, sampling methodology, study design, types of errors identified, findings and factors that led to errors.

1.2. Phase 2: Creating Evaluation Heuristics

After reviewing the errors documented by the articles, heuristics that could be used to evaluate HISs for their ability to facilitate technology-induced errors were developed. Using information from Phase 1, a group of three informatics experts reviewed the articles and conducted a round table discussion to develop a list of heuristics that could be used to evaluate HISs for their potential to facilitate technology-induced errors (based on the published literature). A preliminary list of heuristics was generated. Each heuristic was classified into one content area: 1) Content Issues - information that is presented to the user or information that the user inputs into the system, 2) Functional Issues - the actual capabilities of the system, 3) Workflow Issues - any aspect of the system that can directly affect a users’ workflow (i.e. changes in processes, additional work, increased time for each task, communication and interactions with the system, colleagues or patients, 4) Safeguards – any precaution against error such as alerts, reminders, duplicate checking, etc. Once categorized according to content area, heuristics were ranked according to their ability to identify and prevent medical errors (See Figure 1).

1.3. Phase 3: Heuristic Evaluation

In the usability engineering literature, usability testing is used to evaluate HISs by observing representative users performing representative tasks. Usability inspection is a way of analyzing a system by having an analyst systematically review a system’s interface by applying design principles (heuristics) [3]. Both methods are used in health informatics to evaluate interface design. To test the validity of the heuristics developed in Phase 2, a heuristic evaluation of a demonstration version of the Veterans Affairs (VA) Computerized Patient Record System (CPRS) was conducted. Due to the constraints of the demonstration version, a usability inspection was conducted using a modified list (see Figure 1) of the developed heuristics. All findings were recorded.
2. Results

To test to see how well the evidence-based heuristics identified potential errors, the modified list of heuristics was used to evaluate the VA CPRS using usability inspection methods. The analyst conducted a system walk-through and recorded the findings for each heuristic (i.e. whether the system conformed to or violated the heuristics that were developed, see Table 1). It should be noted that the version of the VA CPRS was a demonstration version. However, we are currently evaluating a full production version of this and several other systems using the heuristics we have developed and described in this paper.

3. Conclusion

Currently, there is significant desire among healthcare organizations to introduce HISs to hospitals and clinics. Most of this research has found that the HIs that are currently being implemented are improving patient care. Alternatively, there is little research that shows how technology may be contributing to errors rather than preventing them. Many researchers use general usability heuristics to assess the usability of HIs. By
Table 1. VA CPRS heuristic evaluation documentation.

<table>
<thead>
<tr>
<th>Medication status is clearly displayed</th>
</tr>
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<tbody>
<tr>
<td>The system is set up to display the date the medication was ordered, the stop date, expiry date, and the status of the order. The system displays all of the necessary information to indicate medication status.</td>
</tr>
</tbody>
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<table>
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<tr>
<th>Minimal number of clicks for entering a medication order</th>
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<tbody>
<tr>
<td>It took approximately 5 clicks to order a medication. This included opening the new order form, selecting the medication and dose, and submitting the order. It was relatively easy and quick to create a new order.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Limit free-text that others may not be able to see</th>
</tr>
</thead>
<tbody>
<tr>
<td>Although some sections of the VA CPRS system did allow for free text, the majority of the fields were not free text. Most of the fields were drop down menus and all free text fields were clearly displayed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medication lists and synonyms have been properly customized to the hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to the fact that the VA system is a homegrown system designed specifically to fit their organization, it is assumed that the synonyms have been customized to each of their hospitals.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Look out for inflexible screen sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>The layout of the system is very accommodating to different types of tasks that clinicians may be performing. Due to the tabs on the bottom of the screen, the clinician has the flexibility to choose the sequence that they feel is best and is not forced to go through every screen.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Information about one drug order should be on the same screen when possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>All drug information is located on the same screen. The system provides a small summary field that displays the drug name and dose. There is also functionality to open up a more detailed report on the ordered medication as well as a complete drug history.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alerts and reminders should be consistent with current organizational policies and procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>It can be assumed because the VA created the system that the alerts were originally based upon their organizational policies and procedures. It is however crucial that they are maintained and updated frequently.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Limit or do not use defaults for medications unless they are clear on their applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>When ordering a medication some of the drugs have possible doses that can be selected as well as possible schedules to administer the drugs. If an order is submitted with either of these fields empty, an error message is displayed informing the clinician to enter a dose and a schedule. Defaults are not automatically added to these fields so there is no chance of the wrong dose or schedule to be selected without the clinician selecting it themselves.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Origin of defaults should be clear to the users –</th>
</tr>
</thead>
<tbody>
<tr>
<td>The system does not use defaults in the medication ordering screens. They do provide options that can be selected for dose or schedule of the medication but the origin of these options is not displayed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Menus are scrollable and clearly marked as such</th>
</tr>
</thead>
<tbody>
<tr>
<td>All menus in the system that exceed the assigned page limit are scrollable and have a scroll bar on the right hand side. The scroll bar is the only indicator that the field is scrollable and if a user is not very familiar with computers they might have a difficult time using this feature.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clearly display date and time medication was updated</th>
</tr>
</thead>
<tbody>
<tr>
<td>No information is displayed that informs the user when the medication was last updated in the system. The system does display dates such as when the meds were ordered and when meds should be stopped.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System checks for duplicate medications, IV drugs, and procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>When a clinician tries to submit a medication order the system automatically runs a check to see if the same medication has already been ordered. If there is a duplicate medication ordered or the medication is currently being taken by the patient an alert pops up displaying the information for the duplicated order. The clinician then has the choice to go ahead and accept the order or cancel it.</td>
</tr>
</tbody>
</table>

Creating heuristics that are based on published research as described in the literature, a new set of evidence-based heuristics was created that assesses HISs for their ability to facilitate technology-induced errors. These evidence-based heuristics proved to be
effective in assessing the safety of the VA CPRS system but they are new and will need to be tested on multiple systems before they can be considered the new standard for usability inspection.

The heuristics that were developed by the researchers may be able to detect error-inducing aspects of HISs. There are a number of other factors that need to be considered when assessing system safety. First, the knowledge level of the users must be considered: experienced and inexperienced users may have differing error rates. Also, user training will affect error rates. Organizations need to consider the time it will take users to gain enough experience with a HIS. Lastly, every HIS has its limitations. The limitations of each HIS need to be fully understood before a system is implemented. These limitations can be found with the use of the heuristics. When a HIS is implemented, the organization and its users must fully understand the HISs impact. With the use of evidence-based heuristics, HISs can be tested for their ability to facilitate technology-induced errors.

References


Televaluation and Usability Assessment of the Human-Machine Interface for a Novel Adaptive Health Knowledge Translation System

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b Northern Ontario School of Medicine, ON, Canada
c School of Health Information Science, University of Victoria, Victoria, BC, Canada

Abstract. We describe results from usability assessment of a novel adaptive health knowledge translation system interface. Search or retrieval logic, navigation, and presentation elements are crucial to delivering best content. Design requirements have been enhanced by assessing participant needs and desired features.

Keywords. usability assessment, knowledge translation, adaptive systems

Introduction

The fields of health sciences, clinical practice, and information technology are merging to automate, organize, and deliver health knowledge and experience across digital networks, including the Internet [1]. Concomitantly, the need for usable and effective human-machine interfaces to promote user adoption and knowledge uptake is critical [2]. Methods aimed at assessing such usability are required early in the software design lifecycle to reduce costly reengineering events later and to even prevent implementation failures during adoption [3,4]. Adaptive interface design requires frequent testing and a rapid method for assessing user satisfaction and usage problems to allow for prototype adjustments [5].

Usability Testing (UT) identifies existing problems through the user’s interaction and experience with the system. It uses audiovisual recording techniques to determine what a user does and what a user thinks by capturing user physical actions, and user system interactions at the interface level. User conceptualization at the cognitive level is recorded by means of “think-aloud” scenarios.

In this paper we discuss our work that made use of “televaluation” and usability engineering methods [6] to assess an early design of an adaptive health knowledge translation framework [7,8] user query interface. We explore outcomes from usability testing. These include “think-aloud” techniques linked with audio-visual records of interface usage for 11 study participants who completed directed knowledge-acquisition tasks. Where relevant, demographic and summative questionnaire data are given. We also provide an assessment of the interface by means of a post-test
qualitative semi-structured interview that was administered to participants who had a health care background and were either practicing or were in training.

We present the data from this study to identify user needs in complex health knowledge task completion and to identify usability problems in the current design. Requirements analysis to build adaptive knowledge packages, which we call Knowledge Kernels\textsuperscript{TM} \textsuperscript{1}, are explored and solutions are recommended for improvement of the user interface and its presentation engine module to the development team. We describe common challenges in the design of user interfaces for improved knowledge acquisition.

1. Methods

1.1. Subjects

Human ethics approval for this study was received from the University of Victoria Research Ethics Board. People with healthcare experience (i.e., a trainee or practitioner in one of the health-related clinical services) were recruited by word-of-mouth. Interested applicants had to be 18 to 65 years old. They had to be able to read, manually interact with a computer, hear, and talk aloud. Those who had previously used the Kernel Reviewing interface were excluded. Informed consent was required.

1.2. Study Materials

Data were collected on paper-based forms for the background questionnaire and post-test qualitative semi-structured interview. The machine-user interface for this study was Knowledge Kernels\textsuperscript{TM}. Workstations, using Internet Explorer to access the test interface, were connected to a central server by broad-band Internet or a local Gigabit network. A battery augmented headband microphone was used for usability testing and for post-test qualitative semi-structured interview recording. The audio signal was synchronized with the screen capture tool (Hypercam [9] software version 2.14.02).

1.3. Study Procedure

The researcher was present for the entire session. Free form thoughts and opinions of the participant were captured throughout the study. Demographic and study population data were collected by means of an 18-item survey questionnaire at the outset of the study session. These data include each participant’s experience with and opinion of health knowledge tools and their related skills. Each participant then pre-read the entire knowledge-acquisition task scenario, which consisted of 14 representative tasks for the user to undertake while interacting with the Kernel Reviewing interface. Each task was to be done in sequence, with subsequent tasks building on previous ones. Participants were encouraged to ask any questions after reviewing this list and before beginning the actual usability testing. After an audio test, each participant was recorded completing the task scenario and encouraged to talk-aloud to express their thoughts and observations. Only technical corrections and very limited interaction by the researcher occurred once usability testing had begun. Following completion of the usability

\textsuperscript{1} Knowledge Kernels is a trademark of Med-Nexus Inc. 2006-2016.
testing, a participant responded to a 13-item, semi-structured interview with the researcher. The interview permitted further elaboration on usability issues discovered during the task scenario. It also gathered requirements data on user experience, which included information needs and user preferences on how best to present knowledge.

Data from the background questionnaire, the usability testing, and semi-structured interview were tabulated and analyzed. Each usability task item was assessed for its goals and subgoals. As well, the data were analyzed and compared to determine the actions required to counter observed problems and any other issues. These problems and issues were grouped and categorized using known methods for coding of both standard and novel problem types. Frequencies and trends of the outcome data were calculated and assessed. Results were summarized and a report was given to the developers of the tested user interface.

2. Results

2.1. Demographic and Summative Questionnaire Data

Eight females and three males, with ages ranging from 21 to 60 years, completed the study. Most of them were between 21 to 30 and 41 to 50 years old. Most of the older participants had advanced healthcare degrees and established practices as psychological associates, medical specialists, and nurse educators. Most of the younger ones were training in a healthcare profession. All but one participant had completed a university degree. Fifty-four percent had a graduate level professional degree. There were three medical students, one psychology student, two specialist physicians, three nurses, one psychological associate, and one allied health worker.

All participants used computers several times daily. More than 90% had started using computers at least 5 years ago; one person had two to five years of experience. All participants had used e-mail and the Internet. All but one had used search engines and word processing software. Clinical software applications, such as an EMR or HER, were used by 80% of participants. More than 55% had used spreadsheets or health knowledge systems. Only one person had computer programming experience.

Seven participants had used health knowledge systems. The frequency of use was: several times daily (2), several times weekly (3), once or fewer times monthly (1), and no frequency of use (1). The most frequently used health knowledge tool was UpToDate [10], which was used by two medical students and a specialist physician.

Study participants used UpToDate to perform searches on medical topics for group medical learning sessions and for clinical cases. The system strengths included rapid search and regularly updated and extensive detailed content with wiki-like related topic links. Among its weaknesses were the lack of published study design or validity assessment information backing the content, and a poor capability to search for age-specific topics or similar context-specific knowledge. Suggestions to improve this tool included: reducing the use of long topic lists to find the knowledge of interest, enhancing the ability to make semantic searches, and providing more explicit information about the knowledge sources. Participants stated that health knowledge systems other than UpToDate, i.e., STAT!REF [11], Health Knowledge Network [12], MyNightingale EMR [13], Mayo Clinic online [14], allowed access to a wide range of knowledge sources but lacked a capability to perform semantic searches. Only one person had previously used the Knowledge Kernels™ health knowledge system. This
experience was with the Authoring Interface and, consequently, they had not been exposed to the study interface.

All participants had used an Internet search engine and 8 used one daily. Six of the participants agreed somewhat with the statement “An internet search engine adequately finds credible health knowledge I need quickly and accurately.” The other five respondents somewhat disagreed.

The responses to “What improvements do you need for accessing reliable health knowledge electronically? (check all that apply):” are shown in Table 1. Medical students in training endorsed the top three items in the table (precise searching, accurate content, and reliable content), as with the other respondents. However, respondents with more clinical experience also placed emphasis on the need for health knowledge systems to be integrated into clinical record systems, learning, and research systems, and to have ubiquitous 24/7 access.

2.2. Usability Testing

Analysis was performed on the 261 usability problems that participants encountered as they completed the task scenario. Each task, each of which has goals and sub-goals, had several problems in usability. Early and later tasks involving complex selection of search topics and context limiters resulted in higher rates of problem occurrence. Table 2 shows each type of usability “problem” identified during testing and its associated occurrence. In contrast, usability “issues” were items identified by participants in the post-test interview.

The “Hypercam screen issue” occurred when monitor’s screen resolution was not optimally set for use with the capture software. This caused an error window to open. The issue was not related to the Kernel Reviewing software and it occurred only once with one participant and 10 times with another. It had no major impact on the participants’ assessment of the Kernel Reviewing interface as the users simply clicked on the window to close it. This and an application termination issue were not mentioned in the post-test interview and were not considered a usability issue.

Table 1. What improvements do you need for accessing reliable health knowledge electronically?

<table>
<thead>
<tr>
<th>Choice</th>
<th>N=11</th>
<th>% N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Searches that are more precise</td>
<td>10</td>
<td>91</td>
</tr>
<tr>
<td>Content that is more accurate to my needs</td>
<td>9</td>
<td>82</td>
</tr>
<tr>
<td>Content that is reliable and credible</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>An ability to capture health knowledge and build it into my own categorized library rapidly</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>An ability to share health knowledge with others and other databases in a standard but customizable format</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>All of the above integrated into and EMR (electronic medical record) able to be used at point of contact with patients</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>The integrated EMR with tools accessible from work or home so I can also research topics linked to my clinical case load or my educational studies</td>
<td>8</td>
<td>73</td>
</tr>
<tr>
<td>No improvements are required. I get all I need now.</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
2.3. *Post-test Qualitative Semi-structured Interview*

The 13 semi-structured interview prompts generated 114 unique issues in post-usability testing discussions. Issue endorsement by participants was tabulated. Each usability issue was then assigned to a summary issue category, either novel or similar to usability testing categories. Table 2 is a summary of these data in which usability issues are ranked based on a formula involving issue frequency and participant endorsement:

\[
\text{ISSUE RANK} = (\text{issue frequency per group}) \times \\
(\text{relative endorsement per issue}) \times (\text{converter value}) \quad (1)
\]

<table>
<thead>
<tr>
<th>Usability problem/issue</th>
<th>Detail</th>
<th>Usability Problem Occurrence</th>
<th>Issue Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search logic</td>
<td>Search logic refers to a number of elements that come together to deliver the content matched to the purpose of the participant.</td>
<td>62</td>
<td>48</td>
</tr>
<tr>
<td>Misleading labels</td>
<td>Refers to the effect on usability of poor naming or use of controls and information in the interface</td>
<td>40</td>
<td>56</td>
</tr>
<tr>
<td>Navigation</td>
<td>The process and path used to find information and content using the tool interface</td>
<td>34</td>
<td>112</td>
</tr>
<tr>
<td>Look and Feel</td>
<td>Presentation style and overall impression as relates to usability</td>
<td>28</td>
<td>72</td>
</tr>
<tr>
<td>Content</td>
<td>Related directly to the nature and usability of the content accessed by this tool during the study</td>
<td>24</td>
<td>199</td>
</tr>
<tr>
<td>Instructions and help</td>
<td>Relates to usability of visible instructions/help or lack thereof</td>
<td>19</td>
<td>56</td>
</tr>
<tr>
<td>Connectivity</td>
<td>Either network or Internet based problems, Can be related to actual network connections or represent broken links, or missing applications.</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Usability-overall</td>
<td>Usability-overall captures issues that do not relate to a specific usability element but that describes the overall system usability</td>
<td>11</td>
<td>56</td>
</tr>
<tr>
<td>Hypercam screen issue</td>
<td>Warning pop-up request from operating system to change screen resolution to meet requirement of Hypercam software to operate properly</td>
<td>11</td>
<td>N/A</td>
</tr>
<tr>
<td>Speed</td>
<td>Speed refers to system responsiveness to user actions</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Application termination</td>
<td>Abrupt unexpected termination of the application</td>
<td>6</td>
<td>N/A</td>
</tr>
<tr>
<td>Prominence of labels</td>
<td>Refers to the effect on usability of correctly named/used but poorly noticeable controls and information in the interface</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>Learning Curve</td>
<td>Speed of learning of interface functions - inversely related to usability intuitiveness</td>
<td>0</td>
<td>72</td>
</tr>
<tr>
<td>Security</td>
<td>Relates to access, privacy, confidentiality, and authorization for use issues</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Desired features</td>
<td>Participants expressed a large number of desired features that were needed to take them from their current methods to meet their intended purposes</td>
<td>N/A</td>
<td>1260</td>
</tr>
<tr>
<td>Current user methods</td>
<td>Current user method refers to the way a participant catalogs and organizes, reuses, and shares health knowledge</td>
<td>N/A</td>
<td>518</td>
</tr>
<tr>
<td>User purpose</td>
<td>Describes the reasons that a participant would use an electronic health knowledge tool for her work or studies</td>
<td>N/A</td>
<td>64</td>
</tr>
</tbody>
</table>
Eq. (1) gives a sense of relative importance of the issue and its group to the user and to the software usability success.

There were three usability issues discussed in the post-test interview that were not noted as usability problems: “Desired features,” “Current user methods,” and “User purpose.” “User purpose” and “Current user methods” were less about the concerns a user had with the software than with identifying their needs, goals, and current ability to solve health knowledge problems. “Desired features” represented creative ideas and software functionality that participants wanted for solving challenges in health knowledge acquisition. All three contributed to our requirements analysis for future features and design.

**Discussion**

Rich data were acquired to assess usability of the Kernel Reviewing interface. The study participants were well versed in computer use and had varied healthcare experience. Trainees were more interested in knowledge credibility and authority because they endorsed precise searches, accurate and reliable content whereas more clinically experienced practitioners, who also supported these, were interested in linking health knowledge for clinical work and communities of practice. Most participants were not using advanced applications for organizing, reusing, or sharing knowledge and experience. Overall, current methods for health knowledge exchange appeared rudimentary and inefficient. There was a need for tools and improvements in semantic contextualization and for expertise in knowledge management and sharing.

For many participants, the overall usability was acceptable and even preferred to that of search engines. There were not many application terminations, and it appears that users with this level of computer experience could cope with these issues. Most users adapted quickly to the new challenges: the “look and feel,” navigational method, and the checkbox control. Participants seemed to prefer a narrow selection of fragments returned from a retrieval query. For authoring context, there appeared to be a conflict between inclusiveness of cross-relationships and key limiters.

Topic searches require a main topic that either is narrowed or broadened by limits of scope. This is especially true if the semantic content of the topic search is not comprehensive and does not include all contexts in the main focus. This causes a confounding effect: seemingly unrelated content will appear with a higher relevance rating simply because of limits in scope. Most participants seemed to want a primary search topic with subtopics that could then be used to narrow the scope hierarchically. Consequently, the tool was thought to poorly combine issues and retrieve relevant content.

Beyond the difficulty with search logic, there are three more usability concerns. They are closely related and, in conjunction with search logic, effect overall usability significantly. The “look and feel” needs to be uniform and yet accommodate some user preferences. Users complained about the small character fonts. Some participants preferred color schemes to clarify the screen displays. As well, there were issues with “Misleading labels” and the “Prominence of labels” which affect how rapidly users learn to use the tool. Navigation issues were related to the “look and feel” as well as the semantic interface of the software, e.g., the use of free-text boxes for alternate search methods, topic maps or trees, and fuzzy logic user scripts. Although participants liked
the checkbox metaphor and appreciated the attempt at contextualizing topics for targeted semantic retrieval, this search method was, by itself, limiting.

Issues with the content were evaluated as well as the search logic. These included what additional resources should be shown with the content, how the content should be presented, and how the presentation affects the intuitiveness of the tool. For example, broken web links were found frequently and were annoying to the users.

Poor Internet performance or short intermittent network failures affected the study although not frequently. These may have caused the “Application terminations.” They may also have caused browsers to exit once “go-back” button had been clicked.

Important knowledge was learned about the features that health knowledge consumers desire. The study described the needs and use purposes of consumers and revealed the distance those consumers are from achieving their goals. The most desired features were the ability a) to sift through the mass of irrelevant data to get credible and reliable best practice knowledge, b) to store and catalog this knowledge in a more intuitive and useful way, and c) to share knowledge with colleagues regarding clinical cases. Advanced semantic knowledge translation tools and systems should be developed to support these features.

This study has resulted in recommendations to developers for software error corrections and for the development of new features. We will conduct further analysis of task elements and their usability problems to more precisely determine software design revisions.

References

Assessing Software Impact on Clinical Workflow and Resource Utilization

Kevin C. MURPHY
Clinical Informatics Service, BC Cancer Agency/Fraser Valley Centre, Department of Medicine, University of British Columbia, BC, Canada

Abstract. A usability study is described that compares a web-based capecitabine-prescribing and dispensing application to traditional manual methods. The behaviours of two small groups, oncologists and pharmacists, were recorded and analyzed using a case study of a patient with metastatic colon cancer. The study indicated for the oncologists that workflow and resource utilization decreased due to the application, however, for the pharmacists the results were less positive. This type of case study simulation can be used to determine the impact of software applications on their users.

Keywords. usability simulation, workflow research platform, automated prescribing, resource utilization

Introduction

The integration of clinical provider order entry software with clinical decision support is a disruptive process that has the potential to increase task time and complexity. Resistance to change by clinicians may impede implementation of sophisticated software systems due to inadequate attention to design, usability and impact on clinician workflow. The Clinical Informatics Service has created a series of software applications. These include web portals, calculators for radiation therapy and chemotherapy dosing, verification calculators for pharmacy as well as 5FU chemotherapy pump calculators. Although these have been designed and implemented with user input and feedback, none have been evaluated for their effect on clinical workflow.

Based on work by Kushnirik [1] to test the feasibility of establishing a workflow research platform, the deployment of a web-based application designed for prescribing and dispensing capecitabine (Xelox®) is accompanied by the simulated assessment of individual work and resource utilization during each clinician’s baseline process then repeating the simulation using the capecitabine software. It was hypothesized that the software would reduce time spent and resources utilized by automating calculations. It was also thought that the application would reduce knowledge-searching and the use of recall/working memory while providing a positive experience for the participants. User feedback was anticipated to offer improvements to the application design.
1. Methodology

There were three phases to the project.

1.1. Phase 1

Phase 1 involved a baseline process analysis through a series of structured interviews with 9 oncologists and 7 pharmacists. The participants were asked to recall the actions and resources required for safe prescribing and dispensing of the initial capecitabine dose for a patient with metastatic colon cancer. The initial tasks proposed were 1) to calculate the patient’s body surface area, 2) to calculate the dose of capecitabine, 3) to determine the nearest dose based on pill strength, pill distribution and 4) to modify the patient’s dose based on impaired renal function. The tasks, actions and resources described were entered into a spreadsheet. Additional actions, tasks and resources were added by the participants. These included verifying lab results, checking for allergies and drug interactions, validating the oncologist’s order against protocol eligibility, completing the patient’s treatment record, preprinted orders and comparing the oncologist’s written capecitabine order against the pharmacist’s calculated dose.

1.2. Phase 2

A clinical scenario was created that described a patient with metastatic colon cancer to be treated with capecitabine. An anonymized case used to train Centre staff in the use of the Agency’s electronic medical record (CAIS) was employed. The scenario included the patient’s demographics, co-morbid conditions, current medications, allergies, height, and weight, history of present illness, physical examination and location of pertinent lab results in the CAIS file.

Using phase 1 input, each study participant was given a set of tasks to perform using their usual methods and knowledge resources. A computer workstation with Morae Recorder [2] installed captured their video, audio output and application use. A digital video recorder captured manual activities. After each session, the participant answered two questions regarding the simulation’s representation of their usual working environment. All printed materials were collected for analysis. Eleven oncologists and five pharmacists participated.

Oncologists were asked to perform 6 separate tasks (see Table 1) and pharmacists were asked to perform 10 separate tasks (see Table 2).

1.3. Phase 3

The participants revisited the identical clinical scenario with the same simulation but using the capecitabine software application. Prior to the session, the participants received a manual describing the application functions and navigation. If needed, participants were given a brief introduction of the application features. After sessions, each participant was asked to complete a survey about the validity of the simulation as well as questions regarding the application, focusing on their experience, its impact on process efficiency, as well as positive, negative and desired features. Seven oncologists and five pharmacists participated.
Phase 1. A spreadsheet was used to separately analyze the two groups of participants: oncologists and pharmacists. The total number of resources and the number of actions needed to complete each task were counted. Frequency of resource use was calculated.

Phase 2. Each simulation session, in which “usual” methods were employed, was analyzed using MORAE Manager, documenting the time each participant took to complete a specified task such as calculating the patient’s body surface area. Each video session was transcribed and annotated in Transana 2.2 [3]. Internal memory resources were coded as recalled or working. The time and resource utilization for each task performed by each participant were exported to Microsoft Excel and analyzed.

Phase 3. The phase 2 analysis was performed on those data collected while using the capecitabine software. The task of assembling printed materials was eliminated from this analysis as all pharmacists had brought paper protocols with them. Results from phases 2 and 3 were compared using descriptive statistics.

### 3. Results

#### 3.1. Phase 1

Oncologists reported using an average of four resources (range of two to 6), employing an average of 5.67 actions to complete four tasks with an average action task ratio of 1.42. Twelve separate resources were described with the top eight by frequency being a web-based Oncology calculator, internal memory, PDF version of the protocol, web

<table>
<thead>
<tr>
<th>Table 1. Tasks performed by oncologists.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Assess the patient’s lab data</td>
</tr>
<tr>
<td>3. Calculate the patient’s capecitabine dose</td>
</tr>
<tr>
<td>5. Complete the patient’s pre printed order</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Tasks performed by pharmacists.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Assemble printed materials such as treatment records, printed protocols, oncologist’s order, etc</td>
</tr>
<tr>
<td>3. Assess the patient’s treatment eligibility</td>
</tr>
<tr>
<td>5. Calculate the patient’s body surface area and creatinine clearance</td>
</tr>
<tr>
<td>7. Determine the appropriate nearest dose based on pill strength</td>
</tr>
<tr>
<td>9. Create a pill distribution for the patient</td>
</tr>
</tbody>
</table>

2. Analysis

**Phase 1.** A spreadsheet was used to separately analyze the two groups of participants: oncologists and pharmacists. The total number of resources and the number of actions needed to complete each task were counted. Frequency of resource use was calculated.

**Phase 2.** Each simulation session, in which “usual” methods were employed, was analyzed using MORAE Manager, documenting the time each participant took to complete a specified task such as calculating the patient’s body surface area. Each video session was transcribed and annotated in Transana 2.2 [3]. Internal memory resources were coded as recalled or working. The time and resource utilization for each task performed by each participant were exported to Microsoft Excel and analyzed.

**Phase 3.** The phase 2 analysis was performed on those data collected while using the capecitabine software. The task of assembling printed materials was eliminated from this analysis as all pharmacists had brought paper protocols with them. Results from phases 2 and 3 were compared using descriptive statistics.
portal, pre printed order, Agency web site, Palm and manual calculator. Pharmacists used an average of 8.71 resources (range of 6 to 12), employed an average of 12 actions to complete 8 tasks with an average action/task ratio of 1.5. Nine separate resources were described with the top eight being the patient’s pre-printed order, a web-based verification application, internal memory, paper protocol, chart, treatment record, CAIS and web portal. Additional tasks listed by pharmacists included checking for drug interactions, assessing the patient’s Pharmanet profile, validating the patient’s order against diagnosis and disease stage and comparing the oncologist’s prescribed dose with their calculated dose.

3.2. Phases 2 and 3

During phase 2, oncologists were observed using an average of 8.27 resources (range of 6 to 10) with 14 used overall. The top eight resources by frequency were: systemic calculator, protocol (PDF version), treatment record, and pre printed order, web portal, CAIS, working memory and Agency web site protocol page. The pharmacists were observed using an average of 8.4 resources (range of 6 to 12) with 12 used overall. The top eight resources were: treatment record, initial cycle verification, paper protocol, manual calculator, CAIS, pre printed order, working memory and web portal.

During phase 3, with the use of the capecitabine application, oncologists reduced their use of resources to a mean of 5.43 (range of five to 6) with 9 used overall. The top eight resources were: capecitabine application, CAIS, web portal, treatment record, web portal, and health unit coordinator used to print orders, protocol (PDF) and FVC Systemic Portal. The use of the systemic calculator, working memory, manual calculations and recall memory were reduced to zero with a 92% reduction in accessing the PDF version of the protocol. The pharmacists increased their use of resources to a mean of 10.5 (range of 6 to 12). The top eight by frequency were: treatment record, web portal, initial cycle verification, capecitabine application, paper protocol, CAIS, pre printed order and protocol (PDF). Working memory use was eliminated with a 67% reduction in manual calculations. Because some pharmacists use the initial cycle verification as a printed record of their process, they still used it in addition to the capecitabine application although its frequency fell by 23%.

Changes in time on tasks for oncologists and pharmacists are presented in Tables 3 and 4. The survey responses for oncologists and pharmacists are shown in Tables 5 and 6.

Table 3. Oncologists’ mean task times in seconds.

<table>
<thead>
<tr>
<th>Task</th>
<th>Baseline (N = 11)</th>
<th>Application (N = 7)</th>
<th>Differences (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Lab Results</td>
<td>33.52</td>
<td>26.8</td>
<td>20</td>
</tr>
<tr>
<td>Calculate BSA</td>
<td>20.73</td>
<td>10.5</td>
<td>49</td>
</tr>
<tr>
<td>Calculate Capecitabine Dose</td>
<td>51.88</td>
<td>29.5</td>
<td>43</td>
</tr>
<tr>
<td>Create Nearest Dose</td>
<td>15.07</td>
<td>1.1</td>
<td>93</td>
</tr>
<tr>
<td>Complete Order</td>
<td>70.13</td>
<td>93.1</td>
<td>-33</td>
</tr>
<tr>
<td>Renal Function Modification</td>
<td>125.08</td>
<td>50.2</td>
<td>60</td>
</tr>
<tr>
<td>Total Task Time</td>
<td>316.40</td>
<td>211.1</td>
<td>33</td>
</tr>
</tbody>
</table>
4. Discussion

The simulation sessions lasted less than 20 minutes. The oncologists thought the simulations represented their usual clinic setting but the pharmacists thought they were less representative due to the absence of two applications they normally use. For oncologists, the capecitabine software reduced resource use (including working memory which is prone to error) and total task times. In addition it provided a positive experience and was considered to be more efficient. The pharmacists rated the simulation lower and did not rate their experience as highly as the oncologists. They increased their resource use which included the paper protocol. This may be due to inadequate training, continuation of previous habits, and design flaws in the application. Although total task time was decreased, the time it took to compare doses was greatly increased likely due to the pharmacists using two separate applications.
The feedback obtained will allow us to examine their work processes in more detail to see if additional features can be developed or if there is an optimal way in which the two applications can be used concurrently.

Table 6. Survey responses given by pharmacists.

<table>
<thead>
<tr>
<th>Mean Score +/- SD</th>
<th>Baseline (N = 5)</th>
<th>Application (N = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This simulation accurately reflects what actions I usually perform in the pharmacy setting when dispensing capecitabine for the first time (Strongly Agree = 5, Strongly Disagree = 1)</td>
<td>4 +/- 1.2</td>
<td>4.25 +/- 0.5</td>
</tr>
<tr>
<td>During the simulation I had most of the resources that I would normally use in pharmacy (Strongly Agree = 5, Strongly Disagree = 1)</td>
<td>3.8 +/-1.64</td>
<td>4.25 +/- 0.5</td>
</tr>
<tr>
<td>Rate your experience with the capecitabine application (Very positive = 5, Very Negative = 1)</td>
<td>N/A</td>
<td>3.75 +/- 0.5</td>
</tr>
<tr>
<td>I found that dispensing capecitabine using the application to be more efficient than the way I did previously (Strongly Agree = 5, Strongly Disagree = 1)</td>
<td>N/A</td>
<td>3.25 +/- 0.5</td>
</tr>
</tbody>
</table>

Morae Recorder provided data for our detailed analysis, which focused solely on task times and resource utilization. Additional analysis will be performed to assess users’ skill with current software. More efficient use of applications such as keeping windows open and re-entering data as needed would be helpful in optimizing workflow in the current environment.

5. Conclusions

The use of an on-site usability platform is a feasible method to assess episodes of work. It allows us to assess the workflow impact of software applications as they are developed or when they are purchased. With usability information, the Centre can make better plans and can mitigate the impact of software on oncologists, pharmacists and nurses in advance of full scale implementation. Clinician input can lead to better software and improved workflow, satisfaction and productivity.

References

Architectural and Usability Considerations in the Development of a Web 2.0-based EHR

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Abstract. In our previous work, we described an electronic health record (EHR) architecture based on Web 2.0 principles. With this architecture, users in healthcare and public health can select, configure, share and control the information and interfaces they use by means of simple techniques such as “drag-and-drop” without the intervention of programmers. We extend this work by discussing architectural and usability considerations important for creating such an EHR. These include: new affordances facilitating element creation, responsiveness while using rich client-side interaction, consistency versus flexibility, security, workflow and evaluation.

Keywords. web widget, Web 2.0, EHR interface, usability

Introduction

Healthcare is a collaborative discipline that has complex information needs which vary according to user, specialty, role, and other factors [1]. Systems have typically been created for specific uses by vendors in partnership with health professionals in the slow and costly iterative process of requirements formulation, programming, testing and reformulation. Even small changes may require programmers, consensus and time. The process can produce an overly complex “one-size-fits-all” design and interfaces that are conceptualized by programmers rather than by health professionals. User resistance and under-utilization can result.

By contrast, Web 2.0 approaches typically include: a) a flexible frameworks for user-controlled content creation, sharing, and system configuration, b) a diverse user-selected information sources, c) a service-oriented back-end architecture (SOA), d) the aggregation and use of “snippets,” short information fragments or feeds, e) the use of “widgets,” or small modular packages of code to perform tasks, and f) “organic” system growth as users contribute to its “evolutionary” development [2]. The gadget-based home pages at iGoogle.com is an example of this approach. Users can customize items such as weather or news feeds in order to get constant updates on only those topics that interest them.

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1. General Description

This system is being developed as an optional front-end for a hospital EHR. It also accommodates external information sources, such as summarized feeds from the medical or public health literature and alerts from external agencies. Sharing of user-created elements is important in this model (Figure 1). For example, a cardiologist could develop a view suitable for cardiology, and share it with others in the department. The process should result in systems that are more usable and suitable to specific situations. It is being tested in two departments. Overall, such Web 2.0-enabled EHR systems could have the following potential advantages: a) a greater fit with user needs, because systems are created by those with healthcare domain knowledge, b) efficiencies due to improved human-computer interaction interfaces and workflow, and sharing of user-created components across systems, c) an agile reconfiguration to meet emerging health challenges, or facilitate the introduction of new treatments or workflows, d) the capture of the user’s previously tacit domain and institutional knowledge and e) improved team communication and collaboration.

Architectural considerations in the development of such a system include the optimal ways of implementing a service-oriented architecture, consistency versus flexibility, methods of visualizing complex data, providing rapid interactivity and response time within a web framework, and the development of new standards and/or use of existing commercial standards.

After reviewing the philosophy of such an approach, and its new core functionalities, we will discuss architectural and usability issues which must be considered, our rationale for the choices we made, and evaluation methods and plans to ascertain the usefulness and usability of the system.
2. Philosophy and Aims

A central aim of this approach is to allow clinical users to create or modify substantial elements of the CIS without programmer intervention, fostering creativity and recombination as well as the usual goals of optimal information display (Figure 2). The possible advantages of such an approach have been elaborated elsewhere [3-5]. This requires paying attention to both the cognitive and educational limitations of typical clinical users, and the types of structures and needs encountered in medicine. These must then be implemented with currently available software and HCI techniques, particularly with regard to interface visualization and interactive capture of user intent. Since simplicity and efficiency are paramount in allowing nonprogrammers to do this, we emphasize drag-and-drop or one-click configuration methods. Other aims include not increasing errors, increasing efficiency, expressivity and control, and allowing the use of advanced visualization techniques such as interactive timelines, custom plotting, calculation and control flow, animation, etc.

New core functionalities include the ability to:

- drag-and-drop creation of widgets from EHR data elements, including composite widgets from all types of data such as notes, labs, orders, etc.,
- share and find widgets and views within a framework that uses standards as much as possible to import non-medical widgets,
- configure external information sources such as RSS feeds from medical journals, or public health alerts,
- create new “mash-ups” simply by using a service-oriented architecture for provision of multiple data sources,
- implement control flow, i.e., create protocols (jointly) or transform data, such as the calculation and display of renal function,
- provide data display in sophisticated forms of visualization, and
- use self-identifying elements, allowing output of one to input of another, aggregation, and annotation.

3. Architectural Considerations

Providing these functionalities requires consideration of medical data presentation structures. Starren and Johnson[6] identify five classes and eight subclasses of medical data presentation, which we find map quite well to available javascript display components, (though they do not include more recent interactive capabilities). Rich internet applications use heavy javascript on the client side to provide interaction and calculation functionality. This entails a tradeoff of speed and complexity. While the current CIS (WebCIS) has subsecond response time, it shows only one data element (e.g., lab panel or note) at a time and so requires many refreshes. The system is used mostly in-hospital, on the local network, hence latency is low. To minimize load time we have used one of the most lightweight client-side javascript frameworks (Mootools) [7] for the basic interface, incorporating other heavier scripts when necessary. The load time for a single “view” page (with 24 widgets) is 6 seconds, which was deemed acceptable by test users. WebCIS requires one second per click, two clicks per element accessed. Sequential viewing of the same elements thus requires close to a minute.
Our model calls for a service-oriented architecture for data delivery. Considerations here include the use of REpresentational State Transfer (REST) versus Simple Object Access Protocol (SOAP) web services, ease of implementation, security and authentication. It is beyond the scope of this paper to discuss these in depth.

The overall application consists of a client-side iframe widget-based framework implemented in javascript, with quercus/php user, tab, sharing and administration functions (see Figure 3). Widget creation from clinical data elements is effected by query creation based on user interaction; ajax calls to a java/jsp backend query the CDW or xml feeds and retrieve data for insertion into the widget. Queries and widget formats (including spatial layout) are stored in a mysql database. External information such as RSS feeds from medical literature are configured by the user directly within the widget header configuration options, available on “mouse-over” of the header. Alerts and “push” feeds (e.g., from public health agencies) are the result of programmed queries run at login and intervals thereafter.

3.1. Workflow

In order to promote use and facilitate pilot evaluation, we have incorporated the usual WebCIS menus into the system (see Figure 2) so that both systems may be used simultaneously and users can capture usual WebCIS elements as a widget. User familiarity with the current system facilitates location of desired elements and eases transition. Additional graphical elements (e.g., the small rectangle icon to the left of WebCIS links in the left-hand menu of Figure 2) indicate widget creation affordances; text (e.g., “Timeline”) also indicates visualization availability.
3.2. Creation of Composite Elements.

Widget creation by drag-and-drop requires specification of both data and format as part of the interface. The New York Presbyterian hospital makes use of a central terminology, the Medical Entities Dictionary, to convert between terminologies of the dozens of different clinical information systems. This provides a unique single five or six digit “medcode” number for almost any component of Dx or Tx (such as lab tests, drugs, note types etc.) used in current systems. We are thus able to store user-made views or panel (widget) configurations as collections of unambiguous medcodes, with associated query and formatting-related information (see Figure 3). Medcodes are incorporated into link javascript and form part of the stored query; format information is generated by the drag-and-drop javascripts (see Figure 4) allowing users to specify position. Element sharing then just entails addition of additional user information to the record.

3.3. Security

Security issues in a web-based system include regulation of access, proper protection of PHI data, minimal redundant storage of data, and methods of preventing the system from attack, particularly in a system which allows users to specify external information sources from other websites. Some measures we have taken include specialized javascript functions which comb and remove any javascript code from incoming xml or other feeds, separation of the interface formatting and configuration storage database from the source clinical data warehouse (CDW) which supplies the usual EHRs (see Figure 3), and use of a double medical record number (MRN) system lookup table – the interface system uses a dummy MRN which is converted by lookup into the real MRN on the CDW side.

4. Usability Considerations

Little formal work has been done on widget-based interface usability. A search of Google scholar, (which was used because it includes commercial material and web widget development has primarily proceeded in the commercial space), on November
13, 2008 with the keywords “igoogle,” “widget,” and “usability” yielded 26 hits. Gwardak and Pahlstorp (2007) in their literature search found no instances of usability guidelines for rich internet applications (RIA) [8]. We were not concerned with accessibility for this work because a vast majority of clinicians are assumed to have full visual and manual capabilities.

While Nielsen’s usability heuristics may not be totally relevant in this new type of interface, in medicine “visibility of system status” is important to avoid errors, and requires assuring that widgets, when closed, reveal something about the status of information inside (e.g., a flag in the remaining header bar about the abnormal results inside, notifying the user to open the widget on re-entering the view). To manage the tradeoff between consistency and flexibility, a standard default layout and landmarks may be useful in quickly orienting a new user to the view created by others. Meaningful co-placement (e.g., placement of PT/INR or CD4 counts with HIV status together) extends this. Multiple possible ways of default arrangement (e.g., by search history, data type, recency, updates only, diagnosis or ICD9 codes, alphabetically) are possible, and includes initial prepopulation of “starter sets” based on logfile analysis of current CIS use. Customizability includes the ability to create meta-information such as custom flags (for example, by changing the colour of the widget header bar, colouring the corners, including icons, changing the title, and so on). Signaling an affordance to the user is one of the challenges in such a new type of interface; preliminary training (such as with very short video) and interaction behaviour (such as cursor change over a drag handle) are used to address this. While no standards exist, common conventions (e.g., red/pink for alerting, triangular alert icons) are followed as far as possible. One aim of this study is to perhaps establish conventions based on user creations. Another affordance which requires good CHI is the means to search for widgets/views created by others. This is being done by keywords, classification, author identification, and automatic listing in some cases (e.g., for the patient being cared for by the same providers, or, for example, mandatory widgets created/provided by the department head).

4.1. Visualization

One advantage of the widget-based framework is the ability to rapidly incorporate new information displays with only the effort of the display programming. We have used freely available client-side javascript tools such as MIT’s SIMILE project Timeline[9]. The Iframe widget architecture allows each component to have independent javascript functionality. Widgets can be expanded to fullscreen size when appropriate.

5. Evaluation

Multimethod evaluation of the system includes several stages of assessment. Focus group feedback from two groups of clinicians (nephrologists and hospitalists) will be supplemented with in-lab Morae [10] usability studies. These include assessment at different levels of complexity, from simple usability (communication of affordances, navigation, the ability to drag and drop elements) to timed exercises which will measure efficiency and time costs/savings resulting from simultaneous viewing and sharing, to completion of four real (de-identified) clinical cases of varying complexity.
using the new system compared with the usual CIS. In order to evaluate possible effects of resource sharing, these will include presentation of shared resources created by one subject for the use of others, and assessment of efficiency, use patterns, and the possibility of errors due to a bandwagon effect.

6. Conclusion

Widget-based systems contain a promise of increasing the efficiency and relevance of information delivery, and may provide other advantages for carrying out medical tasks. Much is yet unknown, but we believe careful attention to these aspects of usability and architecture for this new healthcare application format is needed to realize the potential advantages. Experimental results will no doubt modify and expand our understanding.

References

Comparative Study of Heuristic Evaluation and Usability Testing Methods

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c College of Dentistry, New York University, New York, NY, USA

Abstract. Usability methods, such as heuristic evaluation, cognitive walk-throughs and user testing, are increasingly used to evaluate and improve the design of clinical software applications. There is still some uncertainty, however, as to how those methods can be used to support the development process and evaluation in the most meaningful manner. In this study, we compared the results of a heuristic evaluation with those of formal user tests in order to determine which usability problems were detected by both methods. We conducted heuristic evaluation and usability testing on four major commercial dental computer-based patient records (CPRs), which together cover 80% of the market for chairside computer systems among general dentists. Both methods yielded strong evidence that the dental CPRs have significant usability problems. An average of 50% of empirically-determined usability problems were identified by the preceding heuristic evaluation. Some statements of heuristic violations were specific enough to precisely identify the actual usability problem that study participants encountered. Other violations were less specific, but still manifested themselves in usability problems and poor task outcomes. In this study, heuristic evaluation identified a significant portion of problems found during usability testing. While we make no assumptions about the generalizability of the results to other domains and software systems, heuristic evaluation may, under certain circumstances, be a useful tool to determine design problems early in the development cycle.

Keywords. heuristic evaluation, usability testing, dental CPR, human-computer interaction

Introduction

Computer-based patient records (CPR) have been shown to provide significant benefits to patient care and outcomes. However, poor user interface design is a barrier to using clinical information systems effectively. Many problems can be traced to weaknesses in usability and human-computer interactions (HCI) design [1-3]. Usability and HCI methods are considered important components of the system development process outside of healthcare. In medicine, several studies describe cognitive and HCI methods for evaluating and improving clinical systems [3-5]. Examples are cognitive task analysis, heuristic evaluation, cognitive walkthroughs and usability tests, which are used to provide insights to developers about potential usability problems. These methods can also be used for the summative evaluation of clinical systems. As part of
developing a multimodal interface for dental CPR, the Center for Dental Informatics at
the University of Pittsburgh conducted heuristic evaluation [6] and usability testing [7]
of four commercial dental CPRs. Both heuristic evaluation and usability testing yielded
strong evidence that the dental CPRs have significant usability problems.

Previous studies in other fields have suggested using a combination of different
usability methods to identify design problems [8,9]. Several studies have shown that
heuristic evaluation can predict major usability problems that could potentially occur
during usability tests [10,11]. Jeffries et al. [10] found that heuristic evaluation and
usability testing performed better than cognitive walk-through and software guidelines
in identifying usability problems and stressed the importance of choosing evaluators
who are experienced in providing usability feedback to product groups. Given this
background, the objective of this study was to determine the extent to which heuristic
evaluation and usability tests revealed the same types of usability problems in the four
dental CPRs.

1. Methods

We conducted heuristic evaluation and usability evaluation methods on four major
commercial dental CPRs during the period from January 2005 to July 2005. We briefly
describe our application of the two methods below.

1.1. Heuristic Evaluation

For the heuristic evaluation study, a set of ten heuristics published by Jakob Nielsen
[12] was used to evaluate the four dental CPRs. Two dental informatics postgraduate
students and one dental informatics faculty member evaluated each of the four dental
CPRs. The systems were Dentrix Version 10.0.36.0 (Dentrix, American Fork, UT),
EagleSoft Version 10.0 (Patterson Dental, St. Paul, MN), SoftDent Version 10.0.2
(Kodak Corp., Rochester, NY) and PracticeWorks Version 5.0.2 (Kodak Corp.,
Rochester, NY).

All evaluators were dentists with significant background in informatics and
information systems. The faculty member was an expert in heuristic evaluation, while
the postgraduate students had completed a course in HCI evaluation methods, including
heuristic evaluation. All evaluators were familiar with the CPRs in general, but had no
experience through routine use. Evaluators verbalized the heuristics that they
considered violated while completing the tasks. Thyvalilkakath wrote down the
violations and helped record illustrative screen shots when necessary, using a recorded
macro function in MS Word. While the evaluation was grounded in three clinical
documentation tasks, evaluators were free to explore other clinical (not administrative)
program functions in order to increase the coverage of the heuristic evaluation. For
further details, refer to [6].

1.2. Usability Evaluation

We conducted usability assessments [4,9] on the charting interfaces of working
demonstration versions of Dentrix, EagleSoft, SoftDent and PracticeWorks with four
different groups of users consisting of five novice users in each group. Each participant
used only one software package and worked through 9 clinical documentation tasks
using a think-aloud protocol [4,9,13]. The tasks were explained in detail in [7]. The purposive sample of novice users for each system consisted of one full-time faculty member, two practicing dentists and two senior dental students from the School of Dental Medicine (SDM) and the Pittsburgh area. After the completion of all sessions, two researchers coded usability problems based on an established coding scheme [9]. For each task, both the task outcome (rate of completed tasks, incomplete tasks and incorrectly completed tasks) as well as the types of usability problems that occurred were coded.

1.3. Comparing Heuristic Evaluation and Usability Evaluation Results

Heuristic evaluation results were reviewed to identify violations that led to usability problems during testing. The results were then summarized and described using descriptive statistics. The heuristic violations statements were classified into two groups: one group consisting of specific violations that directly predicted actual usability problems, and the second consisting of general violations that suggested, but did not directly predict, observed usability problems.

2. Results

The number of usability problems identified through heuristic evaluation ranged from a low of 17 (39%) in PracticeWorks to a high of 61 (64%) in Dentrix (see Table 1). On average, heuristic evaluation predicted 50% of the usability problems found empirically. While in some cases, such as for EagleSoft and Dentrix, a significant majority of heuristic violations was specific enough to predict the actual usability problem, most heuristic violations found for PracticeWorks and SoftDent only suggested usability problems.

We illustrate specific (Table 2) and general (Table 3) heuristic violations. As is evident from the examples, specific heuristic violations identified design features, such as buttons and menu items that could be directly tied to the failure or difficulty to complete a task. General heuristic violations, on the other hand, tended to highlight visual and functional designs that could have resulted in a number of usability problems.

Usability issues identified by both methods often resulted in problems that were severe enough to cause users either to fail completing the task or to commit one or more errors in completing it. Previous research has suggested that using a combination of different usability methods is most useful to identify the majority of problems [4, 8]. Problems identified by more than one method may indeed be more severe than those identified by a single method. However, support for this position is equivocal.

Unfortunately, our study produced no insights into which heuristic violations, a priori, were more likely to produce actual usability problems than others. While it would be highly desirable to be able to flag truly serious problems as early as possible in the development process, it is currently an open question on whether this is possible using heuristic evaluation. Future research should continue to investigate the relationship between findings of usability problems using different methods and in what way the most significant problems can be identified as early as possible in the development cycle.
Table 1. The number of usability problems found through usability testing by system, and the number and percentage of usability problems predicted by heuristic evaluation (separated into specific and general categories).

<table>
<thead>
<tr>
<th>System</th>
<th>Number Found through usability testing</th>
<th>Number Predicted by Heuristic Violations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Specific</td>
<td>General</td>
</tr>
<tr>
<td>EagleSoft</td>
<td>60</td>
<td>20 (77%)</td>
</tr>
<tr>
<td>PracticeWorks</td>
<td>44</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>SoftDent</td>
<td>86</td>
<td>5 (15%)</td>
</tr>
<tr>
<td>Dentrix</td>
<td>96</td>
<td>41 (67%)</td>
</tr>
<tr>
<td>Total</td>
<td>286</td>
<td>66 (46%)</td>
</tr>
</tbody>
</table>

Table 2. Sample “specific” heuristic violations that directly predicted a usability problem.

<table>
<thead>
<tr>
<th>Specific heuristic violation</th>
<th>Corresponding usability problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Button highlighting is the inverse of the customary design (button greyed out when selected) (Error prevention; EagleSoft).</td>
<td>When asked to select roots of a single tooth for root canal treatment, users deselected the roots which they were supposed to select due to the nonstandard design.</td>
</tr>
<tr>
<td>Numbers one to 6 represent the six surfaces of the tooth that are normally identified by anatomical terms, e.g. bucco-mesial (Match between system and the real world; EagleSoft).</td>
<td>The onscreen numerical keypad to navigate tooth surfaces was mistaken as a means to enter dental pocket depths in mm.</td>
</tr>
<tr>
<td>Switching between restorative and periodontal charts is difficult (Recognition rather than recall; EagleSoft).</td>
<td>Several users experienced difficulty when switching from the restorative to the periodontal chart. They suggested providing mechanisms to perform this action more easily.</td>
</tr>
<tr>
<td>Trying to record caries on a tooth does not produce a result unless user clicks on one of several poorly labeled buttons (“Eo,” “Ex,” “Tx,” and “Comp”) (Visibility of system status; Dentrix).</td>
<td>Most users experienced difficulty completing tasks that used one of the buttons. The system provided neither feedback nor guidance.</td>
</tr>
<tr>
<td>The tool tip for the button to enter root canal therapy (RCT) on a molar tooth indicates that the procedure applies to incisors (Error prevention; Dentrix).</td>
<td>The tool tip misguided users, who, as a result, failed to locate the icon for molar tooth RCT.</td>
</tr>
<tr>
<td>Deleting a finding on a tooth should only require selecting the finding and pressing the Delete key or similar action (Consistency and standards; Dentrix).</td>
<td>Most users tried multiple times to delete an amalgam restoration by selecting the tooth and by pressing the delete button on the keyboard, an action that was not supported by any system.</td>
</tr>
</tbody>
</table>

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Table 3: Sample “general” heuristic violations which suggested a usability problem.

<table>
<thead>
<tr>
<th>General heuristic violation</th>
<th>Corresponding usability problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>The periodontal chart represents teeth by lines while the restorative chart depicts them more</td>
<td>Users were confused by the poor graphical presentation of teeth and surfaces on the periodontal chart which led many of them to record pocket depths incorrectly.</td>
</tr>
<tr>
<td>naturally (Consistency and standards; EagleSoft).</td>
<td></td>
</tr>
<tr>
<td>Poorly designed periodontal chart with boxes and lines does not resemble teeth and results</td>
<td>Users had difficulty identifying the buccal and lingual tooth surfaces which in turn led to failure in recording pocket depths for all tooth surfaces.</td>
</tr>
<tr>
<td>in visual clutter (Aesthetic and minimalist design; PracticeWorks).</td>
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</tr>
<tr>
<td>The touch screen panel at the bottom of the periodontal chart is small, which makes it</td>
<td>Users experienced difficulty in recording bleeding gums because the icon to record bleeding was not easily recognizable.</td>
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<tr>
<td>difficult to determine what findings are entered and where they are recorded (Recognition</td>
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<tr>
<td>rather than recall; PracticeWorks).</td>
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<tr>
<td>The function of each icon is hard to recognize. Icons are small and the pictures on it do</td>
<td>Often users could not locate the specific icon needed to complete a task.</td>
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<td>not convey specific meaning (Recognition rather than recall; SoftDent).</td>
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<tr>
<td>The icons D, M, P, C in the periodontal chart are not helpful (Aesthetic and minimalist</td>
<td>Users assumed that the icons D, M, P, and C helped in recording the different periodontal findings but instead they indicated only a mode change. This led to users failing to record pocket depths and bleeding gums.</td>
</tr>
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<td>design; SoftDent).</td>
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</table>

References


The User-centered Approach in the Development of a Complex Hospital-at-home Intervention

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Abstract. We discuss the development of a comprehensive remote patient monitoring system that facilitates the self-care of patients undergoing nocturnal home hemodialysis (NHHD), a complex hospital-at-home therapy. The use of a continuous, iterative approach with user involvement for the validation of assumptions can avoid situations where the system serves a patient poorly. An ethnographic analysis was used to determine specific design principles, which were reviewed with the patients prior to development of the system. Iterative designs were tested through usability testing and further validation was done with a member-checking exercise. Patients expressed concern about the physical obtrusiveness of monitoring which, consequently, led to a lack of adherence. The need for monitoring the integrity of the bloodlines was identified as important because one of the most significant fears among patients was potential blood loss. Patients expressed a need for immediate human intervention in response to an alert. The use of ethnography, usability testing, and member-checking methods in a user-centered approach to design can result in systems that better meet the needs of the patients and caregivers alike.

Keywords. user-centered design, patient self-care, home hemodialysis, remote patient monitoring, hospital-at-home

Introduction

Resource shortages in the healthcare system have generated interest in alternative forms of service delivery, such as the Hospital-at-Home approach [1]. In this study, we discuss the development of a comprehensive remote patient monitoring (RPM) system that facilitates the self-care of patients undergoing nocturnal home hemodialysis (NHHD), a complex hospital-at-home therapy. NHHD is a simple variant of

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conventional hemodialysis. It is essentially more frequent therapy, delivered for longer periods of time, as the patient sleeps. NHHD has been shown in some studies to improve cardiovascular health, sleep quality, and eliminate the need for dietary restrictions [2,3] while providing resource and financial motivation [4-7].

Although NHHD has been shown to provide significant improvements in health outcomes and improved resource utilization for the health care system, adoption of the therapy has been slow. Beyond systemic problems, there exist patient-related barriers to the adoption of NHHD. Patients fear they will fail to perform dialysis adequately. They also fear that they will receive substandard care and that they will be socially isolated [8]. As well, it has been found that patients believe that the therapy will be a burden on family members and have fear of a catastrophic event [9].

In this study, we discuss the development of a comprehensive remote patient monitoring system that addresses these patient-perceived barriers and facilitates the self-care of patients undergoing NHHD. Critical to the design of the intervention was the user-centric approach, which attempts to ensure that the system will be optimized for users’ abilities, wants, and needs, rather than forcing the user to accommodate the technology by compromising and changing their own routine. Fundamental to this process is checking the validity of assumptions made in the design. We describe the use of a continuous, iterative approach to the development of a system that meets the patient’s needs by defining design principles based on ethnographic research findings.

1. Methods

An ethnographic analysis based on the Health Belief Model framework (Hochbaum et al, 1999) was done to determine the barriers to adoption and design principles for a system that would facilitate mediated patient self-care. Specific design aspects based on preconceptions were reviewed with the patients prior to development of the system. Iterative designs were tested through usability testing, and further validated in a member-checking process using focus groups comprised of NHHD patients and their family caregivers.

Assumptions, related to the use of remote patient monitoring to reduce the barriers to the adoption of NHHD, were challenged in a series of ethnographic interviews of three renal disease patient groups. The three groups were: 7 NHHD patients, 6 conventional hemodialysis (CHD) patients, and 7 pre-dialysis patients. The recordings of the interviews were transcribed verbatim from audiotape.

A general inductive method was using in the analysis of the transcripts. Transcripts were read repeatedly and text segments were coded for potential themes. As the coding framework developed, transcripts were recoded according to themes identified during the interviews. Once completed for a specific treatment group (NHHD, CHD, or pre-dialysis), major themes were derived that were relevant to the research question. Coding was performed along various factors of the Health Belief Model to form a priori codes, but was not limited to the theoretical framework. Coding was free to assume no presuppositions.

The study protocol was approved by the University Health Network Research Ethics Board (04-0153-AE) and the University of Toronto Research Ethics Board (#18014 for grant application #87285).
2. Results

Data was gathered to inform the first iteration of the system development. A number of unexpected findings from the study resulted in fundamental changes to the design principles and specifications of the system. These findings included a concern by the patients of the physical obtrusiveness of monitoring and that this would produce adherence issues. The need for monitoring the integrity of the bloodlines was identified, as potential blood loss was one of the most significant fears amongst patients. Patients expressed a need for human intervention in immediate response to alerting. Remote monitoring is particularly supported by family-caregivers and is viewed as a surrogate for nursing care. There was also concern over privacy and the “Big Brother” effect of using remote monitoring. Patients expressed concern over the detailed knowledge their caregivers would have of their schedule, frequency and habits when dialyzing at home.

Table 1 indicates the findings and resultant design principles that were used by the engineering team to develop the remote patient monitoring system. The process of finalizing the design principles was iterative and was validated through member-checking.

3. Limitations

A limitation of this phase of the study is the general trustworthiness associated with one-on-one interviews in qualitative studies. Informant biases may occur due to patients wanting to please the interviewer by only sharing information that is positive with respect to the therapy and the planned monitoring (Aspinwall et al, 2005). A sampling bias may also have occurred due to the strict criteria based on the contraindications of NHHD which may affect the generalizability of these findings.

4. Discussion

The purpose of developing these design principles was to guide the engineering team regarding specific functionality of the system. In one sense, these principles become a rulebook for the engineering team, where assumptions that are made through the course of development are tested against these principles to ensure adherence. Violations of these principles will likely result in a sub-optimal system and would no longer be adhering to a user-centric method of design. In reality, there are many design and engineering compromises that must be made in order to develop such a system. Designers and engineers, using a user-centric method, try to adhere to design principles as much of possible. However, budgetary constraints, regulatory issues, and technical challenges often make complete adherence impossible.
Table 1. Ethnography findings and resultant design principles.

<table>
<thead>
<tr>
<th>Finding</th>
<th>Design principle</th>
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<tbody>
<tr>
<td>Lack of self-efficacy. Patients feel they are unable to perform the therapy due to its complexity.</td>
<td>The system will not add to the training requirements of the NHHD patients.</td>
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<tr>
<td>Fear of a catastrophic event in the absence of nursing support. Patients worry about the lack of immediate help.</td>
<td>The system must communicate more than just the status of the dialysis machine, to include physiological vital signs. Automated alerting will result in direct contact by the caregiver on-call to the patient.</td>
</tr>
<tr>
<td>Patients supported the transitional use of remote monitoring, although some patients felt they required some form of monitoring on a permanent basis.</td>
<td>The system will allow for transitional monitoring, such that installation can be done quickly and removed equally so.</td>
</tr>
<tr>
<td>Patients had varying levels of need for remote monitoring. From no monitoring to all, to monitoring through the transition, to a permanent installation. As well, patients had varying needs in terms of the components of remote monitoring.</td>
<td>The system will be modular, where components can be removed and added as needed or appropriate. The patient will have the option to decline the use of any or all of the components of the system, including the camera, so as to respect their privacy and to meet their individual needs. Data acquisition and transmission will be done securely and will comply with the relevant privacy policy and legislation.</td>
</tr>
<tr>
<td>There was some concern over privacy and “Big Brother” effect of using remote monitoring. Patients expressed concern over the detailed knowledge their caregivers would have of their schedule, frequency and habits when dialyzing at home.</td>
<td>The patient will have the option to decline the use of any or all of the components of the system, including the use of a camera, so as to respect their privacy and to meet their individual needs. Data acquisition and transmission will be done securely and will comply with the relevant privacy policy and legislation.</td>
</tr>
<tr>
<td>There is concern by the patients of the physical obtrusiveness of monitoring and that this would produce adherence issues. Patients are concerned how the further tethering to the machine will affect their sleep and the mobility when addressing alarms.</td>
<td>The physiological sensors will be as unobtrusive as possible to the patient, allowing them freedom of motion and will not be uncomfortable so as to interfere with their sleep.</td>
</tr>
<tr>
<td>The need for monitoring the integrity of the bloodlines was identified, as potential blood loss was one of the most significant fears amongst patients.</td>
<td>The system will address the need for ensuring bloodline integrity, without adding to complexity of the existing setup.</td>
</tr>
<tr>
<td>Patients were comfortable with the use of automation for alerting caregivers as their expectation in an emergency. However, they expressed a need for human intervention in immediate response to this alerting.</td>
<td>Automated alerting will result in direct contact by the caregiver on-call to the patient. The system should be scalable to allow a call-centre approach to addressing these alerts.</td>
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<tr>
<td>Family caregivers viewed it as a safety net for themselves to reduce their anxiety and to address what they perceive as a lower level of care in the case of an emergency than what they receive in-centre.</td>
<td>Automated alerting will result in direct contact by the caregiver on-call to the patient.</td>
</tr>
<tr>
<td>Clinicians and administrators were concerned about the technology disrupting their workflow and routine. Cost should not be minimized, as most NHHD programs would not have any direct funding for a monitoring system.</td>
<td>The system will work within the existing workflows of the current NHHD program. The system will not add significantly to the cost of NHHD delivery, be scalable, and will leverage existing data infrastructure.</td>
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</table>
The use of these design principles resulted in an initial system design consisting of the acquisition, transmission, storage, and processing of patient vital signs (heart rate, respiration rate, blood oxygenation, and blood pressure) and selected hemodialysis treatment parameters from various hemodialysis systems. Rules were developed through discussions with domain experts including nephrologists, nursing staff, and renal technologists. These rules would be applied to the data in real-time and alerts generated. In the first iteration of the system, these alerts would be sent to an on-call technologist, via smartphone, who would then assist the patients as necessary. The alerts contain relevant information, current patient vital signs, and the patient’s home phone number for quick access. For further follow-up to the alert, the technologists can remotely login to the system, access all physiological and dialysis data, and take control of the IP camera if necessary.

Additional components include:

- a blood-line disconnection detector. The liquid-sensitive pad lies under the patient and triggers an alarm if blood makes contact. It will also cut power to the hemodialysis machine, disabling the blood pump and stopping further blood loss. It will immediately generate an alert to the caregiver on-call.
- an IP-based pan-tilt-zoom (PTZ) video camera, to allow staff to observe remotely, at the patient’s discretion. This was used as an aid in remotely troubleshooting the dialysis machine as well as providing the capacity to check on a patient during a serious alarm condition.
- A call-bell system, similar to an inpatient setting, which can alert the caregiver on-call.

As a first iteration in the development of the central station, a rudimentary web interface was developed for the on-call staff to access data and the camera. This system could be used to review completed sessions, including all vital sign and dialysis monitoring data.

Subsequent iterations revealed that patients preferred the less obtrusive wireless pulse oximeter rather than other, traditional monitors. This however did not address the acquisition of respiration rate, a desired vital sign. A higher tier of monitoring may be required when medically needed, to include all desired parameters. New monitors are being evaluated for their applicability in an NHHD setting. Patient adherence to the use of the physiological monitor will be a major factor to consider when selecting a device for use in this setting.

5. Conclusion

It is common for system designers to make assumptions throughout the design process. In the absence of users who can validate these assumptions, the design will lack this critical input, often with results that are compromised and flawed.

The use of ethnography, usability testing, and member-checking methods in a user-centered approach to systems design can fundamentally alter the design assumptions of a system, leading to a new set of design principles.

The resulting system has provided an increased level of comfort and reduced anxiety for patients and for family caregivers in particular.
References


Applying a Human Factors Engineering Approach to Healthcare IT Applications: Example of a Medication CPOE Project

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b LAMIH – UMR CNRS 8530, UVHC, Valenciennes, France

Abstract. This paper describes a Human Factors Engineering approach to a medication use system in the context of a hospital medication CPOE project. It presents the results obtained from the organizational analysis and describes the variations in the distribution of tasks among actors in the medication use process, which depend on the organization of the work system. It then focuses on nurses’ medication administration tasks including the preparation and update of pill dispensers. This situation may be characterized according to the distributed cognition framework. The high level organizational features have an impact on the quality and safety of the coordination and communication procedures that characterize medication preparation and administration by nurses.

Keywords. human factors, CPOE, medication administration, distributed cognition, process control

INTRODUCTION

The Human Factors Engineering (HFE) approach to analysis, evaluation and redesign of the healthcare work systems has proven efficient [1]. This approach identifies determinants of the work system that make a situation potentially dangerous. It also provides recommendations to secure and optimize the work system on organizational cognitive and technical levels.

This paper presents a case study of a Human Factors Engineering approach to a medication administration process in a large academic hospital in the context of a medication Computerized Provider Order Entry (CPOE) project. We specifically focus on:

- organizational level analysis, which describes the distribution of tasks among the actors in the medication use system, i.e., the physician in charge of the prescription, the pharmacist in charge of the dispensing, and the nurse in charge of the administration, and,
- the impact of possible task distributions on the nursing activities of preparation and administration of oral route drugs.

The core task of the HFE approach is the analysis of the work system. It requires the understanding, description, analysis and, if possible, modeling of the work situation. It is possible to identify hierarchical levels in this work system [2]:
• The higher level, i.e., the “organizational” level, is that of local and national regulations that have an impact on all subsequent levels, mostly by prescribing the distribution of tasks across the professionals.
• The second level, i.e., the “collective” level is that of operators or groups of operators interacting with each other to collectively handle the healthcare process for a given patient. These collective characteristics of the care process generate both vertical - hierarchical cooperation (i.e., doctor-nurse cooperation), and horizontal - functional cooperation (i.e., nurse-nurse cooperation). It is also responsible of the distribution of medical information among different healthcare professionals and different technical systems or supports (paper and/or electronic documents). Similarly, knowledge and skills necessary to accomplish the tasks are distributed among different operators. This leads to the characterization of the healthcare work situation as a distributed system [3]. In this context, professionals are mutually dependent upon one another: to obtain the right information at the right moment they have to share information efficiently.
• The “individual” level is that of the individual operator - the healthcare professional interacting with his or her technical environment to monitor the patient clinical status.

This paper focuses more particularly on the organizational level analysis, which describes the distribution of tasks among the actors in the medication use system, i.e., the physician in charge of prescribing, the pharmacist in charge of dispensing, and the nurse in charge of administration.

1. METHODS

1.1. Context of the Project

The Centre Hospitalier Universitaire of Lille (CHU Lille) in the North of France is a 3000-bed academic hospital. This hospital is equipped with a Hospital Information System (HIS) that integrates over 80 different applications but it has no facility for medication CPOE, nursing documentation, nursing plans, Medication Administration Record (MAR) or similar related functions. These are still paper-based. Therefore, the hospital envisions installing a CPOE system to support medication ordering, dispensing, and administering tasks. The CHU Lille ordered and participated in a HF preliminary study to assess the state of preparedness of the CHU departments before installing a medication CPOE. In order to support the hospital managers’ decision-making, descriptions and organizational analyses of other hospitals already equipped with a complete medication CPOE have been compared with the analysis made of the CHU Lille medication use system.

1.2. HFE Methods

We performed a systematic qualitative analysis of the medication ordering - dispensing - administration process in several departments of the hospital. An analysis, which focused on cognitive and collective aspects, was conducted on tasks and activities by nurses. Organizational contexts and habits of work were also recorded.
We used standard methods from cognitive psychology and ergonomics. The following data were collected and analyzed:

1. semi-structured and structured interviews of target users;
2. naturalistic observations supported by handwritten, time-stamped, detailed field notes;
3. document and chart reviews;
4. confrontation interviews (nurses were presented with the results of observations and document reviews performed in their departments and were asked to comment on and mentally replay the processes involved in reading and interpreting orders for the preparation of pill dispensers and for the administration itself); and
5. nurse-to-nurse dialogs exchanged during shift changeover.

2. RESULTS

2.1. Organizational Level

According to national and local regulations, the tasks necessary to carry out the medication ordering and administration procedures are distributed among the physicians, the pharmacists and the nurses. The physician is in charge of the therapeutic decision-making and of ordering the meds. The physician is supposed to write the prescription, date it and sign it. The nurse has no medication ordering rights except for a small number of common drugs (i.e., standard painkillers) and only if a written protocol exists in the department. She or he is not supposed to copy a physician’s order on any support except to validate the administration. The pharmacist is in charge of controlling the prescription and of delivering medications to the medical unit. The nurse has to control the meds before administering them to the patient; she must validate the administration and eventually document any unexpected event. It must be noted that in the vast majority of European hospitals, unit-dose dispensing is limited to a small proportion of drugs. Most of the drugs are dispensed either on a nominative basis (drugs for a given patient for a given period of 24 hours to several days) or on a global basis (drugs for several patients and for several days). This organization of the dispensing necessitates a preparation phase from ward stock before the actual administration to patients. Nurses are in charge of this preparation.

The analysis identified different organizations within the hospital. In order to describe and model the various organizations, we used adapted UML activity diagrams. Figure 1 displays one of these diagrams, modeling a paper-based work system. In this organization, the nurses participate in various tasks at each phase of the process.

*Prescription phase:* the nurses participate in the medical rounds with the physician(s). They i) provide information on the patient, ii) gather information, may ask questions, iii) participate in the decision making, negotiate the care plan in anticipation of potential administration problems, iv) eavesdrop constantly on doctor-doctor and doctor-patient dialogs.

*Dispensing phase:* the nurses i) send nominative orders to the pharmacy, ii) order the drugs at the pharmacy and may have dialog with the pharmacists or pharmacist assistants regarding unavailable drugs, or dosages, substitutes, etc., iii) retrieve the drugs delivered from the pharmacy, stack them in the ward locker or in patient rooms.
Administration phase: the nurses i) prepare the drugs for administration rounds (preparation of pill dispensers), ii) administer the drugs to patients, document the administration.

Figure 1. UML model of the distribution of tasks among the physician, the nurse and the pharmacist from the medication use process in an observed paper-based organization.

The organization modeled in Figure 1 differs slightly from the organization one could expect from the description of national and local regulations: the nurses participate in many more tasks than those for medication administration alone.

The description and model of CPOE-based organizations may prove very different. In those organizations, the CPOE system ensures the transmission of information among the actors. The pharmacist’s control of the process is enhanced by his access to nominative orders and to the patient’s medical record. Consequently, the nurses’ participation in the medication use system is more limited: they step in only for the preparation and administration of the drugs.

The analysis of the organizations observed in the different hospitals and departments allowed the identification of a number of organizational factors which include:

- type of cooperation/communication between physicians and nurses (coordination devices): i) common rounds, ii) briefings, iii) opportunistic exchangees
- speed physiological and clinical process for patients: i) type of unit, e.g., ICU; surgery, medicine, long stay, ii) frequency of medication orders update/modifications per day
characteristics of the drugs used in the department: i) type of drugs (i.e., pharmaceutical classes frequently used in the department), ii) type of dispensing: proportion of drugs on nominative vs. global dispensing, iii) proportion of injectable vs. oral route drugs.

- type of technical system to support the tasks: i) paper forms, ii) CPOE

These factors can be combined in many possible ways. For example each type of cooperation may be combined with the type of technical system or the type of unit although some combinations are infrequent, like “common rounds” and “CPOE system.” In turn, these different organizations have an impact on the quality and extent of each actor’s knowledge, on the distribution of knowledge and information among the actors and the technical systems and on the distribution of the control of the medication use process.

2.2. Collective Level

The organization of the administration of oral route medications is structured by the preparation of 24-hour pill dispensers. At some point in the 24-hour period a nurse prepares the pill dispensers for all the patients of the ward. To perform this preparation, the nurse relies on the information contained in each patient’s medication orders list as prescribed by the physician. This preparation takes place in the room where the ward medication cupboard is located, usually the nursing room. Each dispenser is identified by a room number and sometimes also with the patient’s name.

During the 24-hour period covered by the pill dispensers, the physicians visit the patients and place new orders or modify the existing patients’ treatments. These modifications require an update of the corresponding pill dispensers by the nurse. This update is executed as soon as the nurse gets a modified medication orders list. Over this 24-hour time period, different nurses are in charge of updating the pill dispensers and administering the meds to the patients. This makes the whole procedure or workflow more complex as exemplified in Figure 2.

As with the Organizational Level, there are a great number of organizational factors that may vary: i) the nurse in charge of the preparation of the pills dispensers may from the morning shift or the afternoon shift; ii) the meds of a given patient may be stocked in the patient’s room and be prepared only at the time of administration, (iii) etc.

<table>
<thead>
<tr>
<th>Description of a typical medication preparation and administration process distributed among several nurses over several shifts</th>
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<tbody>
<tr>
<td>In this observed example, the night shift nurse, N1, starts her shift by administering the “bedtime” meds. After this last administration of the day, the pill dispensers are empty. She is then in charge of preparing the pill dispensers for the following day: each which has four compartments - one for morning, noon, evening and bedtime administrations. The first nurse of the morning shift, N2, administers the first round of the day, after which the physician performs his medical rounds and modifies existing orders or issues new orders. The morning nurse, N2, updates the pill dispensers accordingly. At about noon, the second morning nurse, N3, administers the second round. In the afternoon, a physician performs a rapid follow-up of the patients, again modifying some orders and issuing new orders. The afternoon nurse, N4, updates the pill dispensers and then administers the evening round.</td>
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Figure 2. Description of the typical medication process.
3. Discussion and Conclusion

The work system in Figure 2 is characterized by a distributed cognition organization. This situation requires efficient coordination and communication among i) physicians and nurses (e.g., the transmission of new orders from physician to nurse enables the proper update of pill dispensers), and ii) nurses of different shifts (e.g., oral exchanges during shift changeovers ensure control of pill dispensers and administration of meds).

The higher level organizational features have an impact on the quality and safety of coordination and communication procedures. For example, each nurse is a source of information for the physicians and for the other nurses. Depending on the organization, the quality and extent of the his or her knowledge about therapeutic care plans and drug management may vary greatly.

For example, based on the analysis of nurses activities and confrontation interviews [4], we could establish that a nurse who participated in medical rounds and who ordered the ward medication from the pharmacy has an extended understanding. He or she more fully understands the medical characteristics of the pathology, the therapeutic care plans including the underlying medical rules, and the medical cases of the patients. As well, the nurse also has a good practical knowledge of drug management. Conversely, a nurse whose tasks are limited to the administration phase presents a more limited understanding of the medical characteristics of the pathology, a more operational knowledge of the therapeutic care plans, and a more operational knowledge of the patients’ medical cases.

Therefore, it is important to ensure that the organization, which is imposed upon healthcare professionals participating in the medication use process, is coherent, i.e., that the distribution of control over the medication process is consistent with the distribution of tasks and with the knowledge possessed by each actor.

The distributed cognition framework completed by detailed models of existing or possible organizations proves very useful to support safe and efficient IT projects in healthcare. This approach provides the project team with structured descriptions of the current and/or expected work systems and helps them to i) understand the complexity of those work systems, ii) deliberately design the future work systems integrating new IT applications and iii) (re-)design safer and more efficient IT systems. It also helps IT personnel and hospital managers to understand that an IT project is much more than simply the replacement of the paper forms with computers. It helps them to understand that an IT system needs to be harmoniously integrated with the activity system to efficiently and safely support the propagation of accurate representational states.

Reference List

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Section 11

Software Design and Development
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Adopting and Introducing New Technology To Improve Patient Care: A Wedding of Clinicians and Informatics Specialists

Jeff Barnett and Ann Syme
BC Cancer Agency, Victoria, BC, Canada

Abstract. The BC Cancer Agency sees 128,172 patients per year, of which 2,186 are referred to the Patient Symptom Management/Palliative Care (PSMPC) clinics for tertiary symptom management. Other than at the PSMPC clinics, screening for symptom distress is extremely variable because of the lack of a systematic assessment protocol. In a recent audit of patients coming to the Cancer Agency, approximately 64% of patients reported experiencing a moderate to severe level of symptom distress. Of the total patients in the audit, only 18 were seen by the PSMPC teams and it is unclear whether or not the remaining patients had their symptoms attended to by a health professional at the BCCA.

The tool which the BCCA has chosen for screening and assessment is the Edmonton Symptom Assessment System (ESAS). Developed by Dr. Eduardo Bruera, ESAS is a nine-item, self-reporting, visual analogue instrument used to measure pain and other symptoms using numeric ratings. Cancer Care Ontario (CCO) has developed an electronic means whereby patients’ ESAS scores are entered and housed in an electronic health record and then used for triage. BCCA is in partnership with CCO to adapt this system for use in BC.

Keywords. palliative care, pain management, symptoms assessment

Introduction

The BC Cancer Agency (BCCA) sees 128,172 patients per year, of which 2,186 are referred to the Patient Symptom Management/Palliative Care (PSMPC) clinics for tertiary symptom management. Other than at the PSMPC clinics, screening for symptom distress is extremely variable across the BCCA because of the lack of a systematic assessment protocol for symptom distress in patients. In a recent audit of all patients coming to BCCA, approximately 64% of patients reported experiencing a moderate to severe level of symptom distress. Of the total patients in the audit, only 18 were seen by the PSMPC teams and it is unclear if the remaining patients had their symptoms attended to by a health professional at the BCCA or were otherwise referred to a community health care provider for this support. Clearly a system of symptom distress screening and triage is needed by the BCCA.

The tool which the BCCA has chosen for symptom screening and assessment is the Edmonton Symptom Assessment System (ESAS). Developed by Dr. Eduardo Bruera, ESAS is a nine-item, self-reporting, visual analogue instrument used to...
measure, on numeric rating scales ranging from 0 to 10, pain and other symptoms: tiredness, nausea, depression, anxiety, drowsiness, appetite, feeling of well being and shortness of breath. The scales are anchored by words such as ‘not tired (0) – worst possible tiredness (10)’, ‘not nauseated (0) – worst possible nausea (10)’, and ‘no pain (0) – worst possible pain (10)’ [1,2].

Cancer Care Ontario (CCO) has developed an electronic means whereby patients’ ESAS scores are entered and housed in their electronic health record. This system is named Interactive Symptom Assessment and Collection or ISAAC. BCCA is in partnership with CCO to adapt this system for our use in BC. ISAAC-BC will permit us to screen patients in distress by assessing 9 symptoms. We can then triage the patients accordingly.

Patients self-report their symptom scores on touch screens in the cancer centre and the data are stored in their personal record. The scores are also stored in a robust research database that will allow us to monitor quality of care and to undertake research related to symptom assessment. ISAAC will reveal symptom distress resulting from the burden of cancer and also from the toxicity of treatment. It could ensure that our patients are better cared for and safer.

1. Methods

ISAAC is built for a web-based environment and can be accessed by patients and clinicians from any computer with an Internet connection. Cancer Care Ontario (CCO) has employed this feature to partner with their community primary care partners creating a “Circle of Care.” The Circle of Care is a care model for cancer patients that provides more seamless support for patients by sharing the work with engaged community partners. It is our vision that ISAAC-BC will be similarly deployed after a full and successful installation by the BCCA.

A rapid cycle quality assessment process, modelled on Langley, Nolan, Nolan, Norman, and Provost [3], was used to introduce ISAAC by the BCCA. We needed to make the change as smooth as possible and to track the sequence of approximations to targeted success.

The “plan, do, study, act” (PDSA) model is an effective way to implement change. The PDSA cycle is a process model for quality improvement that has been used extensively in health care. PDSA cycles consist of small-scale tests of planned actions, followed by assessment and improvement of the initial plan. They allow for an innovation to be introduced in a fluid and malleable way.

2. Results

We designed a proof of concept so that we could best understand the impact of this system on patient and staff outcomes. The design stipulates that 90% of the lung cancer patients will be screened and, of the group who score greater than four on their ESAS, 90% will receive further assessment. Of those patients who receive further assessment, success will be deemed if 90% demonstrate a reduction in symptom distress.

This outcome will be measured as follows:
• Number of lung patients who use ISAAC/total lung patients seen in the proof of concept period (to Jan 31). This metric will be calculated by determining lung clinic caseload and comparing this number with the number of these patients who log onto and input to ISAAC.

• Number of lung patients screened and scoring greater than 4/10 on any area of the ESAS and who consequently receive further assessment. This metric will be calculated by determining which patients scored greater than four and auditing their charts to determine what action has been taken.

• Number of lung patients who receive further assessment and intervention and demonstrate a subsequent reduction in symptom distress. This metric will be determined by comparing patient ISAAC scores over time. Integral to outcome measures are patient satisfaction with the ISAAC system and the impact of ISAAC on clinician workload and satisfaction with care.

Patient comfort will be measured using an ethnographic study, which will examine the patient’s response to the technology interface. Patient satisfaction will be measured using the valid and reliable tool FAMCARE, similar to the one which Cancer Care Ontario employed.

Clinician comfort with the system and satisfaction with its effect on their care and workload will be measured using a Likert scale questionnaire. In addition, brief “check in” meetings will be held to assess the impact that ISAAC has on clinic flow and to devise mitigating strategies if they are needed. This strategy allows us to incorporate the PDSA methodology and to keep the innovation adaptation close to the clinician-patient interface.

After this controlled proof-of-concept, the BCAA regional cancer centres will adopt ISAAC-BC according to the following schedule:

1. Fraser Valley and Abbotsford Cancer Centres (February, 2009)
2. Cancer Centre for the Southern Interior (April, 2009)
3. Vancouver Cancer Centre (June-July, 2009)

There are plans for installation of ISAAC-BC at the Cancer Centre for Prince George when it is commissioned in 2012.

3. Engagement of Stakeholders

3.1. Provincial Stateholders

We have discussed ISAAC-BC with many people in British Columbia who are interested in reducing the symptom burden for patients. They are those concerned with palliative/end-of-life care at the regional health authorities, chronic disease management, primary care providers who track and manage the symptoms, and others in aligned technology health solutions.

The following groups have been briefed on ISAAC and will preview our proof of concept at Vancouver Island Centre (VIC) as a precursor to engagement with us in our “Circle of Care”:

• Ministry of Health Community Care
• Ministry of Health Primary Care Initiative
• Ministry of Health Chronic Care Initiative
• Physicians Information Technology Office
BC Health Line  
Northern Health Authority (NHA)  
Interior Health Authority (IHA)  
Vancouver Coastal Health Authority (VCHA)  
Fraser Valley Health Authority (FVHA)  
Victoria Hospice/Vancouver Island Health Authority (VIHA)

Each group has been assessed with respect to its readiness in the areas of:

- a) palliative care or chronic care leadership and infrastructure,
- b) information management leadership and infrastructure, and
- c) political will at the executive level.

Currently, IHA seems best prepared to adopt ISAAC. This may change the BCAA’s own installation schedule.

As well, CAMEO, a University of British Columbia and BCCA partnership aimed at understanding cancer patients’ use of complementary therapeutics, will be a Circle of Care partner for the Vancouver Cancer Centre as part of the information platform and services. It is hoped that ISAAC can be amended to be programmable so that CAMEO’s specific needs can be met.

The formation of a Circle of Care partnership is hampered by the need to conduct a Privacy Impact Assessment (PIA). Any project that provides electronic patient data for viewing across jurisdictions and by multiple clinicians requires a PIA to ensure that patient privacy and confidentiality are protected. This has become a critical concern for us as we make plans to extend our platform and share data with our care partners.

3.2. National Stakeholders

The Canadian Partnership Against Cancer (CPAC) is looking carefully at what we are doing in BC. ISAAC-BC is a technology adaptation project that may provide either a framework or even a turnkey package for other provinces wishing to adopt ISAAC. ESAS, which is the basis for ISACC, is one of two measurement instruments viewed by a national stakeholders group to be of possible use with a turnkey or framework package. Early interest in adopting ISAAC has been expressed by authorities in Saskatchewan who will attend our proof of concept meeting in November or December, 2008.

3.3. International Stakeholders

An inception plan has been laid out after an initial contact made by Alaska. Authorities there are hoping to adopt ISAAC. They are working closely with us as we roll out ISAAC-BC. They have pursued funding and encouraged their champions to proceed in the spring or summer of 2009.

4. Early Emerging Research Opportunities

Recently, the Michael Smith Research Foundation announced the creation of the Nursing Health Services Research Network. This organization has funds for nursing practice initiatives and technology. Under this auspice, Dr. Elizabeth Borycki, who is an Assistant Professor and researcher in the School of Health Information Science at...
the University of Victoria, wishes to lead a team of nurse and informatics researchers to study how ISAAC interfaces with nursing practices and improves patient outcomes.

The proof of concept methodology and commissioning of ISAAC by the BCCA is providing material for the thesis work of four nursing and informatics students enrolled at the University of Victoria.

BCCA Genome Science is interested in understanding the genetic predisposition of symptom response to interventions. It is hoping that ISAAC data will allow them to collaborate with American and European colleagues who are examining the genetic predictability of symptom response.

5. Discussion

Deployment of ISAAC by the BC Cancer Agency has proceeded at the fastest pace possible. Although we are not as far ahead as we had hoped to be (with all regional cancer centres enabled), we believe that our stepwise methodology will provide needed stability to the system’s introduction thereby ensuring successful deployment and adoption. We have used the intervening time to engage provincial, national and international stakeholders.

Two issues limit our activities. First, we have been constrained by the CCO software. Although it is a wonderful application, we would like to expand its capabilities. It is our intention to have ISAAC-BC support multiple chronic diseases in multiple BC and Canadian jurisdictions. ISACC-BC must be modified to be more flexible and of a more widely-accepted software architecture. Second, as ISAAC extends across the province, we will need to conduct an exhaustive privacy and impact assessment (PIA). These two activities are beyond the budget for which we originally received support, so we are now seeking renewed funding.

References

Designing Technology To Support End of Life Decision Making

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Abstract. Despite being in existence for more than 15 years, the effectiveness of advanced directives has yet to be established. One possible reason for this is an inadequate level of shared understanding among stakeholders – the dying patient, family members and medical practitioners – regarding values and their implications for future actions at the end-of-life. Americans find it difficult and stressful to discuss death. This research investigates whether the articulation and alignment of values and meanings for the end of life can be promoted by framing them as acts of negotiation. This research uses ethnomethodology to examine the needs of this population, followed by grounded theory analysis of the interview data. The author concludes with three design guidelines for designing technology to aid in the exploration of options at the end of life.

Keywords. advance directives, end-of-life decisions, grounded theory

Introduction

Advance Directives (ADs) as a vessel of end of life care preferences have been encouraged and legal in the United States since 1990. Unfortunately, advance directives have had a poor track record. Statistics for 1994 show about 15 to 20% usage in the general population, and about 20% usage in the nursing population, arguably those that need them the most [1]. By 2003, AD completion rates have only progressed to about 50% in nursing home populations [2,3].

Why Have ADs Failed?

This lack of adoption on the behalf of patients and of the medical community indicates that ADs have clearly not served all the stakeholders well [4]. The literature on advance directives shows four key reasons for this failure to fulfill the goal of advocacy for dying patients (see Table 1).

<table>
<thead>
<tr>
<th>Reason</th>
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<tr>
<td>1. ADs may not reflect changes in the patient’s care preferences in response to changing prognosis or pain levels [5].</td>
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<tr>
<td>2. Generically worded ADs are difficult to apply to specific medical situations [6].</td>
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<tr>
<td>3. Surrogate decision makers find it difficult to comply with the wishes of the dying patient [3].</td>
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<tr>
<td>4. Even with the parents’ AD in hand and with prior discussion about the choices, adult children continue to have only about 60% prediction accuracy [7].</td>
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Table 1. Reasons for lack of AD adoption.
The fourth reason shown in Table 1 might be the final nail in the AD coffin. However, the researchers point out that a potential explanation is that the real life benefit of this discussion only plays out over time in several such discussions. They also do not discount the value of an increase in perceived confidence in surrogates’ decision-making abilities in a time of difficult choices [7]. It is well supported in gerontology and hospice literature that increased interpersonal communication regarding end of life choices eases suffering and encourages coping [8-10]. However, Callanan and Kelley acknowledge that carrying on a conversation with a dying patient is difficult because “Today, many families don’t have close, frequent, or continuous involvement with the one dying. Unlike earlier generations, they don’t learn how to be at ease with someone whose life is coming to an end. [11]” As a whole, research seems to indicate the need for a conversation-stimulating tool that engages key decision makers over time to improve shared and surrogate decision-making.

Is Technological Support an Option for End-of-life Discussions?

Studies on health information research show that patients often go to the web to search for information regarding their diagnosis [12]. In particular, online health information research reveals patients searching for potentially sensitive topics, such as information on gynecology [13], suicide [14] and breast cancer [15]. One possible explanation for this behavior is that the web offers a medium for a private exploration of options. The studies, taken together, show a pattern of personal sense-making prior to consultation with a doctor. The non-judgmental, non-threatening environment of a web search facilitates this personal sense-making; any question is permissible.

It is possible that in the end-of-life context, patients and families may also turn to technology as a neutral medium for exploring options and scenarios. Nevertheless, envisioning a digital artifact for use with dying patients raises some issues: what would be an acceptable form of this technology at the bedside? How should it trigger conversations?

1. Exploratory Study

Grounded Theory [16] was used to explore the cultural promoters and barriers to conversations about dying and end of life decisions. By borrowing from the concept of cultural probes as points of inspiration [17], five pictures depicting various aspects of the advance directive process were shown during interviews. The first picture had a humorous quote about death from Woody Allen. It was chosen as a conversation opener and to obtain a sense of barriers to conversations about AD. The next two depicted potential contexts of conversations discussing end of life. They were meant to help understand the content of the conversation. The last two were chosen to elicit reactions to different bedside technologies: more common, screen-based technology and less common, robotic technology. (The fourth image was a digital blending of two images since bedside technology for the dying is not available at the moment.)

1.1. Sample Characteristics

All the subjects were Caucasian Americans. The range was 64 to 80 with a mean age of 72.1. Four interviewees were female and two were male. All were members of an
advance directive advocacy group except for one female interviewee who was the wife of a member. The qualifying parameters were:

1. age above 65,
2. experience caring for a dying person, and
3. having completed an advance directive.

Although using interviewees who are advance directive advocates may skew results, they may also be seen as ‘experts’ in the field. They have had experience approaching and convincing other older adults to complete an advance directive and can offer well-considered opinions.

1.2. Procedure

Images were consecutively displayed on a laptop. Interviewees were asked either to describe what they saw as the content of the pictures and how they felt about it. The interviewer made notes during the interview about points of interest and followed these up with more questions. The interview was audio taped and transcribed as soon as possible after the interview. Six interviews were completed in this way.

1.3. Analysis and Resulting Themes

In keeping with the methodology of grounded theory, the transcriptions were coded to detect recurrent themes across all interviews. New words or phrases of interest are noted as they appeared and were checked backwards against previously processed codes.

The software used was nVivo7. As each item appears, it is categorized into a growing semantic tree. Interviews are stopped when the last interviewee adds nothing new to the coding tree. The findings are presented in the following themes.

1.3.1. Barriers and Promoters of AD Conversations

The key barrier to advance directive conversations is the fear of confronting death. Since the recognition of imminent death is a precognition for completing advance directives, the fear of death is an effective barrier to conversation. LP (female, 73) explains the fear of death as a barrier to conversation in the following way: “Most people don’t want to think about that, they don’t want to think about their death. Unless you’ve lived through it with somebody you don’t. Maybe even if you’ve lived through it with somebody, you don’t.”

Death is also seen as an unreal prospect, one that is not reasonable to consider for a healthy person. When probed as to the nature of this fear, interviewees cited “fear of pain” and “fear of the unknown”.

However, there were situations or contexts mentioned which were favorable to the advance directive conversation. “Sweet spots” that trigger the advance directive conversation.

- Death is more real when contemporaries begin to die after a certain age
- Curiosity about end of life options after having seen a loved one die
- A desire to reduce the burden on family when ill
- Experiencing painful, prolonged deaths
- Adult children exploring options for aging parents
1.3.2. The Process of Completing Advanced Directives

SE (female, 80) tells the story of sitting down with her now deceased husband to write a non-form-based advance directive as a process of “We sat down, we held each other, and we cried and we did it.” The conversation is clearly one carried out between two intimates, after the acceptance of an oncoming loss.

The findings also indicate that advance directives are never truly complete. So many factors change over time that the emerging picture is one of immense risk that the advance directive does not reflect true preferences at the time of illness. Nevertheless, it might be that the details and preferences that are key to comfort choices are not communicated via writing. BC (male, 74) remembers his own mother, who also had an advance directive, verbally reinforcing her wishes to him every time they met.

1.3.3. Proxy Difficulties

The difficulties proxies have carrying out the wishes of the dying is a finding that is under-addressed in the literature. BC, the active AD advocate mentioned above, relates the following anecdote: “When the doctor called me up, asking me if I would like to counter my mother’s wishes, I hesitated. For a moment there, even I found it difficult to carry out her wishes. But in the end, I never regretted it, not one moment.”

This understandable hesitation to refuse treatment with marginal benefits can be multiplied by resistance on the behalf of other loved ones and family members who may not be nominated proxies or alternate proxies, but consider themselves, rightly, as stakeholders in the decision making process.

1.3.4. Technology at the Deathbed/Sickbed

Reactions to the final two images of the screen and the robot were polarized; especially so for the robot card.

LP answered in response to a question on how she felt about the presence of the technology: “I would not want to have anything that would tell her what her vital signs were, you know, if it’s telling her that she’s dying, I don’t think that it’s going to do her any good…” In response to further prompting about what would be good to have, LP responded: “You know, if it is a… funny little television program, that might make her smile. That would be alright.” This view was tempered by SE, who said that: “A toy would be insulting, but if it were something to help her communicate her wishes that would be good.”

The reactions to the robot card were stronger. Extreme negative reactions included SE’s: (extreme disgust and sadness) “Whew. Sure as hell no humanity in there? (pause) Is it going to be just machines that are going to be there for you?” and CW’s (female, 70): “Humph. My first reaction is sadness… I wish that were a person holding him.”

In stark contrast were these reactions. BC said, “The person being cuddled by the robot is very happy. (Laughter). The person is uh, is uh very happy I would say… It looks nice and robust, I think it’s going to hold her safely, I don’t think she’s worried about being dropped.” HN (female, 63) said, in reference to bedsores, “Well the robot thing, that’s cute. Keeps them off their back and their bottoms.”

The common thread in the last two responses was that both interviewees had had extensive experience in professional eldercare. One was male, the other female. The other male interviewee was open to the idea but displayed no strong affect in either direction. Technology at the bedside was most acceptable when there was a clear
utilitarian value. It was somewhat acceptable for entertainment purposes such as music or simple games.

2. Discussion and Design Guidelines

Three design guidelines were formulated for the creation of technology that can help people have conversations about death and dying in a constructive manner.

2.1. Design Guideline #1: User Group Profile and Context

The deathbed/sickbed is clearly a time for conversations, but the study and its findings make it clear that it is not a time for the introduction of new technology. Despite evidence that shows acceptance at some level, the requirement for a clear utilitarian purpose might prove too cognitively heavy for a bedside tool that is a conversation trigger. For this reason, the tool should come into play before the patient’s mobility and cognitive state begin to erode.

Yet the findings on the fear of death and its unreal nature in everyday life indicate healthy older adults may not be receptive to this tool. However, the list of AD conversation promoters show that older adults with a potentially terminal condition are more open to the use of an interactive tool that helps them to complete an advance directive by exploring options in comfort and care. The profile of the user group includes those who have experienced a death of someone close to them, for example, an elderly parent. This user group may continue to have good cognitive function, but are beginning to experience some health difficulties.

2.2. Design Guideline #2: Involve Proxies in Understanding End-of-Life Choices

The second guideline addresses the content of the interaction. The researchers of a successful AD case study [18] offer the following reason for the 85% completion rate – they shifted the focus of end-of-life decision-making away from completion of documents and toward facilitating discussions about values and preferences among families and community units. In this way, conversations about end-of-life preferences could be framed as an act of negotiation of values and meanings.

Hence, this guideline suggests that patients and loved ones have their own end of life value positions evaluated and reflected as a visualization to each other. Visualizing the negotiation progress can help create shared mental models, which speed the conclusion of negotiations [19]. So, those whose positions are further away can then be offered discussion modules, or exercises, for families to work through their differences. The goal here is not to have complete agreement but, rather, a better understanding of a person’s end-of-life choices.

2.3. Design Guideline #3: Support Conversations over Time

An AD tool needs to promote and support end of life conversations repeated over time. Even after the AD is complete, the proxy chosen, and various stakeholders informed of the patient’s decisions, changes in the patient’s health situation may trigger new discussions and new searches for information. It may even cause a revision of the AD.
Since the tool was used in the first place to create the AD, it is an ideal site to host revisions and updates, and to disseminate that information to all the potential stakeholders. Accessing this tool on the Internet will also help facilitate long-distance, asynchronous discussions.

2.4. Conclusion

Ultimately, the goal of these design guidelines is to increase the presence of shared contexts and shared cognition about the goals of care at the end of life. In time, the increase in shared understandings may negate the need for bedside technology; instead the conversation at the bedside may be a product of intimate, productive conversations triggered much earlier in the timeline.

References


Structured Data System for a Breast Cancer Medical Record

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D3T Inc, Hyderabad, India

Abstract. We have developed software for an Electronic Medical Record (EMR) to be used by oncologists and researchers. It has rapid, structured data entry, visualization of clinical information and a searchable data base. Interactive, rules-based forms were designed for structured data entry. The web-based forms have been customized for the clinical staff who enter the data. The forms have been tested by oncologists and their office assistants. Modules have been added to upload images and add legends, metadata, and code classifications such as ICD and CPT. Other features include a search interface and a permission system that controls user access. Oncologists enter detailed information during a patient’s visit to the clinic. The electronic forms capture diagnoses, stage and history, which includes social, family, and medical history. A time map provides a graphical summary of a patient’s record. Visualization of complex clinical information with intuitive navigation increases clarity while retaining the detail necessary for clinical information. Customized data entry forms and automatic coding speed the workflow. The system can potentially interface with multi-institutional data-sharing systems such as Cancer Bioinformatics Grid (CaBig).

Keywords. EMR, oncology, EMR, structured data, data visualization

Introduction

Although several electronic medical record (EMR) systems are available, their features and design vary considerably. An ideal EMR system must be simple for providers to use - providers should be able to enter, search and retrieve clinical data easily. The EMR system should automate tasks such as displaying alerts and assisting in classification coding. It should link to knowledge bases for relevant information and decision support. It must save time and reduce errors.

Particular medical contexts require optimization of particular EMR features. We present a novel EMR tool that has been optimized for breast cancer. It was designed for use by oncologists as well as researchers and has a rapid, structured, data entry; a graphics module for visualization of clinical information; and a fully searchable data base. The system has been implemented with public domain software including Linux, MySQL, Java script, AJAX and HTML. Interactive, rules-based forms were designed for structured data entry. The web-based forms were customized for the clinical staff and were tested by oncologists and their office assistants. Modules have been added to upload images, add legends and metadata, and assist in classification coding such as
ICD and CPT. A search interface for detailed searches was added and a permission system was installed to manage access.

The oncologists can open a web form to enter detailed information during a patient’s visit to the clinic. The form has an intuitive interface to enter and retrieve information about a patient’s diagnosis, stage and history, which includes social, family, present illness and past medical history. System review and physical examination data are collected at a very fine level of detail. Rule-based check boxes provide structure and standardization and text boxes provide flexibility. Pathology and radiology images can be uploaded and attached to the patient record.

A timeline map provides a graphical summary of the patient record. The oncologist can quickly view a complex record that has multiple visits summarized on a timeline. “Mouse-overs” and “drill-downs” display detailed information at any point on the map.

Coding is automated and the chooser can display the codes and generate reports for specific ICD or CPT codes. Intuitive forms can be used generate customized reports and specify database searches using any combination of search criteria.

1. Design

To build the system, we had to model data, design a relational database, and design user interfaces. Anonymized breast cancer cases were analyzed during data modeling. For example, for a typical initial visit of a breast cancer patient to the medical oncology clinic, major data groups including stage, pathologic diagnosis, history of present illness, past medical history, personal-social history, family history, past surgical procedures, system review, current medications, medication allergies, results of physical exams, recent imaging, impression and plan were identified. Next, subsections for each of these groups were defined and a data dictionary for each subsection was created. For example, in system review, several sub-groups including general, eyes, ears, nose, mouth, etc. were defined. Next, the data elements under each of these sub-headings were listed. Under the subsection lungs, for example, cough, hemoptysis, dyspnea, wheezing, and congestion were listed.

All data elements from the database tables are presented in a form that is easy to navigate. Data dictionaries and forms were created for the pathology report, breast cancer staging, imaging and surgery. In order to provide flexibility, text boxes are provided under most headings so that free text and comments could be entered. To automate coding, specific codes are associated with the data elements wherever it is appropriate. For example, a specific ICD code may be associated with a corresponding diagnosis and a SNOMED code may be associated with a corresponding pathologic feature. In order to avoid visual clutter, by default the codes are not displayed but a mouse click on “display codes” causes the codes to be shown.

The form was designed for easy navigation and data entry. The screen is divided into two vertical panels. The panel to the left summarizes the patient’s data and the panel to the right displays data elements such as radio buttons, check boxes and text fields where appropriate. The long form is composed of small sections, which can be called up by clicking the “next” and “previous” arrows or by clicking on the appropriate heading in the summary panel.

Decision support is provided with links to web pages, documents or short notes. Contextual links can be embedded in items on the form in order to display relevant information. For example, the breast cancer staging section of the form can be linked to
a web site containing detailed description of the staging parameters with associated illustrations. A simple text document, table or short description can also be linked. The user sees an icon for a link and upon “mousing-over” sees a one line heading or description. A mouse click opens a popup window with the relevant content. A director or designee can add, remove or edit the knowledge links.

Forms can be used to document every encounter. A new encounter is created by selecting a “new event” function and selecting the date. The type of form that is displayed depends on the type of event selected, e.g., initial oncology visit, follow up visit, pathology, surgery or imaging. Multiple encounters are summarized in a visual timeline display that marks the date and type of each encounter. The user can click on the encounter icon to see detailed documentation about that encounter. A summary view, which shows all the encounters, is listed vertically in a screen with each encounter summarized in three or four lines.

Images such as mammogram, CT scan or histopathology can be uploaded and automatically associated with their event. A “compare” function can pull images from any of the encounters for a side-by-side comparison. This may be helpful in the assessment of disease progression.

The system provides flexible and fine-grained searches. Any single item such as “lobular carcinoma” can be used to search patient records. There are also advanced searches, for example, “find all patients with lobular carcinoma who are less than 30 years old, at a presenting stage of IIB, and have a family history of breast cancer on the maternal side.” Reports can be generated to summarize those cases with specific billing codes or SNOMED codes that occur within a given date range.

2. Technical Environment

Our goal was to build a user-friendly and robust system that could be used on any operating system platform. We chose a web application built with a Linux operating system, Apache web server, MySQL database, and Perl (LAMP) software solution stack. This combination of open source software tools has now become a widely used environment for robust, database-driven web applications. We used AJAX to provide a fast and intuitive user interface. For large institutional users, this system can be deployed as an intranet appliance that is a pre-configured server with all the software installed. It is ready to use as soon as the network manager plugs it in and assigns an IP address to the server. As an alternative to a physical server, a virtual instance (a virtual server that resides and is hosted by an existing Microsoft, Linux or ESX server within the network) may be deployed.

2.1. Security

Access to the application is limited by permissions for different types of users, for example, provider, director and database manager. All communication to the system is encrypted using 128-bit SSL.
2.2. Challenges

It is a challenge to acquire a system that providers find easy to use and it is also a challenge to persuade providers to change from dictation to using electronic forms. To develop a system that providers will accept, it is critical to include the providers in the early stages of design and to work with them to validate system functionalities at each stage. Users adopt the application because it is convenient to use, saves them time, produces a more complete and clearer medical record, improves billing, and has a powerful search capability.

3. Conclusion

Data in breast cancer health records can be presented visually in a clear and compelling manner. Providers can easily navigate and retrieve information. Rules-based forms simplify data entry and produce clear, consistent and standardized health records. The database, which contains fine-grained data, can be searched using a custom search interface. Automated coding saves time and reduces coding errors. The system is designed to share data with other systems for clinic management and research. This system could provide national data repositories such as Cancer Bioinformatics Grid (CaBig) with more timely, accurate and complete data.
The eFOSTr PROJECT: Design, Implementation and Evaluation of a Web-based Personal Health Record to Support Health Professionals and Families of Children Undergoing Transplants

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Abstract. We describe the eFOSTr PROJECT, which has involved the design, implementation and testing of a unique Internet-based Personal Health Record (PHR) to support the families of transplant children and their healthcare providers. There are many gaps in the way that information is stored for children undergoing or about to undergo transplants. This group of children presents the most challenging exercise in information support between geographic and institutionally separated medical teams. They are, however, supported by highly motivated parents and families in life-threatening circumstances. A PHR was designed that allows for secure data entry, data storage, and easy controlled data access by the children’s guardians or parents. The record includes contact and team member names, and medical data such as growth charts, immunizations, allergies, medications, lab values and scanned or digitized medical reports. Families can record the progress of their child as they would with a paper binder and customize their child’s record with a photograph gallery and Internet link section for personal and general interest. Extensive computer-based testing of the PHR is complete. The system is being evaluated to determine the extent to which it meets the information needs of families and health providers in differing situations across Canada. The effectiveness of the system as a means for providing continuity of information and education is also being assessed. To conduct these evaluations, new users are being interviewed and tracked in a qualitative longitudinal study. Characteristics of the needs of the transplant families known to the David Foster Foundation (DFF) in Canada are described so that comparisons can be made to other patient groups who could benefit from their own adapted and specialized PHRs.

Keywords. PHR, EHR, childhood transplants, information needs, longitudinal study

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Introduction

Currently there are many gaps in the way that health information is stored about children undergoing or about to undergo transplants. Paper patient records may be hard or impossible to access by family members and time delays and distance between physician teams as well as incompatible electronic records in differing offices, laboratories, hospitals and pharmacies can frustrate timely care. By adding a personal health record (PHR) as an adjunct to traditional data collection and storage, the possibility exists for the family (i.e., guardians and parents) to better understand their child’s condition [1,2]. It is hypothesized that having some “ownership” of their child’s health information may lead to better understanding, care and compliance with physician’s recommendations for care of the child [3,4]. In addition maintaining an up-to-date record of the child’s health information from various sources could be of value to physicians as an adjunct to current record keeping and information flow [2]. We are not aware of any similar specialized PHR system and anticipate that experience with this highly motivated group of families will provide useful insights into its adaptation to other user groups.

In this paper, the design, implementation and testing of a PHR to address the above issues will be described (the eFOSTr PROJECT). The record, which was developed with the support of the David Foster Foundation (DFF), is designed for several classes of users, specifically: a) parents and guardians of children undergoing or about to undergo transplants, b) the child’s physician and health professionals at the “home” location as well as at remote locations where operations may take place, and c) in the case of older children (teenagers) access by the patient themselves. The user interface is organized around a “calendar” metaphor, with key events in the child’s progress used to enter and retrieve data. The main functionality of the system (which was designed to be accessed over the WWW) includes the following: a) basic patient information and quick access to information about all relevant health professionals dealing with the case, b) full information about all growth, medications, allergies, immunizations and lab results, c) links to educational and family support material, and d) a section where electronically scanned in reports and documentation about the patient can be stored. In addition, the user interface allows for personalization of the system (e.g., including a photo gallery of pictures documenting the child’s progress).

Over the past six months extensive black-box and white-box computer-centered testing of the system and its user interface has been undertaken, with rapid cycles of feedback in the refinement and customization of the system in an iterative development approach. In addition, in response to a strong expression of interest in the project, we are also currently undertaking a study of the use and usability of the initial working version of the system from the perspective of potential end users. In phase I, a telephone based survey questionnaire is being conducted using available families known to the David Foster Foundation across Canada experiencing pediatric organ transplantation. In phase II, subjects (parents/guardians of transplant children as well as health professionals) will be interviewed about their information needs and their initial reaction to the system. Subjects will also be asked to enter data from reports they have collected (e.g., immunization reports, or lab reports) into the system and comment on (“think aloud”) their impressions of the usability (i.e., ease of use). Lastly, a smaller select group will be remotely tracked over time as they interact with the initial version of the system over several months.
It is acknowledged that there will be a large variation in the degree to which different families will make use of the eFOSTr PHR just as some families keep extensive files in numerous binders and others have only limited information. No attempt was made purposely with this version of the system to allow automatic transfer of information from labs, pharmacies, and other EHR’s due to incompatibilities in inter-organizational, inter-provincial and international software and security perceptions by families of information transfers. Although scanned-in documents such as consult letters are read-only in the record and therefore secure, data entered is the responsibility of the entering individual and cannot replace the EMR data at the source. The advantage, however, of a real time, family participating, and full medical team accessible record is obvious if it can be shown to result in better compliance and health of the child involved.

1. System Features and Functions

The overall approach of providing a Web-based access to personal health records requires that access not be limited by user operating system choice (PC, Apple, iPhone…) and that the child’s record be accessible from any location. Arriving at the address of the server (with the starting information supplied by the DFF), security is assured by entering the correct e-mail address and the associated password. Correct response to a random one of three personal questions is required to identify the user. All entries and actions are logged for the user. The home page is illustrated in Figure 1.

As shown in Figure 1, the user’s name appears in the upper right box above the patient name (i.e., the child’s name). Users associated with more than one patient (e.g., a physician) have a pull down list to choose from. A photo, diagnosis, transplant type, and contact address are all chosen by the family. From the home page all other functions are accessible. The “How to get started” button links to a user manual searchable by word or section. Short tutorials are also available in audio-video format. Along the upper left hand side of Figure 1 the links to the main functional components are listed: Patient Information, Medications, Immunizations, View Lab Test Results, Gallery, etc.

Patient information includes a link to a page of names of contacts, health care team, birth date, phone numbers and e-mail addresses. Growth data in table and graphical display is presented for height, weight, head circumference, with calculated surface area and BMI in metric and imperial units. Contacts include addresses of connected users of the system as well as any additional relatives or friends granted limited access, for example, to photos only.

Allergies, medications, and immunizations are listed by date with appropriate details including a separate listing of disease related immunizations and antibody testing results for both before and after a transplant. Lab results are listed by date with normal range for specific labs noted. Graphing of blood levels and daily dose levels of selected drugs and lab results can be produced.

Documents scanned into the record from the user’s computer in PDF format can be sorted by author, date, and other categories and can include photos, X-rays, videos, letters etc. The Gallery is a display of digital photos that can be transferred into the record from your computer with a description of contents, if desired. Links allow for easy transfer to Internet sites such as Web based education sites as well as personal
sites on you-tube etc. from a general list produced by DFF or from a customizable personal listing.

Emergency password generation is randomized and incorporated into a wallet sized card that can be printed out for selected use by the family and patient if emergency access (read only) to the PHR is necessary. Notification of emergency use of this card is indicated on the home page as a reminder to reset the password to protect access to the record (and generate another emergency card). Calendar dates can be flagged with icons reminding of appointment dates and written descriptions of the appointment appear under the calendar within one week of the appointment.

1.1. Technical Considerations

To allow widespread but restricted access to the information contained in the PHR, a web server in a licensed commercial site in Canada was set up to host the application (after a server was used at OA Solutions in Victoria BC during development). Duplication offsite is a standard requirement for back-up. Adherence to Canadian PIPEDA guidelines for the storage and confidentiality of personal health information is a fundamental priority for the project. Neither personal nor group patient information is used for commercial or product promotion in this project. The software for the eFOSTr PROJECT was developed at OA Solutions Victoria, BC under the project management.
of Scott Peterson, Ian Gallagher and Mark Langton. Web browsers supported include Microsoft Explorer, Firefox, and Safari.

2. Evaluation

A two phase evaluation has been planned and is currently underway. In Phase I a telephone survey is being conducted to assess the information needs of families of children about to or having undergone transplants. In addition a questionnaire is being distributed to the families associated with the DFF. The questions included in the interview and questionnaire are designed to assess the following: the number of families traveling outside local hospitals for transplant care, the number of families traveling outside their home province and Canada, whether the family has access to a computer or the Internet at home, whether they have ever had experience with a PHR before and, the number of physicians they interact with. They are also being asked if they would share information with their child’s health care team and if they would use a PHR and feel comfortable with use of an Internet based PHR for their child. In Phase II a subset of the families will be invited to participate in usability testing of the PHR and will be observed as they interact with the system to enter and access information about their child while “thinking aloud” [5]. Criteria for inclusion as patients included registration with the DFF, under age 19 years, preparing for or having received a solid organ transplant and living in Canada. In future work we will also be examining physicians’ and other health providers’ use and reaction to the PHR.

3. Conclusions

In this paper we have described a novel approach to providing web-based access to personal health records for families of children who have had or are about to have a life saving organ transplant. In response to requests for improved access to personal health information and a system to organize it for these families over the years, the David Foster Foundation has responded by funding the first prototype of a specialized PHR. Dramatic expansion and almost universal access to home computers and the Internet as well as the rewardingly successful results of organ transplant technology and transportation possibilities has lead to the eFOSTr PROJECT. It is hoped that the experiences from this project will help other patient groups from the complex chronic care patient to the healthy child dealing with multiple immunizations in different locations. More research is needed in this field to understand the acceptance and resistance to PHR’s and the features that make them work securely and successfully.

4. Acknowledgements

The authors would like to thank the children who participated in the need and ideas behind this project. As well, we thank the families who in spite of the incredible pressures placed on them for their child’s transplant care, were able to spare the time to participate in the project. Health care specialists who dedicate their lives to transplant services are instrumental in making rapid decisions with as much information as
possible from often distant locations performing miracles and are appreciated. We also thank David Foster and the David Foster Foundation for the 22 years of fund raising and the amazing success that has allowed the expansion of financial help for over 400 families from across Canada and led to the need for this project. Elements of the program were contributed by Chris Holt, Lorenzo Oss-Cech, Simon Dabbs, Mike Han, and Sade Ashby.

References

A Comprehensive Infectious Disease Management System

Alex MARCU and John D. FARLEY

*MDIT Innovations Incorporated, Vancouver, BC, Canada*

**Abstract.** An efficient electronic management system is now an essential tool for the successful management and monitoring of those affected by communicable infectious diseases (Human Immunodeficiency Virus - HIV, hepatitis C - HEP C) during the course of the treatment. The current methods which depend heavily on manual collecting, compiling and disseminating treatment information are labor-intensive and time consuming. Clinics specialized in the treatment of infectious diseases use a mix of electronic systems that fail to interact with each other, result in data duplication, and do not support treatment of the patient as a whole. The purpose of the Infectious Disease Management System is to reduce the administrative overhead associated with data collection and analysis while providing correlation abilities and decision support in accordance with defined treatment guidelines. This Infectious Disease Management System was developed to:

- Ensure cost effectiveness by means of low software licensing costs
- Introduce a centralized mechanism of collecting and monitoring all infectious disease management data
- Automate electronic retrieval of laboratory findings
- Introduce a decision support mechanism as per treatment guidelines
- Seamlessly integrate of application modules
- Provide comprehensive reporting capabilities
- Maintain a high level of user friendliness

**Keywords.** HIV, hepatitis C, infectious disease management system

**Introduction**

An efficient infectious disease management system is essential during the course of patient treatment. Infectious disease management requires an overwhelming amount of labor. Data sets are collected, monitored and analyzed at specific time intervals. There are ongoing laboratory investigations. Prescriptions for medication change as the disease progresses. A “cocktail of drugs” must be prescribed for chronic diseases like HIV and hepatitis C and these drugs must be adjusted during the course of the disease in accordance with the treatment response.

Information associated with the treatment is tracked using a paper-based charting system or using an electronic system that often consists of multiple stand-alone applications. If a set of non-integrated electronic systems is used to support disease treatment, the lack of database integration significantly increases data administration and management and places a strain on patient care.
The administrative workload is further increased if the clinic participates in a clinical trial sponsored by a pharmaceutical company. Clinical trials are a way to advance and improve treatment outcomes in chronic diseases like HIV and hepatitis C. Patients are enrolled in clinical trials according to certain criteria and are closely monitored during the course of the trial. The clinic staff must first identify eligible patients by manually reviewing their charts. Laboratory investigations are conducted at preset intervals. Medication is closely monitored. Thorough patient examinations are conducted regularly. All of these factors are reviewed before a decision is made to alter a treatment regimen.

The workload associated with chronic disease management combined with the work added by clinical trials can be so overwhelming as to affect the quality of patient care. Administrative overhead and data retrieval and analysis can be reduced, however, by means of an electronic system that emulates the clinic workflow.

1. Initial System

Initiatives began in September 2007 to develop a comprehensive and effective infectious disease management system capable of monitoring and managing infectious disease treatment. System requirements were gathered in close collaboration with Dr. John Farley Inc. at an infectious disease clinic located in Vancouver, BC. A thorough system analysis was performed on the clinic workflow and on the systems used to aid in daily clinic operation and patient treatment. It was discovered that several electronic systems were used to satisfy the major administrative needs (e.g., scheduling, billing, patient charting, clinical trial monitoring). Paper based questionnaires and forms were used as well.

An initial development schedule was formulated for an infectious disease electronic system that would integrate the administrative tasks and patient management tasks. The system was designed to provide support treatment management of infectious diseases such as HIV and hepatitis. The development was to span more than one year. The system included the features shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Features of an Infectious Disease Management System.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient-centric features</strong></td>
</tr>
<tr>
<td>• Meaningful data collection</td>
</tr>
<tr>
<td>• Electronic Patient Chart</td>
</tr>
<tr>
<td>• Electronic Lab Retrieval Module</td>
</tr>
<tr>
<td>• Decision Support Module (Configurable)</td>
</tr>
<tr>
<td>• Provide Statistical Analysis on data collected</td>
</tr>
<tr>
<td>• Easy generation of predefined and ad hoc reports</td>
</tr>
<tr>
<td>• Visual Graphs</td>
</tr>
<tr>
<td><strong>Administrative features</strong></td>
</tr>
<tr>
<td>• Scheduling</td>
</tr>
<tr>
<td>• Billing</td>
</tr>
<tr>
<td>• User Management</td>
</tr>
<tr>
<td>• Multiple Site/Location Support</td>
</tr>
<tr>
<td><strong>Connectivity Features</strong></td>
</tr>
<tr>
<td>• Access from any Internet connection</td>
</tr>
<tr>
<td>• Enhanced Security</td>
</tr>
</tbody>
</table>
The initial system was developed and installed in two clinics of Dr. John Farley Inc. One central system serves both clinics. The system has several advantages over previously installed systems because it:

- reduces/eliminates paper based processes and improves ongoing cost,
- centralizes and consolidates internal clinic work processes,
- allows for workflow automation,
- eliminates data entry duplication,
- improves data integrity,
- delivers data in a secure manner,
- introduces means of report generation,
- allows for data exportability,
- increases application accessibility, and
- is user-friendly.

2. System Evaluation

The evaluation of the Infectious Disease Management System will be conducted in two stages. The first stage, now complete, evaluated the system in the pilot clinic based on the following criteria:

- Data collection integrity and meaningfulness
- Application performance: use, data entry, data maintenance, error correction, screen layouts, backup and recovery procedures, and report generation
- Effective use of staff time
- Future growth potential
- Flexibility
- Information availability and reporting
- Timeliness
- Data security and confidentiality
- Clinical Staff acceptance
- Required training and support

Questionnaires were used to capture feedback. Based on the response collected, a case study was compiled that showed a reduced administrative overhead of 40% due to the new system.

The second evaluation stage of the system will be conducted in the production environment. The feedback received from this evaluation stage will be combined with the feedback collected in stage to verify whether the results of the initial case study were valid.

3. Future Development

New development will add greater support for clinical trial management. Dynamic forms customization will be added to the patient chart. Use of graphics will combine laboratory investigations with medication information to aid in clinical decision making. The decision support component will be strengthened by using heuristic rules
such as, for example, “if WBC < X alert user Y” where “X” is a data value and “Y” is a specific user or set of users.
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Section 12

Software Selection and Evaluation
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Application of House of Quality (HOQ) to Health Care Management

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Abstract. The House of Quality (HOQ) model is proposed to improve health care quality control. A hypothetical case study is given to demonstrate the applicability and benefits of using the proposed methodology. The benefit and drawback analysis of HOQ are also addressed. Concluding remarks and proposals for further research are presented at the end of this paper.

Keywords. House of Quality (HOQ), workflow management

Introduction

Quality Function Deployment (QFD) is a process that utilizes structured procedures or functions to seek and assure product/service requirements of customers (VOC) and then expresses them as relevant technical requirements. It uses relationship matrices to describe the relations among customer requirements, among technical requirements, and among customer requirements and technical requirements. By using these descriptions, a company can continuously improve its product/service quality to meet the customer requirements. The House of Quality (HOQ) is a part of QFD and is the most recognized and widely used form of expressing these relationships. It translates customer requirements, based on marketing research and benchmarking data, into an appropriate number of engineering targets to be met by a new product/service design [1].

Assume the customers are patients and the company is the hospital. If HOQ is employed, the relationships among patient requirements, among health care delivery design requirements, and among patient requirements and health care delivery design requirements are expressed as sets of symbols. By properly quantifying these symbols, we can rank the importance of each technical requirement. The hospital can then use this ranking to determine the priority of technical improvements in its health care service quality improvement.

1. The House of Quality (HOQ) Methodology

The basic structure of HOQ includes six matrices (see Figure 1). The functions of each matrix are described as follows [2-4]:

- Customer Requirements Matrix
  The matrix with “Customer requirements VOC (What)” is as the labels on the left of HOQ. It documents a structured list of product’s customer requirements
(the voice of the customer, VOC). The information is usually gathered through conversations with the customer wherein they are encouraged to describe their need and problems.

- **Planning Matrix**
  On the right side of HOQ is the planning matrix. It qualifies the requirement priorities of the customers and their perceptions of the performance of existing products. This figure qualifies the relative importance of each of the customer requirements from the customer’s perspective. A questionnaire is used to gather these importance weightings. Analytical Hierarchy Process (AHP) [5] usually is used to evaluate the weight of customer requirement.

- **Technical Requirements Matrix**
  Technical requirements, VOE (How) are across the top. This matrix describes the engineering characteristics or the voice of the company. The QFD design team generates the information by identifying all the measurable characteristics of the product/service that are perceived to relate to the meeting of customer requirements. The data is collected in a way similar to that used with the Customer Requirements. An additional row is included to illustrate for each of these variables the direction of change that is considered to result in an improvement in product performance.

- **Inter-relationship Matrix**
  The body of the house is an inter-relationship matrix of “Whats vs. Hows”. It is the main body of HOQ that translates the requirements as expressed by the customer into the technical characteristics of the product. Each cell in the matrix is combination of an individual customer and one of the technical requirements. The level of inter-relationship discerned is usually weighted on a symbol representing this level of inter-relationship. Each symbol represents a point scale and is entered into the matrix cell.

- **Roof Matrix**
  The roof is a correlation matrix of “Hows vs. Hows”. It is used to identify the technical requirements that characterize the product, i.e., that support or impede one another. For each cell in the roof matrix the question is “Does improving one requirement cause a deterioration or improvement in the other technical requirement?” The “+” symbol means that the improvement of one requirement implies an improvement in the other technical requirement. The “-” symbol means the opposite.

- **Weight of VOE Matrix**
  This matrix is located at the bottom of HOQ. It summarizes the conclusions drawn from the data in the entire matrix and the discussions of the quality team. It expresses the relative importance among the techniques.

### 2. A Case Study

In this section, we use a hypothetical inpatient health care management as a study case to demonstrate that HOQ can be applied to improve health care management. Usually, QFD uses four houses (planning house, design house, operating house, and control house) to clearly establish relationships between company functions and customer satisfaction [3]. However, the simplest QFD exercise uses only one HOQ diagram that
seeks to take customer’s requirements and translate them into technical requirements. To simplify the exercise, the case study uses one HOQ diagram.

<table>
<thead>
<tr>
<th>Customer Requirement</th>
<th>Importance</th>
<th>Technical requirements, VOE (How)</th>
<th>Planning Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inventing EMR/EHR</td>
<td>Increasing physicians</td>
</tr>
<tr>
<td>Safety</td>
<td>9</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Less waiting</td>
<td>4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Less cost</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Comfort</td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weight of VOE</th>
<th>Value</th>
<th>Percentage</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.75</td>
<td>26%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>6.78</td>
<td>37%</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3.03</td>
<td>16%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1.95</td>
<td>11%</td>
<td>4</td>
</tr>
</tbody>
</table>

**Figure 1.** House of Quality.

2.1. A Hypothetical Case

Many inpatients complained that the health care quality in a hospital has become worse. After careful analysis the hospital quality improvement (QI) team found that the main patient requirements are:

- Safety
- Less waiting
- Lower cost
- Comfort

The technical requirements for satisfying these customer requirements are:

- Implementing an EHR/EMR system in the hospital
- Increasing the number of physicians
- Providing better professional education for physicians
- Reducing premiums

First, the patient requirements are documented in the customer requirement matrix of HOQ shown in Figure 1. A questionnaire is used to ask patient to give an importance for each documented requirement using a pre-defined scale (0 to 10) where 0 is the
least important, and 10 is the most important. Then, an Analytical Hierarchy Process (AHP) is used to evaluate the weight of customer requirements based on these scales. The weight for the safety requirement is 0.55; for less waiting: 0.12, for lower cost: 0.18; and for comfort: 0.15. These weights as well as their rank are entered into the planning matrix.

Once all of the patient requirements have been identified, it is important to determine how the necessary requirements can be fulfilled. The technical requirements are provided by the hospital quality improvement team that identifies the measurable characteristics needed to meet the patients’ requirements. In this case, these technical requirements are to implement an EHR/EMR system in the hospital, increase the number of physicians, provide better professional education for physicians, and reduce premiums. They are entered into the technical requirements matrix. The technical requirements that characterize the health care service, i.e., that support or impede on another are documented in the triangular roof matrix of the HOQ. The “+” symbol indicates that one technical requirement supports the other requirement. The “-” symbol signifies that one requirement is an obstacle to the other requirement.

The QI team then uses the matrix cell to indicate the customer requirement and technical requirement inter-relationships in the body of the HOQ. The level of inter-relationship is weighted on a ten-point scale (0 to 10) and is entered into the matrix cell.

Finally, the technical property (weight of VOE) matrix records the priorities assigned to the technical requirements. A specific technical property value is a weighted sum: the scale of inter-relationship is multiplied by the overall weight of the corresponding customer requirement. For example, the technical property value of “Invent EMR/HER” is calculated as in Eq. (1).

\[
7_{\text{safety}} \times 0.55 + 6_{\text{waiting}} \times 0.12 + 0_{\text{cost}} \times 0.18 + 1_{\text{comfort}} \times 0.15 = 4.75
\]  

The final output of the matrix is a set of ranked values that identify the relative importance of each technical requirement in meeting the needs of the patients. In this case, increasing the number of physicians has the highest priority.

3. HOQ Benefit and Drawback Analysis

The HOQ is a part of the Quality Function Deployment (QFD) and it utilizes a planning matrix to relate what the customer desires to how an organization that produces the products/services is going to meet those desires [2]. Although it is a great communication tool and has been used successfully for many different real application cases, it has several problems. Three main problems are as follows [6]:

- The conceptual gap between customers and designers
  The customer requirements are usually expressed by linguistic variables, which can result in ambiguity and multiplicity of meaning.

- The existence of customer segments
  The VOC in the HOQ is usually defined by a single customer group. However, different customer groups may have different sets of customer needs for the same product/service.

- The need for trade-offs among different levels of customer needs
  In traditional HOQ, the customer requirements are usually prioritized by each
individual customer. Then, the QI team compiles a list of priorities for a customer group needs. In this regard, it is often too difficult for a company to discriminate which need is related to each other, and thus, it cannot satisfy every customer’s highest priority requirement.

4. Conclusion

House of Quality (HOQ) has been successfully applied to many real cases in product quality control. However, few researchers have addressed the application of HOQ to health care quality improvement. This paper attempts to do so in order to help health care providers with the identification of the critical technical components needed to improve quality in health care. The methodology of HOQ is introduced. A case study demonstrates the applicability and benefits of using HOQ to quality control in health care. Some problems that are often faced in real applications are described.

Further research is needed in the development of methods to reduce the conceptual gap between customers and designers, to resolve the trade-offs among different levels of customer needs, and to achieve consensus among customer segments.

References

Selecting Electronic Health Record Systems: Development of a Framework for Testing Candidate Systems

Andre W. KUSHNIRUK a,1, Elizabeth M. BORYCKI a, Kristin MYERS b and Joseph KANNRY b

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b Mount Sinai Medical Center, New York, NY, USA

Abstract. The process of selecting electronic health record systems is one of the most critical decisions in the journey towards automating and improving healthcare using information technology. However, there are a wide variety of problems associated with system selection and procurement processes in healthcare. Indeed the literature contains numerous examples of systems that were purchased and customized that failed to meet user needs, were implemented well behind schedule, which cost much more than expected and which in some cases failed completely. In this paper we describe a framework which we have developed and have begun to apply in considering key processes in the selection of electronic health records – i.e. the testing of potential candidate systems to determine if they meet user and institutional needs. The objective of our work is to improve our understanding of and the effectiveness of this critical decision making aspect of health informatics. In our work we consider system selection in terms of strength of evidence obtained from testing candidate systems.

Keywords. electronic health records, electronic medical records, procurement, system selection

Introduction

Selection of a system, such as a hospital-wide electronic medical record system (EMR), represents a critical decision for any organization. However, despite the large costs involved in procurement, decision makers are often only allowed limited access to candidate systems prior to system purchase. In this paper we first describe a framework for considering system selection approaches based on the ability of those making purchasing decisions to actually interact with and carefully analyze candidate systems. We then describe a case study of procurement that was based on both evidence-based analysis of literature and on use of realistic scenarios for testing candidate systems before purchase.
1. The Framework

The framework we propose in this paper for procurement considers possible system selection methods in terms of the “fidelity” of the testing of the candidate vendor systems. The continuum ranges from “low fidelity” testing (simply involving a demonstration by the vendor to the selection committee) to “high fidelity” testing (involving simulation based analyses of the usability and impact of the system on hospital workflow within realistic or real settings prior to selection). In addition, application of realistic clinical information processing scenarios (CLIPS) designed to more fully test systems [1] is considered in the context of where and how such scenarios are presented when testing candidate systems. Based on analysis of the literature and our experiences in advising healthcare organizations in use of new approaches such as usability testing and use of low-cost methods for testing candidate health record systems in situ, the continuum in Figure 1 was arrived at. Figure 1 can be used to place current (as well as future) methods on a continuum from low to high fidelity testing. It should be noted that most current procurement processes can be located on the left hand side of the continuum shown below with few examples of high fidelity testing of vendor products reported.

2. Case Study: Procurement of a EMR at a Large Institution Using Scenario-based Testing

Dr. Kannry, in a previously cited case study identified a unique challenge in health information technology (HIT) procurement which is how to obtain user input in the procurement process [1,2]. Careful involvement of users during selection as well as implementation is critical and can be the difference between failure and success [3-5]. Yet, clinical users frequently have no prior education, training, or experience on which to draw [1-3,6]. Users are frequently called upon to attend demonstrations as part of the selection process [5] and asked to map the functionality demonstrated to their daily clinical needs. Many vendors prefer to demonstrate functionality and play to existing strengths while at the same time shying way from weaknesses [7,8]. It is Kannry’s opinion that the workflow shown may not reflect that of the selection site as much as it may reflect the workflow of the site at which the vendor developed the system.

![Figure 1. A continuum of system testing approaches during procurement.](image-url)
Vendor demonstrations are determined by the script, if any, that an institution supplies to the vendor. Much like a film or television show the script will determine what is shown and in what order. The approach taken at Mount Sinai Medical Center was to employ workflow based scripting as opposed to functionality based scripting [1]. Workflow based scripting follows the clinical provider through typical patient care scenarios whereas functionality based scripting asks to see if the system can do x and y and tries to follow a checklist organized by section. A workflow based approach to scripting has been shown to more accurately represent users’ preferences [9,10].

Extensive scripts were created by Kannry, who was both a selection team member as well as a practicing physician, and subsequently reviewed by multiple specialties. The focus of the scripting was on primary care since the largest number of visits in the hospital based practices were in primary care. The scripts also emphasized the numerous handoffs that especially occur in an academic setting. The script as well as the evaluation form required 6 scenarios and 4 optional scenarios, which were used depending on audience composition. For example, the cardiology-specific scenario was only used when Cardiology attended demonstrations. The Sinai selection team then derived questions from the scripted clinical scenarios for an evaluation form and showed early versions of the evaluation form to potential attendees to determine if the evaluation form could be realistically completed in terms of time as well as the length of the form.

One of the challenges of this approach was leaving out core product functionality that needed to be evaluated. For example, most users would not describe logging on as part of their daily patient care workflow but logging on is core product functionality. After organizing and grouping clinical scenarios along with their related questions, we mapped the questions to core product functionality to determine if any major areas of functionality had been neglected in the clinical scripting. This mapping approach had been tested and validated and found to be an effective evaluation tool for structuring clinician participation in system selection [9,10].

Every demonstration of candidate systems at Mount Sinai Medical Center was monitored to ensure that vendors followed the script and represented functionality that was live at an existing site. At the end of each scenario users were encouraged to grade each scenario on an evaluation form. The demonstration evaluation form was designed to carefully follow the scripted workflow scenarios and result in an evaluation of the scripted demonstration. On the evaluation form, each clinical scenario was organized into sections and clinical users were not forced to deal with mysterious section headers that used IT terminology such as “interfaces, screen design, security layer, etc.” Scenario sections were labeled to reflect workflow and employed headings such as “physician begins patient care, physician sees new patients, physician sees patient”. Users were encouraged to provide additional comments. When the scoring was completed the earlier mapping of core functionality to workflow was used to analyze the user responses along core functionality lines as well as in terms of workflow. For example, the scores could be analyzed in terms of how users graded the workflow “View list of previous notes from multiple specialties/providers” and alternately in terms of core functionality such as “Data Retrieval and Clinical Documentation.”

Comments and repeated themes that each user wrote on the evaluation form were compiled and analyzed. User comments helped the selection team at Sinai to incorporate a more subjective component of user evaluation as well as ensure that the scores were correctly representing user sentiment. Finally, follow-up interviews and focus groups were also held to confirm the selection team’s findings.
3. Conclusions

The case study described above describes an approach to testing of candidate systems that involves CLIPS and careful testing of systems regarding their match to organizational workflow. The approach extends Kannry’s framework [1] which proposes “evidence-based” system selection to include consideration of level of hands-on testing of candidate systems to predict to how well a system responds to test scenarios (along a continuum from low to high fidelity). Current work to extend this even further has involved the proposed use of usability testing methods [11] to allow for a higher level of testing fidelity than currently undertaken. Usability testing applied during the procurement process would involve installation of demonstration systems on site at an organization and observational analysis of representative users interacting with the system in testing. This would allow, for example, systems to be tested in situ by the selection team (rather than demonstrated by the vendor). Along these lines, Lincoln [12] has argued that CLIPS ideally should not be a prearranged set of questions given in advance to potential vendors. This is to ensure that the vendor does not modify the demonstration system to look as though it contains the desired functionality. In order to improve the chances of successful implementation, we are using the framework described in this paper to analyze system testing in procurement and to assist in the development of new selection processes for use by hospitals, health authorities and regions.

References

Getting to 100%: A Framework to Define and Reach Target Order Entry Rates

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Abstract. Following a detailed review of orders entered into a clinical information system, we propose a framework to define computerized physician order entry types and a more useful formula for calculating order entry rate.

Keywords. order entry, clinical decision support, hospital information systems, CPOE

Introduction

Decision Support and Clinical Content

Intelligently designed clinical information systems (CISs) using Order Entry (OE) and clinical decision support (CDS) have been demonstrated to improve quality of care [1]. CDS is achieved through many functions of a CIS which include: the display of patient data in a manner that eases comprehension through trending, graphic and context-sensitive display; automatic calculations; providing links to clinical knowledge bases; and by giving users the ability to organize data by sorting and filtering.

In addition, modern CISs use CDS at the point of ordering in which the submission of an order is, essentially, a structured description of a clinical decision. This more active form of CDS includes: structuring orders to help clinicians remember important order elements; presenting data relevant to the decision; and order sets which focus the clinician on the most important orders, helping avoid omissions, to make ordering more efficient, reduce practice variation and leverages known guidelines and best practices. Also during OE, alerts may be presented to the clinician regarding dangerous events such as drug-lab or drug-drug interactions. These design features can be considered the “clinical content” of the CIS. Most of the evidence attributes the increases in safety and quality of care and improved efficiency and utilization (hence cost) to the this active or OE-related CDS [1].

Direct Versus Indirect Order Entry

All OE-related CDS is believed to be most effective when the clinicians responsible for the decision enter the relevant orders directly, a process called Direct OE, using networked electronic devices where these clinicians immediately interact with the structured orders, order sets and alerts. In contrast, Indirect Order Entry (IOE) is a
process in which one provider relays orders to another (verbally, by telephone or handwriting) who then enters orders into a computer. It is thought that this 2-step, 2-actor process reduces CDS effectiveness by shielding the decision-making clinician from CDS. Our conceptual equation to express this is:

\[
\text{CIS Value} = (\text{Clinical Content}) \times (\text{Direct Usage}) \tag{1}
\]

Here Direct Usage refers to use of the CIS by the primary decision maker for each decision, though in practice, it refers more narrowly to Direct OE. In addition, of course, IOE also carries the additional risk of misinterpretation of the decision-maker’s intent by the person entering the order.

In some organizations, orders are a form of communication used only by physicians. Elsewhere, other providers (e.g., nurses, respiratory technologists) can enter orders independently of a physician, which we term Nurse OE (NOE). For purposes of this paper, we have chosen to use the common term for Direct OE: Computerized Physician Order Entry (CPOE). Hence, the total number of orders (TOE) can be stated as:

\[
\text{TOE} = \text{CPOE (number of orders entered by CPOE)} + \text{IOE (number of orders entered by IOE)} + \text{NOE (number of orders entered by NOE)} \tag{2}
\]

**CPOE Rate**

To achieve the greatest impact from active CDS then, organizations are encouraged to maximize CPOE Rate. Organizations typically measure this rate as the proportion of all orders entered by CPOE:

\[
\text{CPOE Rate} = \frac{\text{CPOE}}{\text{CPOE} + \text{IOE}} \tag{3}
\]

CPOE Rate is typically expressed as a percentage [2]. Typical CPOE Rates described in the OE literature is a single number representing all physicians and all orders without mention of setting (e.g., inpatient or ambulatory) or exactly who is defined as a provider who has CPOE “privileges.” In some organizations with many resident physicians, the CPOE Rate reflects almost entirely orders by these residents who are by policy, documented or understood, required to enter orders directly, while in others, orders entered by physician assistants are counted as CPOE. Many organizations track these rates internally over time, by individual clinician and clinically relevant groups and stratified by kind of order (e.g., orders for lab tests, for intravenous content and rate, for medication administration). Measuring CPOE Rates has several benefits which are that it identifies:

1. unmet needs whether due to design flaws, needed order sets, inadequate workflow support, mediocre training or deficient policies,
2. individuals or groups who are struggling so that solutions can be tailored to their particular needs,
3. individuals or groups who are prodigious CPOE users who can be encouraged to forward ideas for future development, and
4. organizations that believe that quality of care is supported by CPOE, the gap between current and target CPOE Rates.

This paper will focus on some of the challenges in measuring CPOE Rates and understanding the results in order to effect an increase. Clarity around measurement helps avoid misunderstanding the implications of measurement and trends and allows more informed corrective action. One should not assume, however, that raising CPOE Rates will always be beneficial. Though beyond the scope of this paper, it should be kept in mind that there remains a need for impact assessment because CIS implementations may result in unintended negative consequences [3]. Hence, organizations should measure direct impact of CIS, whether via CPOE or IOE, on process and clinical outcome. Nonetheless, as a process measure, CPOE Rate helps to define opportunities for improvement. Given the many influences on CPOE Rate (policy, physician contracts, definition of who is a physician, individual or group variability, specific sets of orders related to safety and quality), benchmarking across organizations is fraught with difficulty. There may therefore be value in either standardizing CPOE rate calculations or describing them to allow comparison.

Many organizations must struggle to achieve high CPOE Rates because physicians may be reluctant to make the substantial effort to adapt to a way ordering that is new to them or because the system is, or is perceived to be, a barrier to care or a burden to the physician. The challenge is expected to be greater in circumstances where physicians are in private practice and not influenced by a contract that includes an expectation for high CPOE Rates, whereas achieving high CPOE Rates will be easier where most orders are placed independently by those other that staff physicians, usually residents or physician assistants.

The meaning of CPOE Rate is dependent on the precise definition of an order e.g., when ordering a Complete Blood Count (CBC) that has thirty components, is this one order or thirty; when ordering a CBC daily for a week is this one order or seven; when a nurse enters an order for a formally adopted protocol on behalf of a physician, is this a nursing order or an IOE order? In the latter example, it seems to make no sense to change the protocol order to one a physician has to initiate each time to move the order attribution from IOE to CPOE just to make the CPOE rate higher. From the perspective of care quality, it may be more important to ensure a high CPOE Rate for medication orders where risks are high and CDS impact potentially greater than for simple lab tests. The purpose of this paper is to describe IOE subsets based on a review of actual OE by a sample of physicians to shed light on how CPOE Rate calculations may be influenced by different kinds of IOE and to suggest a more standardized CPOE Rate calculation and comment on how understanding these rates might be influence their use.

1. Setting

Our Region implemented a Patient Care Information System (PCIS) in 2006/7 at a time when we were responsible for the health of 1.5 million people and had a budget of Can$ 2.3 Billion. The system was a single instance of a commercial product for use at three urban acute care sites totaling 2000 beds and used by 2000 physicians. Order entry is comprehensive, that is all orders are entered through PCIS and include medication, fluid management, admission/discharge/transfer of care, consultation, nursing care, lab, imaging, neurodiagnostics, cardiodiagnostics, and nutrition. PCIS
CDS includes 1,600 order sets. The number of orders entered daily is roughly twenty thousand or approximately ten orders/day/inpatient.

Our Medical Advisory Board approved a policy requiring, within 18 months of implementation, that all physicians place all orders directly. Exceptions could include circumstances where clinical care of another patient took precedence (e.g., sudden clinical deterioration, surgeon in operating room) or when the system was unavailable (e.g., physician in a car or at a site away from system access). CPOE Rates over the eighteen months since activation until now have been stable and high but under 100%: 75% for staff physicians and 90% for residents. Residents account for approximately 2/3 of all CPOE orders. We have no physician assistants.

In our Region, we have a set of orders that nurses and allied health personnel can place independently of physicians. Since these are neither CPOE or IOE orders, they excluded from the CPOE Rate. These orders comprise approximately 4% of all orders. When providers enter orders on behalf of a physician (i.e., IOE), they are required to select one from a list of five reasons:
1. Per previous physician order (in the CIS)
2. Per policy/protocol
3. Written order
4. Verbal order
5. Telephone order

2. Methodology

2.1. Initial Framework Design

A small group of clinical informatics physicians who, with other informaticians, led the OE design, proposed an OE framework of reasons for IOE based on their involvement with order entry on a past system, leading the design of the new PCIS and 18 months personal experience entering, reviewing and managing their own orders and those of colleagues whom they helped during stints as superusers.

2.2. Order Review Process

Following the agreement by individuals from this group of clinical informatics physicians, orders placed by them (CPOE and IOE) were reviewed by one of the authors on several days during a one month period in 2008. These physicians were not blinded to the time frame of review and were not told which patient orders were examined. Review was done by scanning all orders in PCIS on a convenience sample of patients, using the “front-end” of the CIS rather than from data extracted from the underlying CIS database. This approach was chosen to reduce the chance for errors in data manipulation or database queries. Orders placed by other physicians on the same patients during this time interval were ignored.

CPOE orders were documented as such. IOE orders were examined for reasons why CPOE was not used as noted by the provider entering. Where the reason was unclear, the reviewer validated these reasons with the ordering physician, usually within 24 hours of order entry. Patient and provider identifying data was stripped from the final data set. Data captured per order was:
1. physician name (removed from final data set),
2. patient name ID number (removed from final data set),
3. date and time of order,
4. order category: admission/discharge/transfer, medication, lab, diagnostic imaging, cardiovascular test, nursing, consult, clinical communication, intravenous, transfusion medicine nutrition,
5. brief details for some order categories (e.g., name of drug for medication orders) to help ordering physician remember the order when discussed by reviewer,
6. role of provider entering order (physician, nurse, respiratory tech, pharmacist, licensed nursing practitioner, unit clerk), and
7. reason selected by the enterer of IOE orders.

3. Results

An overview of inpatient orders reviewed is shown in Table 1. The five physicians were one each of hospitalist, family physician, internist, obstetrician and orthopod. Summing over the reviewed individual orders, the contribution of each reason in the OE framework to the total IOE number was calculated (see Table 2).

The high rate of CPOE (81%) was not surprising given the physician population studied. Unexpected were orders entered by a performing department and attributed to a physician. These resulted from the need for the performing department to make changes in the original order, for example to change an order for two views of the chest to one for one view because the patient was too unwell for a lateral view. The need to enter previously entered orders is often to make minor alterations such as to the time schedule of medication administration. This is often necessary in the transition from Emergency Department to ward.

<table>
<thead>
<tr>
<th>Table 1. Overview of orders reviewed.</th>
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<tbody>
<tr>
<td>Number</td>
</tr>
<tr>
<td>Physicians</td>
</tr>
<tr>
<td>Patients</td>
</tr>
<tr>
<td>Orders</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Proportion of IOE reasons for each of the reasons in the OE framework.</th>
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<tbody>
<tr>
<td>%</td>
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<tr>
<td>Entered by non-physician provider</td>
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<tr>
<td>Telephone</td>
</tr>
<tr>
<td>Verbal</td>
</tr>
<tr>
<td>Written</td>
</tr>
<tr>
<td>Previous order</td>
</tr>
<tr>
<td>Protocol</td>
</tr>
<tr>
<td>Entered by performing department</td>
</tr>
<tr>
<td>Lab</td>
</tr>
<tr>
<td>DI</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>CPOE</td>
</tr>
</tbody>
</table>
This suggests a more sensible grouping of OE from two (CPOE and IOE) to three: CPOE, IOE\textsubscript{revised} and “Standard OE” (SOE) in which SOE relates to protocol orders, re- orders of previously entered orders and performing department orders. On reflection, SOE orders are, in a way, pre-approved by the ordering physician and would not be expected to have the negative impact on care that IOE may have. The formula for CPOE Rate remains the same (Eq. 3) but IOE\textsubscript{revised} no longer includes the SOE orders. Such a change would look like Table 3. Using Eq. 5, CPOE Rate = 90%. By assigning orders more appropriately, the CPOE rate has risen from 81% to 90% which we believe is a more accurate measure of physician commitment to CPOE and predictor of CPOE impact on the quality of care.

\begin{equation}
\text{TOE} = \text{CPOE} + \text{IOE}_{\text{revised}} + \text{SOE} + \text{NOE}
\end{equation}

\begin{equation}
\text{CPOE Rate} = \text{CPOE} + (\text{CPOE} + \text{IOE}_{\text{revised}})
\end{equation}

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<tr>
<th></th>
<th>%</th>
<th>%</th>
<th>%</th>
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<tbody>
<tr>
<td>IOE</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Entered by Non-physician provider</td>
<td>Telephone</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Written</td>
<td>2</td>
</tr>
<tr>
<td>SOE</td>
<td></td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Previous order</td>
<td>Protocol</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lab</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DI</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Entered by performing department</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CPOE</td>
<td>81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion

The results of the analysis of IOE suggests that IOE is not a homogeneous set of processes and that it may be inappropriate to shift some IOE towards CPOE. Also, it appears that the definition of IOE can significantly affect the CPOE Rate and, therefore, each organization would benefit from understanding this relationship in order to interpret its CPOE Rate.

Let us consider organizations that have a similar physician commitment to CPOE. Those organizations that include OE from performing departments in IOE numbers, or that consider routine re-ordering of previously entered CPOE orders or protocol orders will have higher IOE and therefore worse CPOE Rates. Similarly, those that allow independent OE by nurses and allied health personnel will likely have higher CPOE rates than those who require all orders to be attributed to physicians.

Clarity of order and IOE definition is important for both inter-organizational benchmarking and for understanding the implications of CPOE Rates within it. That is, if an organization counts DI order changes as IOE then those departments with high volume DI orders, say internal medicine, will have lower CPOE Rates than those who rarely use DI, say psychiatry, yet both may benefit equally from using CPOE. If the
original definition of IOE is used, which includes SOE orders, the number of SOE orders places an upper limit on CPOE Rates so that 100% can never be achieved. Alternatively, if CPOE Rate is calculated using IOE\textsubscript{revised}, then CPOE Rates can more closely approach 100%. The “last mile”, the amount CPOE Rate is below 100% should not be looked at as an ultimate goal. First, no one wants physicians to stop urgent care of one patient to enter orders on another nor should we expect surgeons to break sterile technique to touch a keyboard and mouse for OE. Instead, organizations should work with their care quality departments to evaluate process or clinical outcomes to evaluate whether IOE\textsubscript{revised} orders have any negative impact. Then if CPOE Rates can be associated with improved quality, there is a more compelling argument to explore ways to increase this rate. It is likely that CPOE for medication would have a greater impact on quality of care than lab CPOE, whereas high rates of lab CPOE may be expected to improve lab utilization. On the other hand, the reality of unintended consequences makes critical the actual measurement of both CPOE Rate and its impact. One challenge is to focus on clinical areas where such analysis is likely to be gainful.

SOE can be addressed in straightforward ways. There may be good reasons that orders from performing departments should be attributed to the physician whose order is being altered. But these orders should be left out of the CPOE Rate calculation. Dealing with these orders is easy for calculation because they are identified by the CIS in an objective manner. Previous orders re-entered and orders arising from protocols should not figure into CPOE Rates, but, in contrast, the validity of measures of such orders may be highly dependent on human judgment. For example, in our institution, when an order is said to be by protocol, that choice reflects only the judgment of the nurse entering the order. Choices of when to re-enter a previous order or, for example, change a medication schedule with other CIS tools, relies on judgment. We are working on mechanisms to reduce the need to re-enter previous orders both to the reduce risk of error and to reduce unnecessary workload. There is a case to be made for shifting all protocol orders entered on behalf of a physician to ones that can be entered independently by nurse and allied health staff.

Evaluating root causes of IOE\textsubscript{revised} is more difficult if one depends only on data in the CIS. It is impossible to distinguish verbal or telephone orders given for appropriate reasons (e.g., urgent clinical problems interfere with CPOE) from those given by physicians who are not committed to CPOE. Separating these reasons from each other requires real-time examination which is rarely practical. Similarly, orders written because the system is down are difficult to distinguish from ones written by physicians not committed to CPOE unless the system captures the time the order was written (historically, orders were rarely time stamped by physicians in the past when we used paper ordering process) and down-time periods are available to the CIS database (usually not captured there because downtime may be caused for non-CIS reasons). On the other hand, organizational workflows and CIS scope may have a well understood impact on IOE\textsubscript{revised}. For example, in our Region, many elective surgical peri-operative orders are specified in the physician office because they cannot enter orders into PCIS until the patient is registered. This dramatically increases written IOE\textsubscript{revised}.

Likely causes of IOE\textsubscript{revised} are shown in Table 4. Each can be addressed by a corrective action to reduce IOE\textsubscript{revised} though not necessarily to zero. Reducing system downtime is straightforward but may be limited by technical challenges or costs. Many CISs can be made more available (and more easily so) through web-based portals but adequate security must be ensured. To fully address access, the system must also be able to manage situations where the patient is not yet registered formally (as when seen
in pre-admission clinics or when a team is awaiting arrival of a patient with known needs in the Emergency Department). The impact of urgent clinical distractions may be minimized by making CPOE maximally efficient. Finally, this framework does not take into account one other cause of IOE\textsubscript{revised}, the attribution of an order to the wrong physician. This leaves the total organizational IOE\textsubscript{revised} unchanged but may overly penalize some physicians whose names are more often in a nurse’s mind or whose names appear earlier in drop-down lists from which they choose.

### Table 4. Causes of IOE\textsubscript{revised}

<table>
<thead>
<tr>
<th>Telephone</th>
<th>System down</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>System unavailable (e.g., physician in car, at home without computer or network, patient not registered)</td>
</tr>
<tr>
<td></td>
<td>Physician not committed to CPOE</td>
</tr>
<tr>
<td>Verbal</td>
<td>Urgent distraction</td>
</tr>
<tr>
<td></td>
<td>Physician not committed to CPOE</td>
</tr>
<tr>
<td>Written</td>
<td>System down</td>
</tr>
<tr>
<td></td>
<td>System unavailable</td>
</tr>
<tr>
<td></td>
<td>Physician not committed to CPOE</td>
</tr>
<tr>
<td></td>
<td>System unavailable</td>
</tr>
</tbody>
</table>

Many factors may reduce physician commitment to CPOE. Some are very challenging such as when a physician rarely works in the institution or if the physician has a disability interfering with computer use. Although some believe that many physicians resist new technology, this is not at all true of technologies other than information systems, leading one to suspect that unwillingness to use a CIS is often because the CIS is clumsy or not suited to the practice patterns of the physician or because they believe, sometimes quite justifiably, that the system does not contribute to quality of care. In our experience, engaging these physicians or groups who lag behind allows identification of solutions.

Given that achieving 100% CPOE is impossible, organizations should consider focusing on higher CPOE Rates for those orders for which CPOE is most likely to improve safety and quality. These are probably medication and intravenous orders.

When designing a CIS, those responsible should bear in mind the need to measure CPOE Rates and the known elements of a CIS that allows a useful analysis which include:

1. a database of orders that allows separation of CPOE from various forms of NOE, SOE and IOE\textsubscript{revised},
2. orders that can be tracked by individual, and can be rolled up to by groups of interest,
3. contextual information on order date and time, reasons for IOE\textsubscript{revised},
4. whether performing the analysis by direct order review or from a database report, there must be clarity around how CPOE Rate is measured and,
5. Access to information beyond data on individual orders may help e.g., downtime, other reasons for inaccessible CIS, when an order was written or spoken, physician physical location and whether there were distracting urgent events. Whether this level of detail is of value, given that much of it is not easy to acquire or integrate, will depend on the importance attached to wringing the most out of CPOE Rate.
There were a number of limitations to our study. The physicians whose orders were analyzed were a unique group and not representative of the broader population of staff physicians but they are members of the largest clinical departments in our organization. They are interested in the PCIS and committed to CPOE to a much higher degree than most other physicians. Nor were they blinded to the time or intent of this study. So although we would expect that the proportions of IOE may be very different for the broader community, we believe that the orders reviewed were sufficiently varied to validate the framework. However, at least one kind of IOE that the process did not identify was raised during discussions with one of the authors who had reviewed a set of his own orders and found that 5% were orders incorrectly attributed to him rather than to a different physician. This circumstance has been observed in other parts of PCIS when one physician appears at the top of a selectable list or is just on service more often than his or her colleagues and so their name is at the top of the minds of nurses who are not alerted to the legal or other implications. The number of physicians and orders was relatively small compared to the total number of orders in one month in our Region. The order reviewer was not blinded to the ordering physician and made a number of assumptions regarding some IOE based on his own knowledge of the order and context. We believe that this unduly influenced the application of the framework.

The methodology employed in this study is not suited to repeated analysis of large volumes of orders. For such work, a validated extract from the database of entered orders would be better. First, organizations must develop policies regarding who can have access to individual orders and composite data about individuals and how these can be used for quality improvement purposes. Then organizations must decide how such information should be shared with individuals or leaders in order to achieve CPOE targets. In most cases when physicians appear not to be sufficiently committed to CPOE, it is critical to engage with them to understand their reasons because knowing this will help guide corrective changes in the CIS or the process of care.

Whether this framework is generalizable and how other organizations would need to examine local OE practice to ensure an accurate picture of their CPOE Rate will require further study involving a larger number of sites, preferably with varying sizes, academic leanings, inter-professional care responsibilities and different CISs.

References

Evolution of a National Approach to Evaluating the Benefits of the Electronic Health Record

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Abstract. Demonstrating the value of eHealth investments to users and other stakeholders, and driving ongoing optimization of benefits are increasingly important components of eHealth implementations in Canada. For these reasons, Canada Health Infoway is working with provincial partners to make research and evaluation an important component in Electronic Health Record (EHR) investments. Leading provinces working with Infoway, including British Columbia, the Province of Quebec, and Newfoundland and Labrador, are making evaluation a central part of their eHealth strategies and using evaluation results to optimize the benefits of investments. We provide an overview of benefits evaluation strategies and lessons learned. Examples of early evaluations completed and those currently underway provide insights into the challenges and benefits of investments in EHR.

Keywords. EHR, benefits evaluation, indicators, eHealth, Canada Health Infoway

Introduction

In 2006, Infoway developed a Benefits Evaluation (BE) Strategy and Framework. The approach aims to demonstrate the benefits of Infoway’s investments to support continued funding for the Electronic Health Record. The intent of this approach is to also drive adoption and to inform improvement of existing and future investments.

With the support of a panel of Canadian and international experts in eHealth evaluation, the BE Framework (Figure 1) and a set of 27 indicators were developed for the purpose of assessing the impact of Infoway’s investments in Electronic Health Record Solutions (EHRS) on healthcare quality, access, and productivity. These indicators contained in the Infoway BE Indicators Technical Report are freely available on the Infoway website, to encourage application and evolution of the work beyond Infoway.

The BE Strategy includes a program specific approach for six of the investment programs (Diagnostic Imaging, Drug Information Systems, Laboratory Information Systems, Interoperable Electronic Health Records, Public Health and Telehealth) with indicators, methodologies and sampling recommendations which provide thought-leadership and an opportunity for a coordinated approach to BE.
The BE Framework recommends a standardized survey tool be applied to projects. This will provide an early assessment of the effectiveness of the system and end-user adoption, address issues, and share early successes. BE approaches for specialized projects are also developed using the BE Framework. The base survey tool is also freely available, to encourage application of the BE Framework.

Prior to the development of Infoway’s BE Strategy, sound evaluation approaches had not been commonly included in eHealth projects in Canada or abroad. There was, however, growing recognition that evaluation was critical to long-term success. Through an intensive engagement campaign, including meetings with jurisdictional eHealth leadership, presenting and publishing widely, and socialization within the research community, Infoway’s BE Strategy has widely been accepted as a leading approach to evaluating eHealth investments. The BE Plan is now frequently referenced and used as a basis for evaluation within and beyond Infoway’s investments.

1. Implementation of the BE Strategy

Infoway works for provincial partners across the country to select a sub-set of projects for evaluation. Infoway’s strategic investor model is also applied to evaluation; with the Infoway BE Framework and plan establishing the parameters for BE projects which are executed by the jurisdictions.

2. Challenges and the Evolution of the Benefits Evaluation Approach

Advancing evaluation on the agenda for Canadian EHRS projects has not been without challenges. While many recognize the value of evaluation and the importance for better understanding the impacts of EHRS, not all share the same enthusiasm for the actual
evaluation process. Often competing priorities for resources and time, particularly for provincial partners that are primarily focused on the implementation of the systems, can be a deterrent for evaluation interests. Part of Infoway’s initial challenge was selling the importance of evaluation and the perspective that a practical approach was possible. Since evaluation has not traditionally been part of the scope for many eHealth projects, governance for evaluation needs to go beyond the traditional project teams to ensure broad commitment to the benefits a clear mandate to look at long-term outcomes. A notable exception, Newfoundland and Labrador, has had a dedicated Research and Evaluation department for a number of years, which has gained extensive practical experience in the evaluation of eHealth.

The need for effective adoption and benefits-realization extends beyond individual projects. Benefits evaluation in many provinces provides an opportunity to align stakeholders around the intended benefits that can be achieved through the use of eHealth technology. In some cases evaluation provides the impetus to rigorously review assumptions and conditions to achieve the intended benefits of the project plans. The use of results chains in a number of provinces and similar tools and processes in some others, is a positive sign. Activities such as change management, risk management and ideally true “benefits realization” approaches, do need to be better integrated. Quebec is a leading example of EHR evaluation. The Quebec Health Record (QHR) has developed a model, using the Results Chain technique (Figure 2) to link benefits with several eHealth investments areas.

Figure 2. Quebec Health Record Results Chain.

Consistently, research capacity and data availability is a popular topic among academics and evaluators. Effective evaluation requires bringing together the right partners and expertise to conduct the evaluation. The academic community has the skill
set and resources to play a major role in this work, but, with some exceptions, has not been well aligned to the business requirements of the eHealth offices. Building a common understanding of the objectives of evaluation in this context has been an important step.

Since Infoway began work in evaluation, significant progress in evaluation of EHRS has been made across Canada. Increasingly there is strong buy-in and leadership in many provinces. An interest in taking a more outcomes focused approach to projects is emerging. Most promising is greater engagement of stakeholders across the health system and alignment to provincial goals for health system transformation progress.

3. Examples of Benefit Evaluation Results

Below are some evaluation results from Infoway sponsored projects which are demonstrating how EHRS are leading the way to change, and the benefits of Infoway investments across Canada.

3.1. Pan-Canadian Aggregated Diagnostic Imaging Project

This project assessed the pan-Canadian aggregated benefits of implemented Diagnostic Imaging (DI) Systems. The Infoway DI program is focused on investing in implementations of digital storage of diagnostic images to permit clinicians to access and view images regardless of where they are located or where the test was conducted.

Results from the evaluation project found that Diagnostic Imaging Systems:

- Resulted in a 30-40% improvement in turn-around times (the process time from patient check-in or registration in Diagnostic Imaging to when the report is available on the system to the referring physician). This improvement means that clinical decisions, and subsequent treatment of patients, can now occur sooner thus reducing patient wait times and patient lengths of stays
- Improves remote reporting enabling 30-40% of Canadian radiologists to support care delivery and improve access for remote geographies and populations
- Improves the productivity of radiologists. The 25-30% improvement in productivity is estimated to result in the equivalent of 450-540 radiologists delivering 9-11 million exams annually
- Saved an estimated $42 million by participating in a coordinated procurement process

3.2. EMRxtra – Chronic Disease Management Project

This project in Sault Ste. Marie, Ontario involved the creation of an interface that allows pharmacists to access lab test results, allergies and other vital data from the electronic medical records of consenting patients.

Positive results gathered from the project’s evaluation included:

- The identification of 94% more drug-related problems
- A 97% increase in pharmacist-primary cared provider activities
- A 246% increase in medication management recommendations made by pharmacists to primary care physicians.
3.3. *Ontario Drug Profile Viewer*

The Drug Programs Branch of the Ministry of Health & Long Term Care (MOHLTC) developed a Drug Profile Viewer (DPV) System for implementation in emergency departments (EDs) in 177 Ontario hospitals. A DPV is a web-based application that health care providers access via workstations in the hospital. It provides healthcare providers with secure, quick and easy access to the drug history of Ontario Drug Benefit patients.

The project was evaluated shortly after its implementation and the early results supported the adoption process and facilitated continuous improvement of the application.

The results from surveys administered to Drug Profile Viewer users found that:
- Nearly two-thirds of health care providers agreed the DPV report helped identify potential adverse drugs events.
- About three-quarters of health care providers agreed that the DPV helps streamline therapy, prevent duplication, ensure patients’ medication continues upon admission and promotes patient safety.
- More than half of health care providers thought it shortened assessment time which allows for faster diagnosis.

3.4. *Patient Safety Learning System*

The Patient Safety Learning System is a British-Columbia province wide web-based reporting and learning system used by health care providers in acute care settings to support identification, investigation, and analysis of all safety and risk-related incidents. The system also captures and facilitates responses to client feedback and enables claims management.

The evaluation demonstrated that the project is having a positive impact on culture of patient safety as:
- In the neonatal intensive care unit (NICU) pilot, there was a 158% increase in the number of reports submitted.
- The number of non-registered nurses reports increased to 26% from 8%, indicating a greater diversity of those reporting.
- 84% of reports (up from 2%) were submitted within 48 hrs and the average time to notify Quality, Safety and Risk Management dropped from 25 days to only one day.

4. Conclusion

Evaluation is recognized as an important tool for demonstrating the impact EHR technologies have on our health care system, the way clinicians operate and the changes in patients’ experiences. What we learn through evaluation can assist in spawning innovation for future improvements and advancements in our system. While conducting evaluations on EHRs is not without challenges, the Infoway Benefits and Evaluation Framework and Strategy has assisted in providing a path for Infoway investment projects and other EHR projects to follow and use. As interest and investments in EHRs increases in Canada, we also anticipate the methods and
indicators we use to measure will continue to evolve. The increasing interest in evaluation as a core component of eHealth implementations provides an excellent opportunity for increased partnership between the research community and jurisdictional EHR initiatives. Infoway will continue to foster this growth and development in evaluation for the benefit of the future of EHRs technological development and integration in Canada.
Physicians are not a Homogenous Group

Mitra SAJEDI and Andre W. KUSHNIRUK
School of Health Information Science, University of Victoria, BC, Canada

Abstract. The issue of “Physicians' Adoption” is one of the big challenges facing wide-scale implementation of electronic health records (EHRs). An important question is why the number of physicians using EHRs in their practice has not reached the level expected. While this issue has been addressed widely in the literature, the term “physicians” is used generally to encompass a broad range of roles and responsibilities. Physicians are not a homogeneous group and, without a good understanding of the differences among physicians, it is not logical or feasible to come up with a universal blueprint devised to convince all physicians to accept an EHR implementation in their practices. First we discuss the barriers to implementing an EHR based on the characteristics of different types of physicians and then introduce an “Adoption Score” for physicians and provide a tool to measure the barriers. We discuss the importance of this scoring system and how similar methods can be helpful to assign an adoption score at an organizational level.

Keywords. EHR, physician adoption score

Introduction

Since the introduction of the concept of electronic health records in the 1980s and then with the “Computer Based Patient Record” in the report of the Institute of Medicine in the United States in 1991, many studies have evaluated the effect of implementing an Electronic Health Record (EHR) system on the quality of patient care. It has been agreed that “the universal adoption of EHR will bring with it many benefits including improvements in quality and the concomitant reduction in medical error rates, enhanced cost effectiveness, and greater consumer involvement in their health care decision making.” [1]. However, Burt et al suggested in their paper that fewer than 18% of physicians are actually using EHRs in their offices [2].

As the main end users of EHRs, physicians are the subject of many surveys investigating the major barriers to their adoption of EHRs [3,4]. Across various study designs, data collection methods, settings and target populations numerous barriers have been identified: financial, technical, training, cultural, communication [3,5-7] internal and external influences [8] work flow and time [4], privacy and safety [4]. At this point the question is not, “What are the barriers?” but “Are we dealing with all of these barriers in all settings?” and, within a setting, “Is the weight of each barrier the same for each physician?” Physicians are not a homogeneous group. When it comes to the adoption of EHRs, one would expect different reactions from a newly graduated radiologist working in a tertiary center versus a GP practicing in a small town who is nearing retirement. Likewise, a GP working as an ER doctor in a small town who
requires close communication with ER and ICU attendings at a tertiary centre to better manage his or her patients may be more motivated to accept a telehealth/health informatics implementation as compared to a pediatrician running a solo practice in a small town. Different characteristics such as age, specialty, practice setting and location, experience, past exposure to technology and environments all can influence the way a physician reacts to the implementation of EHR.

Yarbrough and Smith [9] in their systematic review of the literature on physician acceptance of information technology described studies using two popular methodologies to predict the adoption process such as Technology Acceptance Model, TAM, and Theory of Planned Behavior, TPB. Although they have been used successfully in other industries, they have not shown any promise in predicting the adoption process of physicians’ acceptance of new technologies.

1. Methods

Most of the studies looking at physicians’ adoption of EHR are descriptive in nature rather than quantitative. To compensate for this deficiency, we describe a novel quantitative method to determine physicians’ likelihood of adopting EHR using a “Physicians’ Adoption Score”. It can be used as a tool for designing a targeted approach plan when trying to introduce EHR in an organization.

We need to consider organizational factors, individual/personal factors and IT related factors when talking about physicians’ adoption to EHR: In order to create a scoring system we had to consider measurable “proxies” for some of the variables in each group. (some of the proxies will be representing more than one group). The factors are described in Table 1.

Table 2 provides measurement parameters for these factors. By calculating scores from each subgroup and finally adding the scores together we can come up with a number that will represent the adoption score of an individual physician. The higher the score, the smoother the transition towards EHR implementation will be.

2. Discussion

By using the method described in this paper, it makes sense that a young GP working in a government funded tertiary care hospital may be more willing to accept EHR implementation as compared to a pediatrician nearing retirement, working in a solo practice in a small town. By telling a local health care region manager that the average score of physicians in an area is 8/29, he will know that considerable work needs to be done in order to make EHR implementation acceptable. Subgroup scores can offer insight into whether the problem is more financial or if it is related to the aging population of physicians in a small town, the shortage of physicians, or to work flow issues.

The “Physicians’ Adoption Score” method is the first step towards introducing an “Organization Adoption Score” which could be determined by considering individual “Physicians’ Adoption Scores” along with those of other end users, like nurses and pharmacists, as well as the administrative characteristics of the organization. This work is ongoing.
The older the history of using IT/IS, and the more successful experiences in using them in a setting makes it easier to accept the concept of transition to the next step. Those physicians who are already using on-line scheduling and billing systems show less resistance to technology-related changes.

### Practice Settings

**Existent IT/IS**

The more developed a country is, the more people expect to see technology related changes in health care systems. Meeting patients' expectations can be a motivation in introducing EHR in practices.

**Pressure**

The effect of physicians' social networks cannot be ignored and it is more obvious in hospital-based practices as compared to office-based ones.

**Effect of Peer Pressure**

The more developed a country is, the more people expect to see technology related changes in health care systems. Meeting patients' expectations can be a motivation in introducing EHR in practices.

**Hospitals**

Working in an academic center is an important factor in physicians’ adoption score. There may already be some degree of IT/IS in place, fewer funding issues, more IT support and they may be connected with other academic centers already using EHR.

**Effect of Public Pressure**

The more developed a country is, the more people expect to see technology related changes in health care systems. Meeting patients’ expectations can be a motivation in introducing EHR in practices.

**Practice Location**

Because of funding, staff training and IT support issues, community-based physicians in small towns are more resistant towards accepting EHR implementation, but this is not often the case for physicians working in community hospitals in small towns, especially ER doctors and ICU physicians. Remote consultation with tertiary centre “intensivists” and ER “attendings” is the advantage that gives this group of physicians a powerful motivation towards accepting EHR and tele-health initiatives.

**Financial Resources**

When solo or small-group practice physicians are responsible for the cost of implementation and ongoing maintenance costs, a high level of uncertainty towards accepting EHRs is understandable. Different financial considerations exist in a GP’s private office or in a government-funded hospital. Initial and ongoing maintenance cost is a big issue that physicians do not have to deal with if they are working in a hospital.

**Financial Resources**

Physicians in solo and small-group practices are dealing with funding issues, staff training, management changes and ongoing technical support. The most resistance has been reported from this group of physicians. These issues are a part of the management and administration responsibilities in a hospital, and not that of individual physicians.

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**Type of Specialty**

The higher the level of technology-dependency in a specialty, the more likely physicians will be comfortable accepting technology related changes in their work places, e.g., radiology versus psychiatry.

**Personal exposure to information technology (IT)**

It is important to know how comfortable physicians are in working with computers and if they are using hand-held devices such as the Blackberry® in their day-to-day work. Place of medical education and training is another related factor, because different countries and even different medical schools in a particular country have different types and levels of technology available and in some cases the use of technology is mandatory for medical students and residents. Location of training can affect how comfortable and familiar a physician is accepting technology-related implementations.

**Level of Specialty**

We need to be clear if we are dealing with GPs, specialists, sub-specialists or a combination of them.

**Age**

Younger doctors are usually more comfortable with technology and generally are less resistant to change as compared to those who have been practicing medicine in for years or decades with an established practice pattern.

**Experience**

We need to be clear if we are dealing with resident physicians, the newly graduated, experienced MDs or those nearing retirement, or a combination of these. Studies have shown that residents and newly graduated physicians adopt change easily.

## Table 1. Factors affecting the adoption of an EHR system by physicians.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
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</tr>
<tr>
<td><strong>Level of Specialty</strong></td>
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</tr>
<tr>
<td><strong>Type of Specialty</strong></td>
<td>The higher the level of technology-dependency in a specialty, the more likely physicians will be comfortable accepting technology related changes in their work places, e.g., radiology versus psychiatry.</td>
</tr>
<tr>
<td><strong>Ratio of Patient/Provider in the Office/Hospital</strong></td>
<td>Knowing how busy an office/hospital is may help to understand why physicians in a specific setting are resistant to EHR implementation. If the shortage of physicians is already a problem in a hospital or in a busy office, EHR implementation can initially affect the work flow negatively and this issue should be acknowledged in advance.</td>
</tr>
<tr>
<td><strong>Financial Resources</strong></td>
<td>When solo or small-group practice physicians are responsible for the cost of implementation and ongoing maintenance costs, a high level of uncertainty towards accepting EHRs is understandable. Different financial considerations exist in a GP’s private office or in a government-funded hospital. Initial and ongoing maintenance cost is a big issue that physicians do not have to deal with if they are working in a hospital.</td>
</tr>
<tr>
<td><strong>Settings</strong></td>
<td>Physicians in solo and small-group practices are dealing with funding issues, staff training, management changes and ongoing technical support. The most resistance has been reported from this group of physicians. These issues are a part of the management and administration responsibilities in a hospital, and not that of individual physicians.</td>
</tr>
<tr>
<td><strong>Practice Location (Rural versus urban)</strong></td>
<td>Because of funding, staff training and IT support issues, community-based physicians in small towns are more resistant towards accepting EHR implementation, but this is not often the case for physicians working in community hospitals in small towns, especially ER doctors and ICU physicians. Remote consultation with tertiary centre “intensivists” and ER “attendings” is the advantage that gives this group of physicians a powerful motivation towards accepting EHR and tele-health initiatives.</td>
</tr>
<tr>
<td><strong>Academic/Teaching Hospitals</strong></td>
<td>Working in an academic center is an important factor in physicians’ adoption score. There may already be some degree of IT/IS in place, fewer funding issues, more IT support and they may be connected with other academic centers already using EHR.</td>
</tr>
<tr>
<td><strong>Effect of Peer Pressure</strong></td>
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</tr>
<tr>
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</tr>
<tr>
<td><strong>The Usability of Existent IT/IS in Practice Settings</strong></td>
<td>The older the history of using IT/IS, and the more successful experiences in using them in a setting makes it easier to accept the concept of transition to the next step. Those physicians who are already using on-line scheduling and billing systems show less resistance to technology-related changes.</td>
</tr>
</tbody>
</table>
The next step will be testing and validation of the method proposed in this paper. Testing can be done in two health regions; one with relatively long history of EHR implementation and the other at the early stages. The first part will be a retrospective descriptive study in the first region. By gathering demographic/historical data and calculating the scores retrospectively and by looking at the process of implementation, we can evaluate the capacity of our scoring system for predicting physician response to EHR implementation. The second part is a prospective cohort study in region two, with more controlled criteria in place from the beginning to decrease the potential limitations such as missing data and recall bias. The results of these two studies should be a useful way of testing the validity and reliability of this tool. We are at the design phase of the study at this time.

Before that, we need to clarify our definition of some variables such as “nearing retirement/experienced”, “small/mid sized practice” and “partially funded/partial IT/partial computer exposure”.

There are also limitations in the process of testing this method including the dynamic nature of information collected and deciding on the most appropriate time to freeze the data for evaluation, lack of standardized evaluation documentation, missing data, recall bias and justification of some “grey-zone” scores.

It is concluded that the basic concept of the method described in this paper can be used to facilitate not only the process of projects related to EHR implementation but can also be modified to be used in other HI related projects dealing with the adoption new technology issues.

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### Table 2. Physicians’ Adoption Scoring System.

<table>
<thead>
<tr>
<th>Measurement Parameter</th>
<th>Categories</th>
<th>Score Value</th>
<th>Measurement Parameter</th>
<th>Categories</th>
<th>Score Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong> (score: 0-2)</td>
<td>&gt;60</td>
<td>0</td>
<td>Location II. Hospitals</td>
<td>Rural</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>1</td>
<td></td>
<td>Urban, Small Town</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&lt;30</td>
<td>2</td>
<td></td>
<td>Urban, Big City</td>
<td>2</td>
</tr>
<tr>
<td><strong>Specialty</strong> (score: 0-3)</td>
<td>GP</td>
<td>0</td>
<td>Location II. Hospitals</td>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Specialist</td>
<td>1</td>
<td></td>
<td>Average</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sub-specialist</td>
<td>2</td>
<td></td>
<td>High</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Sub-specialist/High Tech.</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Experience</strong> (score: 0-3)</td>
<td>Close to Retirement</td>
<td>0</td>
<td>Location II. Hospitals</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Experienced</td>
<td>1</td>
<td></td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Newly Graduated</td>
<td>2</td>
<td></td>
<td>Private</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Resident Physician</td>
<td>3</td>
<td></td>
<td>Fully Supported</td>
<td>2</td>
</tr>
<tr>
<td><strong>Setting: I. Community Office</strong> (score: 1-3)</td>
<td>Solo- Practice</td>
<td>1</td>
<td>Location II. Hospitals</td>
<td>MD: pt No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Small Sized Practice</td>
<td>1</td>
<td>Academic/Research Centre</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mid- Sized Practice</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large Group Practice</td>
<td>3</td>
<td>Previous IT/IS in Place</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td><strong>Setting: II. Hospital</strong> (score: 1-3)</td>
<td>Community</td>
<td>1</td>
<td>Location II. Hospitals</td>
<td>Some</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Secondary Level</td>
<td>2</td>
<td>Urban, Small Town</td>
<td>Yes</td>
<td>2</td>
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<tr>
<td></td>
<td>Tertiary Level</td>
<td>3</td>
<td>Urban, Big City</td>
<td>low</td>
<td>0</td>
</tr>
<tr>
<td><strong>Location: I. Community offices</strong> (score: 0-2)</td>
<td>Rural</td>
<td>0</td>
<td>Location II. Hospitals</td>
<td>Personal Computer Exposure</td>
<td>average</td>
</tr>
<tr>
<td></td>
<td>Urban, Small Town</td>
<td>1</td>
<td>Urban, Big City</td>
<td>high</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Urban, Big City</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total (score: 3-29)
References

The Development of a Risk Identification Screening Framework for Healthcare Information Systems

Elizabeth KEAY \(^1\) and Andre KUSHNIRUK

School of Health Information Science, University of Victoria, Victoria, BC Canada

Abstract. Health information systems are costly, especially when they are not used or when they impede workflow. Risk assessment is used to identify and remedy problem areas so that systems are safe. While there are discussions of design project risk management, for example, see McConnell \([1]\), there is little information about screening the fit of a system with respect to its users, the task and the healthcare organization. Such analyses could be important in improving the fit of information systems in healthcare, thereby decreasing risk of system and project failure. A risk-screening framework for health informatics is presented.

Keywords. risk management, medical error, patient safety

Introduction

Risk management is important to ensure that organizations get the best possible system, that is, the best “fit” of the system with respect to its users, the task and the organization. A “fitted” system is a safe system. Risk management involves a series of steps that help identify risks, analyze them, evaluate them and either treat the risks or, if the organization can tolerate them, accept them. The Enterprise Risk Management (ERM) standard for the public sector, including BC health authorities, has not been designed specifically for software risk management \([2]\). The complex health information systems that carry out many organizational functions such as data processing, and patient care/monitoring need to be structured and tailored to the health information setting. Tailoring begins with the creation of a screening risk identification checklist for health authority or other CIOs.

Models and frameworks can structure our approaches \([3]\). The Eason model is one such model. Eason’s model was designed to describe the interaction between humans and systems at three levels: 1) the person interacting with the technology in isolation (i.e. basic usability), 2) the person performing a work task using the system, and 3) the wider socio-technological context of system use \([4]\). In healthcare, gaps in fit at these levels can cause medical errors. Reason has also developed an influential error model \([5]\).

Using Reason’s model, medical errors can happen at the “sharp end” at the user level (e.g. the level of occurrence of adverse events) or at the organizational level as latent errors (where adverse consequences may lie dormant within an organization or...
system and are the predominant cause of error). In a review of healthcare information systems at the NHS, Agnew et al note that the sharp end is mainly concerned with outcomes such as morbidity or even mortality while the blunt end has policies and structures for risk control such as processes, procedures, regulations and rules [6].

Ideally a risk management framework is predictive so that errors are prevented. This is similar to formative evaluation whose purpose is to improve the system under development so problems can be identified as they emerge and the system can be improved as it is being developed [7].

The WHO Working Group on Methods and Measures for Patient Safety has drafted a review of the acute care sector data gathering methods that could be used as data collection methods for risk management in patient safety settings. These can be retrospective such as audits, mortality rounds, complaints, and interviews. They can also be prospective, such as failure modes and effects analysis, safety culture surveys, concurrent observation and checklists [8], and, of course, a risk management plan.

Any risk management measures must meet certain quality criteria such as: thoroughness (the methods should find as many usability problems as possible when the user performs tasks with the evaluated system), validity (find usability problems that are real problems in use; e.g., complexity of tasks, ambiguity and illogical menu systems), reliability (consistent), cost effectiveness, and clarity (understandable and usable in a decision-making process, where the decision-makers are not experts) [9]. In addition, there should be an estimate of the severity of problems, including [9]: 1) frequency, i.e., how often the problem occurs; 2) impact, i.e., how easy it will be for the user to overcome the problem; 3) persistence, i.e. will users overcome the problem after the first time they encounter the problem or will they repeatedly be affected by the problem.

1. Eason’s Levels and Measures for Risk

The literature provides guidance for risk identification corresponding to Eason’s three levels: the individual, the task and the organization, the most complex. There are models and measures for each level that can begin to structure a screening framework.

1.1. Risk at the Individual Level

This is the sharp end of healthcare where the patient suffers an adverse event. Patient factors include medical condition, social factors, language barriers, etc. [10] Staff factors include knowledge and skills, motivation, fatigue, and stress [10]. Eason used the term usability to describe the quality of the individual-technology interaction [4] for the staff interacting with the patient. There are standards of quality in the ISO 9421-11 that define usability as the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments.

Effectiveness is the accuracy and completeness with which specified users can achieve specified goals in particular environments. Efficiency refers to the resources expended in relation to the accuracy and completeness of goals achieved. The system should be easy to learn so that the user can rapidly start using the system. Once the user has learned the system, a high level of productivity is possible. The casual user is able
to return to the system after some period of not having used it, without having to learn everything all over again. Satisfaction is the comfort and acceptability of the work system that users and other people affected by its use experience. Users are subjectively satisfied when using it [9]. The ISO 9216 Quality Model consists of four parts where part 1 has a usability component [11].

Daniels provides a list of some potential usability measures including the following: the time taken to complete a task; the ratio of successful to unsuccessful interactions; the time spent recovering from errors; the number of user errors; the number of erroneous actions following an error; the number of features the user can remember during debriefing after the test; the frequency of use of manuals and the time spent using them; the number of times the user expresses clear joy or frustration; the number of times the user is sidetracked from the real task [11].

There is also the intent of the user: people operating hazardous systems might see quite different possibilities for what to do with them compared with what had been envisaged by the designers. This is often important in risk analysis because of the way in which risk arises from people knowingly doing things that cause risk (for instance violating rules) but without intending the outcome of a catastrophic failure [12].

1.2. Risk at the Task Level

Factors here include guidelines, protocols, and clinical data availability [10]. A successful human-computer interaction depends upon the degree to which the system and the user can agree on the characteristics of the tasks they are performing [4]. This again comes down to the concept of fit. Design may force constraints on the users because of how information content, sequencing, and format are handled. Since these factors are controlled by the IS, its design has an inevitable, strong effect by constraining the possible ways that information workers can perform work [13]. If these constraints interfere with the task, the user can have a feeling of helplessness and frustration when handling technology that causes an increased sense of worry, stress and uncertainty [9]. This can create an unsafe situation for the user and patients.

Part of the skill of the task analyst is in recognizing how data conflict and being able to see, for example, that the official account of how something works (e.g., according to training systems or senior management) is at odds with actual practice [14]).

Task analysis is the process of identifying system functions that have to be performed, the required input and output formats, system constraints, information categories and flow, and the communication needs of the users and task difficulty and the knowledge and skills required by the task [15,16]. This will be difficult to capture in health care, especially at the sharp end where knowledge is dense, complex, changes rapidly, and is embedded in a complex social setting that resists scrutiny by those who are considered to be “outsiders.” Cognitive work is used for both patient care and technical tasks [17]. One health care example is the hierarchical task analysis (HTA) which is a method of systematic human error reduction and prediction approach (SHERPA) that facilitates the identification of errors that could occur, and of the points during the task at which they might occur, by applying a classification of potential errors to the output of an HTA. Phipps et al [18] identified anesthesia errors that could be reduced through standardization by this method.
1.3. Risk at the Organizational Level

Factors here include staffing/workload, equipment available and maintained, managerial support, financial and other resources, policies [10]. The new technical system has to engage with the complex world of tasks, procedures and culture within the organization; it has to be part of a working socio-technical system. To avoid negative consequences for themselves and where possible to achieve system benefits, the many stakeholders that are at the receiving end of the new system will be active in responding to the technical system [19].

Yusof et al have developed the Human, Organization and Technology-Fit Factors (HOT-fit) Model based on the Delone and McLean IT Success Model [20]. This model has several potential risk measures for each of its parts. The most useful from a risk point of view is the net benefit measure that includes individual and organizational benefits. Individual benefits can be assessed using job effects, efficiency, effectiveness, decision quality, and error reduction. Organizational measures include cost reduction, due to fewer medication errors and adverse drug events (ADE) occurring; improved efficiency in patient care delivery, specifically pertaining to tests and drug orders; increased use of generic drug brands; the number of consultations; and the length of waiting lists.

While these studies provide guidance they are mainly outcome measures at the sharp end they also do not address organizational intent. Organizational intent is qualitative. It requires identification of the obligations and powers that affect system actors and the identification of organizational risks that arise from dysfunction where these obligations and powers are concurrent, for example from individual intentions to meet these obligations even when they are somehow problematic in the context, or from individual intentions to set these obligations aside from some contextual reason [12].

Another characteristic not captured is the fact that people build into technology certain interpretive schemes (rules reflecting knowledge of the work being automated), certain facilities (resources to accomplish that work), and certain norms (rules that define the organizationally sanctioned way of executing that work) [21].

2. The Model

In considering risk in the development of healthcare systems, we have mapped Eason’s three levels to Reason’s model to come up with a new framework. Essentially, as illustrated in Figure 1 errors are events caused by a poor fit at both the blunt and sharp edge of Reason’s model.

3. Conclusions

It is expected that a risk identification framework focusing on the three levels of the Eason model will begin to target some of the potential gaps in the fit of a system with its users, tasks and healthcare organization when considered in conjunction with the Reason model. This paper outlines some of the difficult issues that a screening risk management framework will need to capture. Some of these issues are: developing a predictive orientation based on processes that extends from the individual to the
We will be developing and testing the utility of the framework in analyzing and predicting technology-induced medical error.

References


Extending the Infoway Benefits Evaluation Framework for Health Information Systems

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Abstract. A proposal is made that extends the current Canada Health Infoway Benefits Evaluation (BE) Framework for Health Information Systems (HIS) being deployed in Canada. The current BE framework takes a micro view of HIS quality, use and impact at the local level whereas the extended framework takes into account the broader socio-organizational and contextual aspects known as the meso and macro views of HIS deployment. The meso view addresses the people, organization, network and implementation dimensions. The macro view focuses on the contextual dimensions of technology standard, funding/incentive, legislation/policy and professional practice. Validation of this extended BE framework is being planned through a comparative review of recent HIS evaluation literature, a Delphi-consensus process with HIS experts and users, and multiple validation studies with recent HIS implementation projects in British Columbia.

Keywords. HIS evaluation, benefits evaluation, Infoway framework

Introduction

In 2007, Canada Health Infoway published a Benefits Evaluation (BE) Framework for health information systems (HIS) that are being deployed in Canada through its jurisdictional partners and investment programs [1]. This framework is a key component of the electronic health record (EHR) benefits realization strategy outlined in Infoway’s Corporate Business Plan 2008/09 [2]. The Infoway BE Framework is based on the Information Systems Success Model by DeLone and McLean that was first published in 1992, then revised in 2003 after extensive theoretical and field validation by others [3,4]. Within the current Infoway BE Framework, there are three broad dimensions of HIS: quality, use and net benefits. The quality dimension covers the technology aspects of the system, information and service. The use dimension covers system usage and user satisfaction. The net benefits dimension covers care quality, patient access and provider productivity. To provide focus, the current framework excluded organizational and contextual factors such as strategy, culture and business process as out of scope. See Figure 1 for an overview of the Infoway BE Framework.

The current Infoway BE Framework includes 20 categories of evaluation measures under the three conceptual dimensions that were derived from a systematic review of 20 HIS field studies published over the last 20 years [1]. To guide the evaluation effort,
Infoway also produced a detailed Benefits Evaluation Indicators Technical Report with the help of an expert advisory panel and subject matter experts [5]. This report describes the evaluation measurement tools, methods and indicators for the six Infoway investment programs in laboratory, drugs, diagnostic imaging, public health, telehealth and interoperable EHR systems. While the current BE framework excluded organizational and contextual factors, it is well received by the HIS community for its simple yet coherent view, and has been adopted as the basis for a pan-Canadian framework in HIS benefits evaluation [6]. Presently, efforts are underway in different jurisdictions across Canada to evaluate the impact of HIS deployment to demonstrate their benefits, especially those funded through Infoway’s investment programs. Examples include the recently completed pan-Canadian diagnostic imaging benefits evaluation study [7], the Quebec Health Record value chains modeling report as phase one of its BE project [8], the Infoway patient access to quality care BE indicators technical report [9], and the evolving British Columbia eHealth coordination and integration project and eHealth BE plan [10].

While the current Infoway BE Framework provides a coherent view of HIS quality, use and impact at the local level, it does not address the broader socio-organizational and contextual aspects of HIS deployment. This critique is supported by the recent literature review by van der Meijden et al [11] on the determinants of success for inpatient clinical information systems based on the model of DeLone and McLean, where they found three categories of contingent factors that did not fit. These factors are in the areas of system development, implementation process, and organizational culture and characteristics. Within our own ongoing research and teaching of HIS theories/frameworks and evaluation methods we have also identified a number of theories and concepts that are deemed relevant to the success of HIS deployment. In this paper, we propose these ideas as an extension to the current Infoway BE Framework to broaden its conceptual dimensions and practical utility to the HIS community.

Figure 1. The Infoway Benefits Evaluation Framework, adapted from DeLone and MacLean IS Success Model [1].
1. Conceptual Framework Extension

Over the past decade, through our own ongoing research and teaching of HIS theories/frameworks and evaluation methods, we have identified a set of theories and concepts that are relevant to the success of HIS deployment. Our key theoretical foundations, drawn from widely cited literature the information systems, organization science and health informatics disciplines, are briefly described below. Some relevant concepts have also been included in the extended framework.

1.1. The Information Technology Interaction Model

In 1995, Silver et al published a teaching model of information systems (IS) known as the Information Technology (IT) Interaction Model as part of a Master of Business Administration (MBA) core course on IS [12]. The authors’ intent was to provide a managerial view of an information system to MBA students that takes into account the IS, the organization, the implementation process and the external environment involved. The IS covers the technical/functional features, use and consequences. The organization covers the firm strategy, business processes, structure and culture, and IT infrastructure. The implementation process covers the initiation, build/buy, introduction and adaptation stages. The external environment covers the industry, power, competition, growth, regulation and technology trends. This model has been well received by the business/IS communities and is still used today in many MBA/IS educational programs; it provides a well-balanced explanation where “the consequences of IS in organizations follow largely the interactions of the technology with the organization and its environment” [12:361].

1.2. Technology Acceptance Models

The Technology Acceptance Model (TAM) was first introduced in 1986 to examine factors that lead to IS acceptance in organizations [13]. Since that time, TAM has had extensive refinement, validation and extension, with the latest proposed model being the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al [14]. The model describes four constructs that determine behavioral intention and use behavior toward IS adoption: performance expectancy, effort expectancy, social influence and facilitating conditions. These four constructs translate to perceived usefulness, ease of use, social norms and existing organizational/technical infrastructure factors that influence the degree to which the IS will be adopted and used. Such behavior is further modulated by gender, age, experience and voluntarism of usage. Initial validation of the UTAUT model has shown promise of its ability to predict IS acceptance and use behavior in organizations [14].

1.3. Implementation Research and Managing Change

In the past 20 years, there has been a significant amount of work done in IS implementation research, which is concerned with the theories, methods and implications of IS implementation in organizations [15,16]. Different theories/frameworks have been reported that include the diffusion of innovation [17], improvisational change [18], the social constructivist perspective [19] and the multi-
level approach [20]. At the same time, the importance of managing organizational change and its effects on IS implementation are well recognized [22,23]. Such practice-based approaches as Kotter’s organizational change model [23] and Pare’s project risk assessment framework [24] are among the examples of change management approaches used to ensure successful IS implementation. To transform an organization, Kotter emphasizes the need for a sense of urgency, a powerful guiding coalition, a vision, communicating the vision, empowering those to act on the vision, focusing on short-term wins, consolidating improvements to produce more change, and institutionalizing the new approach [23]. The risk assessment framework by Pare offers a systematic approach to ensuring successful IS implementation by reducing risks along the technological, human, usability, managerial and strategic/political dimensions [24].

1.4. People, Organizational and Social Issues

Increasingly, health informatics research is moving beyond the traditional boundary of local systems with a technical focus to addressing the broader people, organizational and social issues in IS deployment. In 2001, Kaplan et al [25] outlined an informatics research agenda advocating the use of different social science inquiry methods to address a wide range of settings that range from individuals, institutions, trans-organizational to transnational levels. The issues include reshaping of institutional boundaries, changing work practices and standards, politicization of healthcare and changing roles of providers and consumers [26]. The sociotechnical approach is an example of inquiry methods that is concerned with the introduction of IS into healthcare organizations in ways that can become part of the social practice [27,28]. A basic premise of this approach is to recognize the complex “messy” nature of healthcare work, which does not lend itself well to rigid structures and standardization. As such, successful IS deployment is seen as ongoing negotiation and adaptation of interrelationships between the IS and work practice involved across multiple healthcare professionals and settings.

2. An Extended Infoway BE Framework for HIS

The current Infoway BE Framework takes a micro view of HIS quality, use and impact at the local level, while excluding the contextual and implementation issues in IS deployment. As such, the BE framework is not able to explain which are the key factors that lead to successful HIS implementation, what organizational strategy and culture best fit with HIS, how to ensure sustained HIS use, or why systems fail in some circumstances. Since many Canadian healthcare organizations and jurisdictions are still in the early stages of HIS deployment, it is critical to gain a solid understanding of these broader issues to ensure sound HIS investments are being made that can produce the desired impacts. In the past few years, we have explored alternative theories/frameworks such as those outlined in section 2, and conducted field studies that could extend this BE framework [28-35]. Drawing on these lessons, we propose “an extended BE framework for HIS in contexts” with a set of propositions that include a meso view to address the people, organization, network and implementation dimensions, and a macro view to address the contextual dimensions of technology
standard, professional practice, funding/incentive and legislation/policy. The two views are described below. Figure 2 shows the extended BE framework in contexts.

2.1. Meso View of HIS Deployment

The meso view takes into account the people, organization, network and implementation dimensions of HIS deployment. These dimensions are based on the TAM/UTAT models that posit an individual’s profile, behavior and intentions as predictors of IS acceptance [13,14]; the IT interaction model that attributes the impacts of IS to organizational dynamics [12]; the sociotechnical approaches to practice change and its consequences on professional practice, roles and relationships [27,28]; Kotter’s model for managing organizational change through leadership, vision and action [23]; and Pare’s systematic risk assessment of IS projects [24]. Our propositions are that successful HIS deployment at the meso level depends on: (a) its people believing the HIS to be useful, easy to use and supported by the organization; (b) the organization dynamics being conducive to HIS adoption and use; (c) the network relationships being agile in redefining inter-organizational roles, responsibilities and accountability; and (d) the implementation process being well managed to foster change and reduce risks. The possible types of evaluation metrics for these dimensions are: (a) people - in terms of performance/effort expectancy, social influence, facilitating conditions and personal characteristics; (b) organization - in terms of the type and fit of its structure/culture, strategy, process, infrastructure; (c) network - in terms of the range and depth of alliances, partners, affiliates and governance present; (d) implementation process - in terms of the type and intensity of the processes, changes and risks involved. We believe that, collectively, these meso level factors can have a direct moderating effect on the adoption, use and impact of HIS in organizations.

![Figure 2. An Extended Benefits Evaluation Framework for Health Information Systems in Contexts.](Image)

2.2. Macro View of HIS Deployment

The macro view is aimed at the contextual dimensions of technology standard, funding/incentive, legislation/policy and professional practice. These dimensions are based largely on the influence of the external environment described in the IT
interaction model [12]; the need to examine contextual issues in HIS deployment at the transnational level as outlined in Kaplan’s informatics research agenda [25]; and the broader unintended social consequences of HIS as seen through the sociotechnical lenses [27,28]. Our propositions are that successful HIS deployment at the macro level depends on: (a) the extent to which technology standards such as HL7 and SNOMED CT are incorporated into HIS; (b) the funding/incentive mechanisms available such as alternative payment schemes to entice change at the organizational and practice levels; (c) legislation/policy such as privacy laws that governs HIS adoption and use; (d) professional practice standards on the roles and responsibilities of healthcare providers relevant to HIS. The types of evaluation metrics to be considered for these dimensions are: (a) technology standard, in terms of the type of healthcare data, messaging and terminology standards available and in use; (b) funding/incentive, in terms of the type of remuneration and incentive programs available; (c) legislation/policy, in terms of the type of healthcare legislative acts, regulations and policies in place; (d) professional practice, in terms of roles/responsibilities and practice standards defined for HIS use.

We believe that, collectively, these macro level factors can have an indirect moderating effect on the adoption, use and impact of HIS in organizations.

3. Planned Validation Approaches

Presently this extended BE framework is tentative only, and is awaiting confirmation through empirical evidence of its validity and robustness. Our preliminary validation effort based on the findings from four recent Canadian HIS studies has shown a high degree of consistency with all of the meso/macro level factors identified [36-39]. We plan to validate this extended BE framework in three ways. First is a literature review to compare our propositions with the people, social, organizational and contextual issues associated with HIS deployment that have been reported. This will be a semi-quantitative comparison on whether the factors identified in the BE framework are found in the literature and the extent to which they have significant influence. Second is a Delphi process to seek consensus with HIS experts and users to determine whether the extended BE framework resonates with their worldviews, day-to-day practice and perceptions of HIS deployment. Third is through field observations/interviews in HIS deployment projects currently underway within our School. Presently we are in the early stages of evaluation planning on several Infoway and BC Ministry of Health funded initiatives including eDrug/PharmaNet2 and the Electronic Medical Record in private practice. Most importantly, we plan to triangulate these findings to identify areas of congruence and divergence in the suggested meso/macro dimensions. The output will be an “Extended BE Framework for HIS in Contexts” that can be used to examine HIS deployment through the entire system lifecycle of initiation, introduction, use and adaptation across the micro/meso/macro dimensions as described in Silver’s IT interaction model [12].

4. Conclusion

This paper describes an extended benefits evaluation framework to make sense of HIS deployment. The framework goes beyond HIS quality, use and impact at the local level to address the broader socio-organizational and contextual aspects. Much work lies
ahead to validate this extended BE framework to determine its validity, robustness and generalizability. Most importantly, we need to ascertain the overall utility of this framework by demonstrating through rigorous yet pragmatic HIS evaluation studies on the benefits that can be realized from the HIS investments being made to improve the Canadian healthcare system.

References

Abstract. We describe an evaluation plan for electronic clinical documentation. Guided by Canada Health Infoway Benefits Evaluation Framework, the evaluation was performed across a single organization with four health care sites and included reviews of documentation practices from the nursing and health disciplines. Data collection methods included chart audits, shadowing, surveys and focus group meetings. Key recommendations drawn from the data analysis will help to guide documentation format and practice improvements.

Keywords. electronic clinical documentation, evaluation plan, Infoway Benefits Evaluation Framework

Introduction

It has been suggested that the use of information technology (IT) in health care will reap benefits related to patient safety, quality of patient care, cost-effectiveness and efficiencies in clinical settings[1,2]. One such technology is electronic clinical documentation (eDoc). However, there has been little research to tie specific patient outcomes to the use of IT [3]. While there is an emerging body of literature examining the adoption of technology in health care, the studies to date are varied and lack a widespread analysis of evaluation issues [4]. To promote standardization in evaluation of IT adoption, Canada Health Infoway proposes a theoretical framework to guide evaluations of IT adoption in a number of systems and settings [5]. An evaluation, which was planned in accordance with the framework, examined the adoption, use and user satisfaction with eDoc across one organization with four distinct sites. Implications for clinical practice for those considering implementations of electronic clinical documentation will be offered.

1. Background

Quinte Health Care (QHC) is a four site organization with a mandate to provide primary and secondary care to a rural population in southeast Ontario. One of the strategic goals of the organization was to build a robust electronic documentation system as part of a larger IT strategy that would make patient information accessible at all QHC sites. The implementation of electronic documentation occurred simultaneously with the introduction of the “Charting by Exception” methodology.
phased approach was taken over a period of approximately one year, beginning with in-patient acute areas.

Post-implementation, several concerns persisted related to professional standards of documentation, access and use of the electronic devices (“computers on wheels” or “COWs”), and comprehensiveness of the documentation (i.e., the ability to “tell the patient’s story”). Further, ongoing requests for screen revisions led to speculation that nurses were not confident in the accuracy of the documentation. The use of the COWs at the patient’s bedside was problematic and muscle strain injuries increased as nurses stood in hallways to chart at the mobile workstations.

It was evident that a comprehensive evaluation was required. The evaluation needed to consider the implementation process of electronic documentation, the implications for professional practice, and the type and number of electronic devices required by the project. A participative approach was initiated by the professional practice department to gather nursing input to these key questions. This served as a vital starting point for dialogue and the eventual development of an evaluation plan by the evaluation team.

2. Evaluation Plan

The full benefits associated with IT adoption are yet to be realized. There is a widespread effort to introduce technologies into clinical settings as enablers of clinical practice [6]. Only through evaluations of IT implementations will a) clinical practice be informed to make improvements, b) patient outcomes be impacted, and c) technologies be leveraged to guide knowledge generation in health care.

2.1. Theoretical Framework

Canada Health Infoway Benefits Framework has six conceptual dimensions. It provides a robust conceptual basis from which evaluation designs can be drawn for numerous areas including electronic clinical documentation systems. The six dimensions are 1) System Quality, 2) Information Quality, 3) Service Quality, 4) Use, 5) User Satisfaction and 6) Net Benefits (Quality, Access, and Productivity). The dimensions that this evaluation plan referenced were Use and User Satisfaction. Consequently, the methods of data collection were designed to assess these two dimensions.

2.1.1. Evaluation Questions

There were five questions associated with this evaluation project:

1. How were staff complying with electronic documentation?
2. How were staff managing the change in learning to use the electronic system?
3. What were the changes associated with awareness, attitude, skill, opinion and motivation to use the system?
4. Were there any positive changes in professional practices related to documentation?
5. Were the staff satisfied with the current hardware devices?

To address these questions, a mixed methodology of quantitative and qualitative approaches was used. A mixed methodology provides a balance of objective and
subjective data. Consequently, the data collection methods used were chart audits, surveys (of key stakeholders/managers and clinical end users), focus groups and non-participant observation/shadowing of staff. Evaluators met with senior management representatives as well as practice leaders to collaborate in the evaluation plan design. Practice leaders were instrumental in setting up the schedules for interviews, focus groups and shadowing experiences.

2.1.2. Setting

The evaluation was conducted from September-November 2007, approximately 18 months post-implementation of electronic clinical documentation, at four sites of Quinte Health Care, Belleville, Trenton, Picton and Bancroft, Ontario, Canada. Only in-patient units were included. Nurses and Health Discipline Professionals were invited to participate in the evaluation.

2.1.3. Data Collection Methods

Data collection methods included chart audits, shadowing, surveys of key stakeholders and clinical end users and focus groups.

3. Findings

While the findings from the evaluation suggest there are opportunities for improvement and optimization, the results also demonstrate user satisfaction with the electronic clinical documentation system. Highlights from the findings are reported in Table 1.

4. Conclusions and Recommendations

Quinte Health Care undertook a significant step on the path to a fully integrated electronic health record. Simultaneously, it implemented eDoc and standards-based Charting by Exception. Both ventures are substantive change management challenges for any organization – particularly so for four clinical settings with distinct patient populations and with significant distances between sites. While the results indicate there are areas for optimization, staff indicated an openness to explore avenues for enhancing and optimizing eDoc. Nursing and health discipline staff spoke freely and frankly. They offered suggestions for improvement, voiced their concerns about the impact of eDoc and sought feedback on their documentation. The following recommendations were offered following an analysis of the data:

- Provide refresher courses on Charting by Exception documentation methodology to further integrate the methodology into practice
- Review workflow of documentation process and module/screen components
- Customize the eDoc system to reflect care of distinct patient populations
- Integrate outcome measures (i.e., HOBIC) into any new optimization
- Schedule focused chart audits; communicate results to staff
- Review ergonomics of computer equipment
Surveys: Clinical End Users
Clinical end users were defined as those in clinical staff positions such as nurses and health discipline professionals.

185 clinical end users responded
The surveys were designed to:
- Identify strengths and deficiencies with the current documentation processes
- Determine system use and user satisfaction,
- Determine staff perceptions of charting methodology, hospital and service standards
- Elicit documentation system improvement ideas

- 41% prefer to document patient care using eDoc
- Users’ comfort with eDoc
  o 21% are very comfortable
  o 50% are comfortable
  o 24% are somewhat comfortable
  o 4% are NOT comfortable at all
- For those reporting very comfortable or comfortable, 86% reported to be in that state within 6 months
- 50.3% - eDoc chart tells the patient’s story
- 49.7% - eDoc chart does not tell the patient’s story
- 70% respondents report a computer is available for their use
- 77% - increased duplication of documentation
- 30% - quality of patient care has not been affected

Table 1. Evaluation of the electronic clinical documentation system at Quinte Health Care.
5. Implications for Practice

The following “lessons learned” are offered as considerations for organizations that are considering introducing electronic clinical documentation:

- Avoid, if possible, the introduction of a new charting methodology with the initiation of electronic documentation.
- Provide for initial and ongoing professional practice support.
- Develop and trial chart audit systems as part of the implementation phase and ensure the process provides accurate feedback to nurses regarding the quality of documentation.
- Recognize that the learning process will require at least one year to reach a level of comfort in the organization and gains will be made incrementally after that time.
- Assess the level of computer literacy of the user population and, where possible, provide education sessions in basic computing.
- Ensure the vision and purpose of the project are clear, patient-focused and well communicated and that goals are realistic, while measuring progress.

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<th>Focus Groups</th>
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- Need ergonomic review of equipment

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Strategies to Increase Familiarization and Acceptance of Electronic Health Records among Health Professionals and Consumers

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Abstract. There are many reasons an organization may choose to implement electronic health records. The challenge is to acknowledge the benefits and deficiencies of the electronic health record, to understand the driving forces for implementation and the barriers to it, and to effect change in the workplace and consumer behaviour. Indeed, one challenge is the determination of the organizational stance with regard to these factors. If all of these factors are seriously considered and the risks to implementation measured, a successful implementation should ensue.

Keywords. EHR implementation, risk assessment

Introduction

Electronic health records (EHRs) can benefit health professionals and health care consumers. Without their acceptance, implementation will be difficult, their features will be under-utilized and their adoption rate will be slow. An interdisciplinary working group needs to make implementation decisions based on the members’ perceptions of a new system. Stakeholder involvement beyond the interdisciplinary team needs to be encouraged because buy-in is paramount. If clinicians reject the system, implementation will be in jeopardy. Change management, that is, how to lead people through change, and the value of change should be considered. In order for system implementation to be successful, clinicians need to know why and in what way this change will affect them and others within the organization. They need to know the practical benefits and rewards for the organization as a whole.
1. Benefits to Stakeholders

There are many benefits of adopting EHRs: some benefit the clinicians and their decision-making process, others benefit the patients whose information is stored in the EHR. While there are many benefits derived from EHRs, only some will be discussed.

The EHR supports and improves the quality of patient care by decreasing drug risks and by enabling access to a more complete medical record. Administrative costs are reduced and the productivity of health care workers is enhanced by decreasing the duplication of tests and by promoting the integration and coordination of health services. Clinical and health service research is supported by providing access to high quality data, access to research findings and improved data management and analysis. EHRs ensure patient confidentiality, provide more security for patient information and provide up-to-date patient information on a need-to-know basis. Future health care development is enabled through improved health resource allocation [1].

2. Deficiencies of the EHR

There are several deficiencies of EHRs. While these are caused for a variety of reasons, all of these deficiencies are costly to clinicians, patients, and the success and adoption of the EHR. While not all situations and implementations are homogenous, several of the main deficiencies include:

- a lack of code sets and consistent standards for information,
- costly implementation due to the need to purchase and/or upgrade hardware and software coupled by with the lack of available funding,
- challenges during implementation due to the lack of staff resources, trainers with sufficient leadership skills, clinician usage and employee trust, and
- systems are not always interoperable with each other and there is not always an existing regional information transfer network available [2].

3. Barriers to Implementation

While there are many barriers to EHR adoption, some of the main themes are generally consistent throughout implementing organizations. These barriers include both internal and environmental barriers incurred in both the short and long term. Barriers to automation can be as unique as the organization attempting to implement the technology. While there is no hard rule as to which barriers an organization may confront, the following are common themes [3]:

- Insufficient number of people to implement all of the desired changes
- Cost (system and induced costs)
- Lack of education or effort made for clinical buy-in
- Difficulty with data entry methods
- Rigid, predefined, structured data entry
- Lack of capacity to include audio files
- Natural skepticism of physicians
- Feelings that the system being forced onto providers
4. Driving Forces for Implementation

There are many situations, an organization may experience that will motivate it to adopt an EHR. While these are generally based on the inefficiency of manual methods that can be automated, there are many driving forces for an organization to adopt electronic record keeping. The driving forces for implementation mentioned may vary across organizations due to what they currently have implemented and their strategic direction, however, many common trends emerge, regardless of geography.

First of all, increased care quality and patient safety is usually the paramount driving force, and risk, when implementing electronic health records. This should lead to a clinician obtaining a holistic view of the patient. Ideally this will lead to increased medical knowledge and decreased medical errors. Chronic disease patients become easier to track and manage proactively in an electronic environment, allowing patients to move across providers with their information still available to their next provider. Clinicians practicing across multiple locations would be able to provide seamless service to their clients as the physician paper chart would no longer be the sole record of that patient. Additional savings can be achieved in reduced malpractice costs, lower storage and supply costs, generic drug substitutions, increased provider productivity, decreased staffing requirements, and increased reimbursement for more accurate evaluation and coding. Reductions in patient chart access times and transcription costs could also be realized. One of the most important driving forces for implementation would be the way encounters are handled. With electronic health records, encounters would become continuous as opposed to the episodic care that is provided today [4].

5. Resistance to Implementation

There are several reasons an organization may resist change or implementation. The reasons are usually personal and shared amongst similar groups. Fear of change is a consistent theme. Some of the reasons clinicians are resistant to implementations include, but are not restricted to [5]:

- Feelings that “a depersonalized notion of ‘information’, centred on the interaction between the individual and the ‘system’ rather than on the interaction between human beings”
- Initially there will be a temporary loss of productivity and strain on staff
- Fear of job loss and the unknown
- Difficulty with data entry and navigation
- Feelings of having the system forced onto them
- Feelings of not having input on the selection of system and the applications implemented

6. Incentives and Perceived Benefits

In order for clinicians to successfully adopt an EHR they need to believe that there are benefits for doing so. Only if the benefits the technology offers outweigh the associated costs will the clinician contemplate the behavioral change required to adopt a new technology. These benefits may be realized in the short or long term, and need to be at
least perceived by the clinician in order to trigger a behavioral change. While not comprehensive and inclusive, some of the incentives and perceived benefits of EHR adoption are:

- a reduction of adverse drug events,
- for physicians, an increased revenue and decreased losses under fee-for-service reimbursement,
- a reduction in drug expenditures,
- an improved use of radiology tests and charge capture,
- an increase in quality of care and patient safety (chronic disease and other provincial registries),
- an increased access to information,
- an ability to see patients at any site and have their information available,
- a decreased duplication of effort, and
- a more holistic patient profile [3,6].

7. Implementing Change in the Workplace

Change seems to have become an everyday part of doing business and it often seems to happen quickly and continuously. Our health care organizations are no exception. It is not uncommon for employees to be confronted with simultaneous change. Successful leaders will be able to guide people through the uncertainty that accompanies periods of change, they will give employees reasons to change, and they will implement successful everyday strategies to achieve sustainable change.

In order for leaders to guide people through the uncertainty that accompanies change, they will have to respond to the new reality for leadership by moving from:

- Stability to Change and Crisis Management: leaders must accept the inevitability of change and accept it as a potential source of energy,
- Control to Empowerment: leaders have to guide workers to be the best they can be by creating a climate of respect and development for all employees,
- Competition to Collaboration: leaders must create a climate of teamwork and community that fosters mutual support and collaboration,
- Uniformity to Diversity: encouraging diversity is the way to attract the best human talent and for the organization to develop a broad mind-set,
- Self-centered to Higher Purpose: honesty, integrity and accountability to stakeholders are crucial, and
- Hero to Humble: behind-the-scenes leaders quietly build a strong company by developing others [7].

According to Senge et al [8], to achieve sustainable change, employees need to be given 3 major reasons. First, they need to know that it matters to them, they need personal results. Direct personal benefits are the first source of motivation for sustaining deep change. Secondly, they need to see that their colleagues take it seriously. Therefore, leaders need a network of committed people. We naturally pay attention when people we know and rely on talk about something new, it adds credibility. Finally, they need to see that it works; they need to see concrete business results. As new business practices lead to better results, it increases credibility and more people are willing to commit to the change.
Strategies for everyday change have to be used by good leaders who are working on a daily basis to gradually shift behaviors and attitudes toward the desired change [7]. Many strategies can be used including: 1) disruptive self-expression (A leader must act in a way that others will notice and that reflects the behaviors he or she wishes to instill in employees); 2) variable-term opportunism (A leader must look for, create, and capitalize on opportunities to motivate others to change); 3) acknowledge negative consequences of change (A leader must acknowledges that change can be inconvenient, stressful, and downright scary. The fear of facing personal loss and of quickly having to learn entirely new tasks must be acknowledged and dealt with appropriately in a timely manner. Leaders must listen to what is being said, and not said, and deal with it immediately); and 4) start small and grow steadily (A leader must find a few partners who share their passions and ideas, identify key practical issues and work on them. Leaders and employees must remember that profound change is a self-reinforcing process).

8. Implementing Change in Consumers

Consumers can react to change with an uncanny similarity to employees [9]. Before discussing how to implement change in consumers, it’s important to examine some reasons for barriers to change implementation that result from individual resistance:

- Habit: Reliance on programmed responses to deal with life’s complexities.
- Security: Change may be threatening to feelings of security.
- Economic Factors: This one is more applicable to the workplace. Workers may fear that their lack of understanding of the changes may result in poor performance evaluations.
- Fear of the unknown: Change brings doubts about stepping away from known processes.
- Selective information processing: The tendency to ignore new information that may challenge the status quo.

There have been several models developed for change implementation, such as Kurt Lewin’s three step model and John Kotter’s, even more elaborate, Eight-Step plan for implementing change. Although both models focus on managing change within organizations rather than on service consumers, these well known models identify important points that may also be applicable to consumers. Lewin’s model calls for “unfreezing the status quo, moving to a new state, and refreezing the new change to make it permanent” [9]. However, what should come between these three steps is what is more important to consumers. The consumer mindset needs to be handled with a more deliberate approach, which means there should be transitional steps between Lewin’s three steps, making the whole process more fluid reducing the sense that the change is being forced upon them.

Kotter’s Eight-Step plan is a more detailed approach. Again, there are some steps in this plan for implementing change that are applicable to consumers. These include:

- establishing a sense of urgency, by creating a compelling reason for change,
- forming a coalition with enough power to lead the change,
- communicating the new vision, and
- reinforcing changes by focusing on success resulting from the new changes [9].
Based on these models for managing organizational change, one can develop an implementation strategy designed specifically for consumers. It is important to understand the consumer population that the change will effect and have a clear reason for the change. Consumers need to be made aware of the benefits and costs of the proposed change and be included as stakeholders in the change-planning process. Planning the change should include identifying those processes that could be affected by the change and what the effect could be. Piloting the changes will provide results that could ease the change process and contribute to a subsequent evaluation of the organizational impact of the change. The results of the process analysis and pilot project should be shared with the all stakeholders, especially the consumers. Natural resistance to change should be anticipated resulting in different levels of adoption of the change among consumers [10]. The above strategy to implementing change in consumers is drawn from a review of expert models and market assessments, and presents a combined approach that aims to enhance the process of change implementation in consumers.

9. Conclusion

When system implementations are done using some, but not all, of the strategies, success is not always guaranteed. Considering the issues mentioned previously, clinician acceptance and familiarization with the systems implemented have increased. This has led to more successful clinical system implementations where clinicians feel they have a stake in the system; they see the value it possesses and benefits to both themselves and the patients. The topics outlined above are all key ingredients to the successful implementation of a clinical system. If any one of these components is lacking or missing, the chance of a successful clinical system implementation is diminished. By using these strategies to increase familiarization and acceptance of a new system, whether electronic or manual, clinicians will ultimately become champions of the implementation and lead to its success.

References

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Section 13

Technology Adoption and Evaluation
IT for Advanced Life Support in Hospitals

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Abstract: In this study we analyzed how IT support can be established for the treatment and documentation of advanced life support (ALS) in a hospital. In close collaboration with clinical researchers, a running prototype of an IT solution to support the clinical decisions in ALS was developed and tried out in a full scale simulation environment. We have named this IT solution the CardioData Prototype.

Keywords: computerised decision support, computerised documentation, advanced life support, socio-technical design

Introduction

Cardiac arrest is a hyper-acute situation where correct and immediate treatment according to existing guidelines [1] is to be delivered under substantial time pressure. This provides two kinds of problems: first, keeping clinicians updated with the skills to act correctly when they are in the situation of performing advanced life support and, secondly, collecting data for secondary use so that treatment in the long term can be improved. The incidence of cardiac arrest in hospitals ranges between one and five events per 1,000 hospital admissions [2]. Reported survival to hospital discharge varies from 0% to 42% with the most common range being between 15% and 20% [2]. There is a need to ensure that the quality of the treatment of patients with a cardiac arrest in hospitals is the best possible [3]; this is reflected in the education of clinical staff at the Copenhagen University Hospital Herlev. During training programs conducted in a simulation environment, it is possible to imitate the clinical challenges of resuscitating a patient suffering from a cardiac arrest and to train the application of a treatment algorithm as described by the European Resuscitation Council (ERC) [4]. It is also a challenge to ensure that relevant and necessary documentation is collected during the resuscitation process as mandated by legislation and to satisfy the Utstein Style [5] of data collection for secondary use in research. Our project goal was to develop an information technology (IT) application that, during advanced life support (ALS), would support treatment as well as the documentation requirements.

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The Clinical Setting

A hyper acute event occurs when a patient in a hospital suffers from a cardiac arrest. The staff at the hospital is trained to immediately initiate airway support with a facial mask and to administer external thoracic compression. An alarm system in the hospital activates a resuscitation team consisting of a cardiologist, an anaesthetist, an anaesthesia nurse and two hospital porters. One nurse in the department where the incident has taken place is allocated to the team as well. All the team members have dedicated roles. Membership on the team is not permanent; the roles in the team are assumed by those on call in the different responsible departments.

The Treatment Algorithm and Clinical Research

The treatment algorithm used is described in the European Resuscitation Council (ERC) Guidelines for Resuscitation 2005 [1]. It is implemented in Denmark by the Danish Resuscitation Council [6]. The treatment algorithm includes standard activities that must be performed in time intervals of 2 minutes. Decision points are inserted in the algorithm to ensure that treatments are chosen in accordance with the clinical observations; this means that there are different ways to proceed depending on the clinical situation.

One of the most important developments in relation to the treatment algorithm is named The Utstein Style [5]. This work was conducted in 1997 but is still valid as the basic topic in clinical studies in ALS. The Utstein Style is a consensus among experts on what uniform reporting in resuscitation should be and it gives recommendations for clinical studies in ALS.

Training Resuscitation Procedures

All staff members in the hospital are trained in initiating basic life support and the resuscitation team members are trained in practising ALS. At Copenhagen University Hospital Herlev the training is conducted at the Danish Institute for Medical Simulation. The training techniques are based on a full-scale simulation; the only alteration from real life is the fact that the “patient” is a full-sized electronic doll connected to a computer. In this simulation setting, it is possible to repeat procedures several times until they are well known, comprehended, and applied by all the team members.

1. Methodology

Our methodology was based on participatory design (PD) [7] including observations, literature studies, and prototyping.

1.1. Data Collection

Based on literature studies, we analyzed the external requirements such as the legal demands, and the research and development needs related to treatment and

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2 Utstein Abbey: Name of the place where the first Utstein Symposium was held at the Norwegian Island ofMosteroy.
documentation of cardiac arrests in hospitals. Based on observation studies in simulation settings, group interviews, and a questionnaire given to team leaders, we analyzed the internal requirements of the resuscitation teams. The PD observation studies were conducted at the Danish Institute for Medical Simulation [8]. The team members we observed were participants in a training program. The simulation setting allowed us to get an impression of the clinical work. Due to ethical issues, it was not possible to follow the usual methods in PD, which make it almost obligatory to conduct observation studies in real-life settings. As patients who suffer from a cardiac arrest are unconscious, they cannot give their informed consent to our presence at the resuscitation scene.

1.2. Data Processing

The literature study made it possible for us to set up a theoretically ideal resuscitation scenario, and afterwards to compare it to our observations of the simulated scenarios. Hence, it was possible for us to identify where the challenges were for the team as it followed the treatment algorithm and generated the appropriate, detailed documentation. We could speculate on how IT might be most useful. In our data processing we used the method Diagnostic Maps [9] to organize our findings. We described the challenges, the possible causative agents, the consequences for the resuscitation team performing ALS, and suggested new ideas for IT solutions.

1.3. Findings

In the observation studies, our major findings concentrated on lack of registration of the total time from the collapse of the patient to end of treatment and time intervals according to the treatment algorithm. This was in accordance with the findings in the group interviews and the questionnaire completed by team leaders. In our literature studies [3,5,10] and interviews we found that, in general, it was difficult to achieve documentation on an adequate level for clinical use as well as for research.

In the development of the CardioData Prototype, our focus was on the match between hardware, software and the work environment. We developed and tested the CardioData Prototype in an iterative process with clinicians from the resuscitation teams. The tests were conducted in the simulated scenario and were based on our analysis of findings and an existing paper prototype. We chose an Ultra-Mobile PC, which had a touch screen with a simple, dedicated user interface. This made the device easy to use even while performing ALS under stress.

2. Analysis

The major problems in ALS treatment are difficulties in forming a general view of the situation during the resuscitation, time management, and the ability to strictly follow the treatment algorithm. The most important findings were concentrated on lack of registration of time and time intervals caused by the very stressful working conditions. A primary consequence of this is the risk of a less effective patient treatment because the algorithm is not strictly followed. A secondary consequence is the difficulty in collecting data for research and quality improvement. We found that some of the time registration challenges and the need for a clinical overview obviously could be solved
with an IT solution. We also found it possible to support decisions concerning ALS treatment.

In the ALS setting there will always be a defibrillator. There are many different brands, but most of them support time management and to some extent other functions, for example, data collection. The user interface, however, is often too complex in a resuscitation setting. Support functions, like conversion to child dosages, are not integrated in defibrillators, neither is the ability to display a treatment summary while ALS is still being performed. We examined the idea of using an audible voice or sound to support the team but our observation studies and interviews indicated a complex, noisy environment and the clinicians were not interested in bringing even more noise into the resuscitation scene.

3. Results

The CardioData Prototype supports time intervals defined by the treatment algorithms, chest compression rates and ventilation procedures. By default it supports treatment of adults, but it is possible to choose a user interface that can support resuscitation of children of various weight intervals. It supports documentation of defibrillation, as well as collection of data and re-evaluation of the patient during ALS. It also supports documentation of various medications and intubation of the patient. When the resuscitation is terminated, it is possible to send the collected data to a database, for example the local electronic health record. The functionalities behind the user interface of the CardioData Prototype are listed in table 1. These were the features of ALS that we found IT to support meaningfully.

The tests we performed, using the CardioData Prototype in the simulation training session was very successful. The clinicians found the functionalities useful and supportive for both decision-making and documentation. The primary challenge is to find the right person on the team to control the CardioData Prototype. Socio-technical design including design of work practice is an important issue. We tested it both with the two hospital porters and with the team leader, the cardiologist, and the hospital porters seemed to maintain the best overview of the situation. By controlling the CardioData Prototype, the porters are able to keep track of time and to support the work of the rest of the team.

4. Discussion

The primary strength of the CardioData Prototype is its support of the documented relevant functionality and doing so through a simple user interface. The functionalities in the CardioData Prototype are developed to support primarily decision-making for the team leader, but also to keep track of time and time intervals under stressful working conditions. The collected data can also be used for research.

The main challenge in the prototyping process was to design a user interface that is simple and intuitive, as it is to be used in a life critical setting by persons who perform ALS infrequently and under urgent conditions. It is also a challenge to support resuscitation teams that are put together ad hoc. Due to this, only the functionalities we
The CardioData Prototype is still an early prototype. It is not yet being used in a real-life setting. At the moment it is being tested as a device to ensure the quality of training at the Danish Institute for Medical Simulation. The primary results are very promising and the instructors and clinicians are very satisfied with the use of the CardioData Prototype in this setting. The CardioData Prototype makes it easier to give feedback on the test scenarios for resuscitation; this includes observation and comparison of the thoracic compression rate and the ventilation rate. During training, the instructor controls the CardioData Prototype.

Still at issue is the optimization of the user interface. There is also the challenge of optimizing the use of the CardioData Prototype and its relationship to the other technical devices present. The CardioData Prototype has not yet been connected to the time monitoring of the defibrillator, which would permit it to connect clinical events to the cardiac rhythm “on-line.” More tests and socio-technical design needs to be performed to clarify who in the resuscitation team should control the CardioData prototype. Other user interfaces may be better and still need to be evaluated, for example, a projected image, which can be seen by all team members, might be useful.

Table 1. Functionalities in the CardioData prototype.

<table>
<thead>
<tr>
<th>Start and restart</th>
<th>It is possible to restart the CardioData Prototype if the same patient gets another incident of cardiac arrest.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algorithm for adults</td>
<td>Default setting in the user interface</td>
</tr>
<tr>
<td>Algorithms for children</td>
<td>Options to choose treatments within weight intervals for every 5 kilograms</td>
</tr>
<tr>
<td>The total time</td>
<td>The total time from the CardioData Prototype is turned on is registered.</td>
</tr>
<tr>
<td>The cardiac rhythm, defibrillation and time intervals (2 minutes)</td>
<td>The result of the observation can be documented as shockable- or non-shockable cardiac rhythm. The number of Joules to be delivered is indicated on the button. A clock counts down two minutes from the last rhythm observation registered and supports the treatment algorithm.</td>
</tr>
<tr>
<td>Cardiopulmonary Resuscitation</td>
<td>Before intubation of the patient: “30:2” - this refers to 30 thoracic compressions alternating with two ventilations. After intubation it changes to continually thoracic compression and ventilation. The ventilation rate and the compression rate are visualised with icons. The icon changes rate according to whether the patient is intubated or not. The time of intubation can be documented.</td>
</tr>
<tr>
<td>Medication administered</td>
<td>Adrenalin 1 mg, Atropine 3 mg, Amiodaron 300 mg Other medication administered If “child” is chosen, the dosages shown on the buttons are following the weight intervals.</td>
</tr>
<tr>
<td>Summary</td>
<td>Spontaneous circulation. The button is activated when a spontaneous circulation is achieved, and it terminates the total clock. Summary or termination. The button is activated if the team needs a treatment summary during the resuscitation. A new window is opened and shows a list of the treatment with an exact time log. When the resuscitation is terminated, it is possible to send the collected data to a database.</td>
</tr>
</tbody>
</table>

found most important are displayed in the user interface in order to keep it simple; we refrained, for example, from medications that are rarely used.
5. Conclusion

At the Danish Institute for Medical Simulation, we developed and tested the CardioData Prototype in a situation as close as possible to reality. The people taking part in the test were real clinicians with experience in ALS. The clinicians’ evaluation was positive. We find it important to continue the development and testing of the CardioData Prototype so it can be used in a clinical setting. We found the modified PD method very useful in the development process. Our work contributes to research in the field by investigating the optimization of the resuscitation paradigm. It also contributes to the study of clinical work in a hyper-acute setting using a simulation environment. Further development is needed and our collaboration will continue.

References

Effective Solutions in Introducing Server-Based Computing into a Hospital Information System

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Abstract. Server-Based Computing (SBC) is a technology for terminal administration that achieves higher security at lower expense. Use of SBC in large hospitals, however, is not widespread because methods to effectively implement the technology have not been fully established. We present a system design that uses SBC in a large-scale hospital and then discuss the implementation problems and their solutions. With the exception of network traffic estimates, the server size estimates were validated. Three results from an evaluation of an SBC implementation were: 1) security was re-enforced by applying multiple-policy adaptation to a single client terminal, 2) cost reduction was realized by having fewer PC failures and a lower power consumption, and 3) user-roaming was found to be effective in reducing the number of iterative operations performed by users.

Keywords. thin-client, security, usability, user-roaming, remote desktop

Introduction

Server-Based Computing (SBC), also known as thin-client computing, has drawn the attention of hospital managers for its superiority in cost-reduction and privacy-protection. With SBC technology, middleware servers (SBC servers), which are installed between PC clients and servers, are able to process multiple user applications and to behave as virtual clients. The servers provide each PC client with screen display information only; they do not transfer the actual data (see Figure 1). The three-tier mechanism not only enhances the security level of the system but also enables inexpensive PCs such as thin-clients to be deployed, thereby decreasing system management costs.

The introduction of SBC, however, does not appear to be widespread, particularly in large-scale medical facilities. The method of SBC-based system design has not been fully established. This may explain SBC’s lack of popularity even though the technology is well suited to medical facilities that must maintain the highest level of privacy, data protection and terminal administration. Though SBC technology was put to practical use earlier, only a few papers assessed its use in hospitals: University...

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Medical Center Utrecht in the Netherlands [1] and Kyushu University Hospital [2] in Japan. These papers have provided only the overview of the system or described a small-scale installation such as in operating rooms. They did not focus on the problems that would arise with large systems such as one with over 1,000 PC clients. Since the benefits of SBC, such as its cost-effectiveness, are supposed to be greater for larger installations, it is important to prove that SBC can be effective in a real, large medical facility.

In this paper, system design of SBC in large-scale hospital settings is presented. Problems with the implementation and their solutions are discussed to clarify its effectiveness on security reinforcement, cost reduction and usability enhancement.

Figure 1. Differences in system configuration and data transfer methods for (a) the server-client model and (b) the Server-Based Computing (SBC) model.

1. System design

The SBC infrastructure was built at Tottori University Hospital (TUH) in Japan. The university-affiliated hospital has 33 clinics and 697 beds. The hospital information system (HIS) was used by approximately 900 employees who worked with approximately 1,100 client terminals. The introduction of SBC was started in January 2008 when HIS at TUH underwent replacement. Before SBC was installed, issues with the SBC technology and its adaptation to a hospital setting were discussed for seven months by several working groups. The results of these discussions were incorporated into the system design. The issues, which included post-operation problems, were also discussed to develop additional SBC functionality.

1.1. Design of Network System

In the three-tier model of SBC (see Figure 1), the traffic between the HIS server and the SBC server tends to be heavy because the SBC server has a number of executing applications for a number of logged-in users and each application consumes a certain network bandwidth. On the other hand, the traffic between a SBC server and its PC clients needs less bandwidth because only the screen information and user input events are transmitted. Therefore we deployed gigabit switches (Cisco Catalyst 3750G) as server-firm switches connected to core switches of the HIS (Cisco Catalyst 6506) and 100Mbps edge switches (Cisco Catalyst2960) dedicated to client PCs.
Under the SBC model, two different security policies can be adapted to the client PC - policies for local applications (executed on the client PC) and SBC applications (executed on the SBC server, but displayed virtually on the client PC). Users cannot differentiate on which computer the application is running because both applications look as though they are executed on the local client PC. Therefore, by a simple network configuration, we can provide seamless operation for users of systems that have different, seemingly incompatible, policies. With the TUH configuration, client PCs are allowed to connect to the Internet while the SBC servers are denied connection. As a result, use of the Internet by the HIS is prohibited but users at the local client PC have access.

1.2. Design of Middleware (SBC) Servers

1.2.1. Sizing of SBC Servers

The maximum number of clients that one SBC server can handle is crucial to obtain optimal cost-effectiveness. An overestimate will cause poor system performance because the servers will have insufficient capacity. An underestimate will result in an excessive investment in lightly-loaded servers. We conducted a scenario-based stress testing to determine the configuration described as below:

- Reference SBC server: Hewlett Packard ProLiant BL460c Server Blade with Dual Core Intel Xeon processor 5160 (3 GHz, 1333 MHz FSB), 4 Gbytes memory and 32 GB x2 (RAID-1) hard disk drives
- Application: EPR systems (IBM Japan, Fujitsu and NEC), DICOM Image Viewer (GE Yokogawa Medical Systems), EKG Viewer (Fukuda Electronics) and Radiology Information System (PSP)
- Test scenario: 15 trial items including, a) start and quit the EPR application, b) view a bed map, c) search disease names, d) view a radiology order list, e) print an injection order, and f) perform arbitrary operations such as replaying a movie and cine-mode movie, and zooming-in or out using the DICOM image viewer
- Stress testing: starting with 5 users and adding groups of 5 users until there were 20 users operating within the same scenarios
- Obtained data: status of the SBC server resources: CPU, memory and network traffic

As a result, the average loads of the servers over 5-minute intervals with 20 users were about 76% for CPU and about 3.5 Gbytes for memory (see Figure 2). Therefore the results showed that one SBC server was able to handle 20 simultaneous PC clients. For safety clearance, we decided to set the maximum number of PC clients at 15. Finally, 70 SBC servers were deployed to serve the simultaneous connections of about 1,100 PCs. Again for safety clearance, server memory size was increased from 4 to 6 Gbytes. Consequently, Windows 2003 Server Enterprise Edition was deployed because it manages internal memory in excess of 4 Gbytes.
1.2.2. Selection of SBC Software

In addition to the stress testing, we assessed SBC server software. There were two major types of software in commercial use at the time we made the evaluation: Citrix Presentation Server by Citrix and GO-Global by GraphOn. Based on the requirements outlined by the working groups at TUH, the most crucial selection criteria were user authentication by RFID (non-contact IC card) and flexibility of customization. As a result of the comparison, we deployed GO-Global since GraphOn’s distributors in Japan had expressed full support of customization in accordance with our requirements including RFID. Otherwise, the essential functions and performance were nearly identical for both software applications.

1.3. Design of Client PCs

Of the 1,000 PCs deployed with the previous HIS at TUH, there were about 270 laptop PCs. These became major sources of failures: 68% of all PC failures came from the laptops. They were replaced by thin-clients in the new system. In addition, 470 desktop PCs were recycled and reused and, for some, the hard disk drive was replaced with flash-ROM. The design was intended to reduce failure rates of the PCs as well as their initial installation expense and administrative cost.

2. Problems with Applications Using SBC

We extracted ten issues related to the operation of the SBC system and categorized them into three groups: security, session and peripheral devices.

- **Security:** authenticating users by external media such as IC cards; reducing the time for switching users and logging in; identifying operators who transfer files between PCs and servers; and sharing clipboard data although only PC to HIS server transfers are permitted.
- **Session:** storing a user’s virtual displays and making them available on different terminals (user roaming); restricting the number of sessions that each user and each PC can possess; integrating session information that users have on different SBC servers; and forwarding a PC’s IP address to the HIS for the purpose of access control.
Peripheral devices: handling multiple displays; and switching to the appropriate printers when users “roam.”

We gave priority to those closely related to usability and developed the improved functions for SBC. We describe one of the major functions in the next section.

3. Implementation to Improve Usability

3.1. User Roaming

In SBC model, display screen information of each client PC is kept on the SBC server to which the PC is connected. The information is preserved on the SBC server even when the connection is broken. Making use of this characteristic, we developed “user roaming” so that users can retain their screen regardless of the client PC they use: They can roam to the nearest PC without doing repetitive operations such as logging in or out.

4. Results

4.1. Evaluation of System Design with Regard to Server Sizing

To validate of the estimates we made of server size, we compared the estimated loads with those of the SBC servers actually installed. Nagios [3], a open-source-based network monitoring application, was used to measure the consumption of server resources. Table 1 shows the estimates made during system design and the actual measurements. The actual values for CPU and memory, which were measured with 13 users, are scaled up linearly to 20 users. The results show that the extrapolated loads on the servers were nearly equal to the estimates.

On the other hand, the actual loads of traffic were much less than were estimated: the consumption of network resources under GO-Global environments was smaller than we had expected. This indicates that quantitative assessment with regard to network traffic is indispensable to the SBC design.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Estimate</th>
<th>Actual</th>
<th>Linear extrapolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>76% for 20 users</td>
<td>50% for 13 users</td>
<td>77% for 20 users</td>
</tr>
<tr>
<td>Memory</td>
<td>3.5 Gbytes for 20 users</td>
<td>2.5 Gbytes for 13 users</td>
<td>3.8 Gbytes for 20 users</td>
</tr>
<tr>
<td>Traffic</td>
<td>1 Gbps for server firm switches</td>
<td>58.1 Mbps</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>100 Mbps for edge switches</td>
<td>2.8 Mbps</td>
<td>N/A</td>
</tr>
</tbody>
</table>

4.2. Security Reinforcement

In addition to the intrinsic advantage of SBC such as privacy protection by prohibiting downloads from confidential servers, we could reinforce comprehensive network security by applying different security policies to each client PC. As a result, the Internet connectable network had security that was compatible with the intra-network without having to separate the two. This simple configuration can make the network
secure and usable because it does not need a special arrangement of security devices nor does it require the user to be concerned about security risks.

4.3. Cost Reduction

Introduction of the thin-client has been able to reduce PC failure rates. Prior to implementing SBC, 77 failures cases occurred per year. After deploying SBC, TUH has logged 39 failures in the past 10 months.

After implementing SBC, power consumption was reduced. The average power consumption by client PCs was 40.5 KiloWatts before SBC installation. After installation, SBC servers and client PCs consumed on average 36.1 KiloWatts.

4.4. Usability Enhancement

To evaluate the effectiveness of user roaming, the frequency of user login before SBC implementation was compared to the frequency after implementation. The frequency of login operations dropped from 7,225 to 5,801 per day. The frequency of user roaming was, over the course of a week, an average of 1,378 times per day. The results indicated that the “user roaming” function was able to reduce the login and logout operations of users by about 20%, which was nearly equal to the frequency of user roaming. Moreover, the number of simultaneous sessions between servers and PC clients decreased from 630 to 530. The introduction of SBC not only enhanced the operative efficiency of the system but also reduced the overall workload of the system.

5. Conclusions

SBC was originally designed to strengthen internal control as well as to reduce the total cost of the system. In this paper, we showed that SBC could be effective in large hospitals and that it can provide useful solutions that fit the workflow of clinical staff and leads to enhanced system usability.

References


Applying Natural Language Processing Toolkits to Electronic Health Records – An Experience Report

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Abstract. A natural language challenge devised by Informatics for Integrating Biology and the Bedside (i2b2) was to analyze free-text health data to construct a multi-class, multi-label classification system focused on obesity and its co-morbidities. This report presents a case study in which a natural language processing (NLP) toolkit, called NLTK, was used in the challenge. This report provides a brief review of NLP in the context of EHR applications, briefly surveys and contrasts some existing NLP toolkits, and reports on our experiences with the i2b2 case study. Our efforts uncovered issues including the lack of human annotated physician notes for use as NLP training data, differences between conventional free-text and medical notes, and potential hardware and software limitations affecting future projects.

Keywords. natural language processing, NLP, medical language processing, MLP, toolkits, i2b2

Introduction

Automated computer processing of speech and language is referred to as natural language processing (NLP). Several of those researching and practicing at the intersection of health care and informatics are interested in applying NLP to electronic health care. A good example is in the increasing adoption of Electronic Health Records (EHR) in medical practice, where a large part of the clinical information is in natural language format. Making such information accessible for automatic, computer-based interpretation and processing within the context of EHR systems has been a research challenge for years. If properly realized, NLP promises advantages to health care that are general to the application of NLP and specific to health care. Under general application, NLP may reduce the separation between human and machine by improving human-computer interaction with more natural interfaces. With health care, NLP seems better suited to computerizing traditional physician note-taking than other tools such as form based interfaces or manual annotation of input texts. In this latter context NLP is referred to as medical language processing (MLP), automated computer processing of unpublished written text by medical professionals about their patients.

Successful MLP systems exist but they are constrained to particular problems. For example, an adaptation of MedLEE [1] is capable of mapping clinical information to

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coded form. MedLee performed as well as five of six experts upon evaluation. The coded form is expected to improve interoperability between clinical applications and allow automated processes to employ the natural language data.

Recently, the NLP research community has begun to make their algorithms, methods and data structures available as reusable software toolkits. With the availability of these NLP toolkits, NLP has become more useful as a general application. This movement sparks several intriguing questions pertaining to a) the ease of applying these toolkits, b) the resulting software system and its restrictions, and c) the overall suitability of NLP toolkits for electronic health care.

We participated in the Informatics for Integrating Biology and the Bedside's (i2b2's) natural language challenge (http://www.i2b2.org/NLP) which encourages and promotes development of medical language processing systems that extract important information from free-text health data. The 2008 challenge involves construction of a multi-class, multi-label classification system applied to free-text patient records, focused on obesity and its co-morbidities. The goal was to correctly replicate the textual and intuitive judgments of experts on obesity and its co-morbidities. For each category (e.g., obesity, asthma, gout), each free-text patient record was assigned a label of “Y” (yes, the patient has the co-morbidity), “N” (does not have the co-morbidity), “Q” (Questionable), or “U” (Unmentioned). Textual judgments included every label whereas intuitive judgments (“guessing”) included “Y,” “N” and “Q.”

The i2b2's challenge was undertaken three months prior to the challenge's deadline by a Computer Science graduate with no prior training in NLP. We report on the efforts and pitfalls encountered. The effectiveness of the resulting implementation should give potential adopters of NLP an indication of the costs and benefits of integrating toolkit-based NLP functionality into their health systems. We also discuss several of the limitations of NLP toolkits and offer recommendations on how to overcome these limitations.

1. Background

This section will provide a brief NLP tutorial for those new to the area of NLP. Better coverage of NLP can be acquired by reading Jurafsky and Martin [2] as well as Nugues [3]. Readers requiring an introduction to linguistics could read O'Grady and Archibald [4].

Word segmentation or tokenization is often a first step in NLP. Tokenization involves separating words and sentences from free-text. Tokens are typically separated by white space. There are several instances where this is not the case such as separating “I’m” into “I am” or separating punctuation from a sentence's last word. Tokenization algorithms are often system- and application-specific.

Each extracted token is assigned part-of-speech (POS) tag (e.g., noun, verb, adjective). This is partially accomplished by using an NLP lexicon, that is, a known set of words. These words are typically linked to their POS tags. NLP systems also utilize the concept of consistency of language structure: arbitrary words chained together make a sentence. Only certain POS tags are likely to follow a given POS tag. For example, it is likely that a noun follows the word “the,” e.g., “the disease,” whereas it is unlikely that an adverb follows “the,” e.g., “the perhaps.” A lexicon and knowledge of language consistency form the basis of POS tagging.
NLP systems can employ a corpus to automatically learn POS tags and tag sequences rather than having a person manually instruct (e.g., code or configure) the NLP system. This semi-supervised learning usually requires a corpus annotated by trained individuals with meta-information (such as POS tags).

Generally a noun phrase such as “the painful feet” is regarded as a semantic concept. Concepts used in processing are noun phrases extracted from the free-text. Some NLP systems construct an entire parse tree (i.e., an internal data structure and linguistic representation) of a sentence to extract noun phrases and other semantic information. When NLP systems process only noun phrases (and possibly verb phrases or preposition phrases), they can implement chunking. Successful chunking identifies the noun phrases and constructs a simpler parse tree containing a sequence of single words and chunks (noun phrases).

Each noun phrase can be canonicalized. For example, the phrase “the painful feet” might be converted to a canonical form “pain foot.” It is often necessary to convert phrases to a canonical form so that NLP systems recognize semantic equivalence and similarity between concepts, within and across sentences. In this example, “foot” and “pain” can be semantically related to “the painful feet.” Canonicalization is also referred to as normalization.

2. Toolkit Comparison

The goal of this non-exhaustive NLP toolkit comparison is describe the current state of NLP toolkits, highlight those that may be useful for MLP, and to provide some information about various NLP toolkits. A search was performed in IEEE explore (http://ieeexplore.ieee.org), the ACM digital library (http://portal.acm.org), Pubmed/Medline (http://www.ncbi.nlm.nih.gov/pubmed) and Google. Keywords such as “natural language processing,” “NLP” and “toolkit” were used. The following toolkits were found:

- NLTK (http://nltk.org)
- LING PIPE (http://alias-i.com/lingpipe)
- MALLET (http://mallet.cs.umass.edu/index.php/Main_Page)
- GATE (a framework and, thus, omitted from Table 1; http://gate.ac.uk/documentation.html)
- openNLP (http://www.opennlp.org/projects.html)
- MII Natural Language Processing Toolkit (http://www.mii.ucla.edu/nlp)

The result of this search is presented in Table 1. The help documents and application programmers interface (API) were examined for each toolkit in order to complete the categories shown in the table.

Most of the toolkits used chunking of noun phrases rather than performing a full syntactic parse. Few of the toolkits facilitate MLP through specific mechanisms such as a medical vocabulary. There is no complete solution for someone who wishes to implement MLP. Researchers may wish to combine toolkits to achieve comprehensive coverage of NLP and MLP. For example, one could combine openNLP with SPECIALIST.
### Table 1. Non-exhaustive toolkit comparison with main categories emphasized.

<table>
<thead>
<tr>
<th>Category</th>
<th>Natural Language Processing Toolkits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NLTK</td>
</tr>
<tr>
<td>Purpose</td>
<td>NLP</td>
</tr>
<tr>
<td>Speech</td>
<td></td>
</tr>
<tr>
<td>Tokenization</td>
<td>○</td>
</tr>
<tr>
<td>POS Tagging</td>
<td>●</td>
</tr>
<tr>
<td>Parsing</td>
<td>○</td>
</tr>
<tr>
<td>Parsing</td>
<td>●</td>
</tr>
<tr>
<td>Syntactic</td>
<td>●</td>
</tr>
<tr>
<td>Stochastic</td>
<td>●</td>
</tr>
<tr>
<td>Features/Unification</td>
<td>●</td>
</tr>
<tr>
<td>Co-reference</td>
<td>●</td>
</tr>
<tr>
<td>Semantics</td>
<td>○</td>
</tr>
<tr>
<td>First Order Logic</td>
<td>●</td>
</tr>
<tr>
<td>Description Logic</td>
<td>●</td>
</tr>
<tr>
<td>Lexical Disambiguation</td>
<td>●</td>
</tr>
<tr>
<td>Medical</td>
<td>●</td>
</tr>
<tr>
<td>Abbreviations</td>
<td>●</td>
</tr>
<tr>
<td>Acronyms</td>
<td>●</td>
</tr>
<tr>
<td>Spelling</td>
<td>●</td>
</tr>
<tr>
<td>Temporal</td>
<td>●</td>
</tr>
<tr>
<td>Corpus</td>
<td>●</td>
</tr>
<tr>
<td>Utilities</td>
<td>●</td>
</tr>
<tr>
<td>Hidden Markov</td>
<td>●</td>
</tr>
<tr>
<td>Max Entropy</td>
<td>●</td>
</tr>
<tr>
<td>General Corpus</td>
<td>●</td>
</tr>
</tbody>
</table>

○ indicates only partial completeness, ● indicates a high degree of completeness

### 3. Effort and Pitfalls

#### 3.1. Hardware

This i2b2 submission was implemented and tested on a MacBook with a 2.2 GHz Intel Core 2 Duo processor and 4 GB of memory, running Mac OS X 10.5.5. Processing 4 MB of data required approximately 10 hours and 1 GB of memory. Python (2.5.1) processes, consequently NLTK, can not be split across multi-core processors which may have affected the program's run time. The intensive processing was run at night and results were cached. This improved the rate of subsequent processing and resulted in few lost work-hours.

#### 3.2. Tokenization

Dividing the medical free-text into tokens was achieved through simple tokenization on whitespace. A manual inspection indicated that this appeared to be an acceptable approach. Parsing tokens that were not separated by whitespace was problematic. For example, the tokenization algorithm must differentiate between an abbreviation such as “b.i.d.” and a word conjoined with a period such as “physician.”. Simple rules were devised to achieve proper tokenization. The rule for this example is: “separate the period from the token if, without the period, the token is known.” Although these rules worked well upon manual inspection, they are easily tricked.
3.3. Syntactic Tagging and Sentence Chunking

The i2b2 submission learned syntactic tags and syntactic tag sequences from Penn Treebank data (supplied with NLTK). This data excluded medical free-text. As a consequence, many words appearing in the medical free-text were unknown to the software, and the tag sequences of the medical free-text differed from that learned. The heterogeneous format of medical free-text, which consisted of some text including various headers, sections and footers, further complicated chunking. Inspection revealed that many sections started on a newline, were capitalized and ended with a semicolon. A regular expression and a simple algorithm were employed to extract each section. This preprocessing step permitted non-free-text sections to be ignored and provided contextual information for the classifier: classifier features could be prefixed with the section name and period (e.g., “history.diabetes”).

A classifier based on keywords was evaluated without MLP (considering all words) and with MLP (considering only identified nouns, adjectives and verbs). The MLP system generally improved final classification and several categories resulted in a substantial improvement such as the category diabetes, where the system’s performance more than doubled. The final submission based on noun phrases approximately doubled the performance of the keyword-based classifier. This evidence would support the benefits and relative success of the implemented syntactic tagging and sentence chunking system.

3.4. Concept Normalization

Noun phrases were considered to be representative of concepts within the medical free-text. Noun phrases representing a similar semantic concept could easily differ syntactically (e.g., “large red ball” and “red large ball”) and words within a noun phrase could differ morphologically (e.g., “diabetes” and “diabetic”). To remove these differences, noun phrases were normalized by applying the Lancaster stemmer available in NLTK. After stemming, the tokens were sorted. This improved classification. For example, the correctness on one run improved by about 6% (textual) and 4% (intuitive).

3.5. Negation

A simple negation algorithm was implemented. Several key negation tokens (“no,” “none,” “non,” “neither,” “nor,” and “without”) were selected after manual inspection of the medical free-text. A concept was negated if a negation token was seen prior to the concept. This algorithm seemed to match with the inspected text but has obvious shortcomings (e.g., “diabetes was not present”). The negation token was ignored upon sentence termination whereas negation continued to be applied if a negated concept was followed by any of the following tokens: “of,” “or,” “with,” and “from.” This trivial algorithm affected the classification results, though minimally.
4. Conclusion

Several lessons were drawn from participation in the i2b2 challenge. Medical free-text differs from conventional text such as newspapers or books. There appears to be greater use of abbreviations, acronyms and short phrases rather than full sentences. Also, medical free-text appears to contain more spelling mistakes and ungrammatical productions than conventional text. Given these differences, MLP could benefit from human annotated physician notes for use as NLP training data. This would allow the MLP system to automatically learn some of these differences. Unfortunately, no annotated corpus is available for such automated learning.

Both learning and processing of free-text is time consuming. Although better algorithms, different programming languages or faster computers can decrease MLP run times, researchers and implementers should be prepared for long processing times.

The textual and intuitive submissions ranked 27th of the 28 challenge submissions, leaving several opportunities for improvement. It is likely that extracting noun phrases from medical free-text produced an incomplete and inaccurate model of the patient. Applying classification algorithms to a more complete and accurate patient model could result in better free-text classification. Two model components, time and uncertainty (e.g., “without significant tremors”), are absent but should be captured due to their importance in medicine.

Although this initial attempt at MLP was far less successful than desired, it should be possible to incorporate simple MLP into existing systems. Systems working with keywords and key phrases could benefit from simple MLP through processes such as normalization. Systems requiring a coarse result from textual input, such as a more intelligent help system that better interprets key phrases, or a context sensitive interface that requires coarse estimates of input text, should profit from MLP. Regardless of the project, it is easy to underestimate the complexity and difficulty of MLP without previous MLP experience.

Acknowledgements

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References

Improving the Efficiency and Accuracy of a Tablet PC Interface for Computerized Provider Order Entry Through Usability Evaluation and Provision of Data Entry Strategies

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Abstract. Six nurses participated in usability testing sessions during which they entered 35 physician orders using a tablet PC. Their performance was recorded and then replayed to code the user and system behaviours associated with order entry. Results indicate that problematic user navigational and data entry behaviours occur more frequently than system related behaviours but that the latter are associated with much higher error rates. Field-specific data entry strategies introduced during user training were adopted 77.6% of the time and resulted in improved efficiency.

Keywords. CPOE, tablet PC, usability testing, data entry strategies

Introduction

The tablet PC’s putative navigational ease, handwriting recognition capability, portability, and wireless network connectivity appear to address a number of data entry and work flow integration issues related to the implementation of health care information applications such as computerized provider order entry (CPOE). Recent evidence indicates that the use of desktop and hand held computers for CPOE have resulted in a number of unintended negative consequences [1], including technology induced errors [2,3]. As new computer hardware and alternative modes of human-computer interaction become available, it is imperative that their impact on performance be thoroughly evaluated, especially for error sensitive applications such as CPOE.

The extent and methods used to provide clinician training and support are critical for successful CPOE implementation [4,5]. Novice CPOE users, who intend to use the software on non-desktop devices such as tablet computers, face multiple challenges: not only must they learn to negotiate a new application interface, they must also acquire the requisite navigational and data entry skills for effectively using the tablet PC interface. In addition, some data entry controls with which users are familiar and skilled in the desktop environment, are more difficult to use with the tablet PC interface.

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They appear identical and have the same functionality, but some of the actions required to use that functionality, such as scrolling, are more difficult to execute.

Although one might expect that computer users would develop performance optimizing strategies over time through trial and error or experimentation, this is not supported by empirical evidence. Research indicates that even experienced users of complex computer applications such as spreadsheets and computer aided design (CAD) are unlikely to spontaneously acquire these strategies [7,8] and that this suboptimal application use is persistent [9,10], with obvious implications for productivity. A cognitive analysis of user interaction with a commercial CPOE system [11] also demonstrated that strategies are not readily apparent to users.

**Study Objectives**

This paper describes a portion of a larger, laboratory based usability study of a tablet PC interface for CPOE to identify potential generic and application-specific usability issues. Its focus is to identify and measure both user and system behaviours which affect the efficiency and accuracy of navigation and data entry, and to evaluate the effectiveness of field-specific data entry strategies provided to users.

**Study Setting and Background**

The study took place at a large provincially operated residential facility for developmentally disabled individuals. A legacy MS-DOS based physicians’ orders database application, developed in-house has been used for over 10 years. Orders are handwritten by staff physicians in traditional fashion and then entered in the database by nurses, each of whom has an assigned caseload. A tablet PC was purchased to explore the advantages of its use for order entry during physician/nurse rounds. The combination of stylus input and handwriting recognition 
appear to provide a more intuitive user interface, but this must be empirically verified.

1. **Methodology**

1.1. **Subjects**

Subjects were 6 female nurses employed at the facility, all with previous experience using the facility’s existing DOS-based doctors’ orders software. Five of 6 nurses were aged 40 to 64 years and trained at the college level. Their average length of nursing service was 23.7 years (range 15 to 36 years). They had worked for all or most of their careers in long term care settings (average 20.3 years; range 13 to 34 years).

1.2. **Procedure**

Each nurse participated in two usability evaluation sessions that consisted of several segments involving specific tasks. On average, sessions occurred 8 days apart (range two to 15 days) with the primary determinant being nurses’ schedules. Both sessions took place in the researcher’s office. The same room setup and recording methods were used throughout (see Figure 1).
Subjects were seated at a desk with a convertible style tablet PC (HP tc4200 running Microsoft Windows Tablet PC Edition 2005) positioned in portrait mode on the desk in front of them. Room lighting consisted of a single halogen floor lamp which provided bright but diffuse ceiling-directed light. The researcher, seated in the same room to the right of the subject, was not able to directly view the tablet PC screen during task performance but was close enough to observe a subject’s general behaviour, and to intervene if required.

During Session 1, subjects received tablet PC training including navigation skills (pointing, tapping, scrolling), the use of the tablet input panel (TIP) for entering handwritten data and the use of data entry objects such as drop-down lists and text boxes. This provided the opportunity for limited practice during which the researcher could observe and correct any fundamental problems.

To improve the efficiency of data entry, the researcher provided subjects with four content specific data entry strategies. That is, depending on the nature of the data to be entered and the attributes of a given data entry object, there is an optimal method (strategy) for entering the data which requires less time, involves fewer taps and has a reduced risk of unexpected outcomes.

The focus of this paper is on three usability testing segments during which subjects entered a total of 35 physicians’ orders. The first segment of five simple orders (during Session 1) was to assess the “walk-up usability” of the interface. No order entry training was provided prior to this segment. After its completion, the researcher answered subjects’ questions and re-iterated the appropriate data entry strategy for use at each field. The next segment consisted of entering 15 orders of varying complexity, representative of the diversity that occurs in clinical use. A similar set of 15 orders was entered during Session 2. All orders were derived from the order entry application currently in use at the site and were entered from printed lists.

Prior to each order entry segment subjects were asked to “think aloud” while completing tasks, i.e., to verbalize their thoughts, especially concerning questions or problems they experienced. It was explained that although computer screen and camcorder video provided the opportunity to record their behaviour, their thoughts were valuable in terms of understanding their interaction with the system.

During task performance, the researcher’s interaction with subjects was limited to the following situations: 1) verbal prompts to think aloud if a subject spoke infrequently, 2) token verbal or gestural acknowledgment of speech directed at the researcher, but to which further responses could have been potentially distracting or
interruptive, 3) response to subjects’ direct requests for help or when the researcher observed that subjects had reached an impasse which they were unable to resolve.

Three types of recording took place during each task set. Hypercam© video capture software recorded the action on the tablet PC screen and subject verbalizations. Video and audio recording of subjects’ overt behaviour (tablet PC screen and subjects’ hands) was accomplished with a tripod-mounted camcorder. This additional type of recording was used due to the exploratory nature of the research and the desire to capture all forms of potentially meaningful subject behaviour. The third type of recording consisted of a software-based logging routine embedded within the order entry software which permitted the duration spent at each object to be calculated. This software as well as that used by subjects during all usability evaluation testing was developed by the author using Microsoft Access, Version 2002.

At the end of Session 2, subjects completed a 10-item, paper-based quiz to determine if they could match the appropriate content-specific data entry strategy with data items which might appear as individual fields within an order entry screen.

1.3. Data Analysis

Movie files were viewed three times with Transana© video analysis and Windows Media Player© software to prepare a transcript of participant verbalizations, code and quantify 54 operationally defined user and system behaviours, and to further code and annotate the transcripts. A total of 4692 events were coded during order entry from playback of 10 hours of video. Categories of coded events included: Navigation, Data Entry Problems, Handwriting Recognition & Correction, Slips, Mistakes, Interaction with Experimenter, Messaging, and User Insights. The use/non-use of four field-specific data entry strategies provided to participants during training was also coded, as were data entry errors. Data were recorded and summarized with Access database applications developed by the author.

2. Results

Accuracy is characterized by the number of errors which occur when a task is performed. Errors can be characterized as either slips, mistakes detected by the application or mistakes undetected. “Slips” refer to those errors which users detected themselves and corrected. “Mistakes detected by the application” are errors that were not noticed by the user, but which were detected by the order entry screen’s data integrity rules and brought to the user’s attention by way of an error message. “Mistakes undetected” refers to errors which were not noticed by the user or the system and were saved with the order. As Table 1 indicates, the combined total of errors detected by the user and the application was 89.9% (125/139) indicating that the majority of errors were caught and corrected before an order was saved.

For purposes of this study, efficiency is defined as the number of unnecessary or problematic behaviours exhibited by either the user or the system and by the time required to complete a specific task (data entry field). As indicated in Table 1, the combination of user navigation and data entry behaviours (1069) represents 75% of the overall total of 1429. Although the frequencies of some navigational behaviours such as “extra taps” and “taps on non-target areas” are very high, they are not associated with errors, but do represent wasted time and effort for the user. By comparison,
system behaviours such as “misrecognitions” are relatively frequent and are much more highly associated with errors (47.9%). Although it is beneficial that 85.3% (87/102) of misrecognitions were detected before orders were saved, the time and effort required to correct misrecognitions reduced efficiency.

Table 1. User and system behaviours and their relationship to errors

<table>
<thead>
<tr>
<th>User Behaviours: Navigation</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>Total</th>
<th>Slips</th>
<th>Mistake Detect App</th>
<th>Mistakes Undetected</th>
<th>Total Errors</th>
<th>% Problems Assoted Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mistaps</td>
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<td>45</td>
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<td>17</td>
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<td>18</td>
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</tr>
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<td>50</td>
<td>81</td>
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<td>76</td>
<td>438</td>
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<td></td>
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<td>107</td>
<td>8</td>
<td>65</td>
<td>33</td>
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<td>233</td>
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<td>Scrolling Problems</td>
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<td>2</td>
<td>2</td>
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<td>5</td>
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<td>1</td>
<td>5.3</td>
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<tr>
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<td>0</td>
<td>11</td>
<td>0</td>
<td>1</td>
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<td>34</td>
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<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
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<table>
<thead>
<tr>
<th>User Behaviours: Data Entry</th>
<th></th>
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<tbody>
<tr>
<td>Disregard</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>11</td>
<td>12</td>
<td>6</td>
<td>42</td>
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<td></td>
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<tr>
<td>Failure to erase previous value</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>14</td>
<td></td>
<td></td>
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<td>Reload TIP Required</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attempt to save incomplete order</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>21</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple values / data types</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>55.6</td>
<td></td>
</tr>
<tr>
<td>Wrong data in field</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Format</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>14.3</td>
</tr>
</tbody>
</table>

System Behaviours

| Misrecognitions              | 28 | 39 | 42 | 32 | 52 | 20 | 213 | 76  | 11  | 15  | 102 | 47.9          |
| Other Recognizer Issues      | 5  | 2  | 4  | 2  | 5  | 4  | 22  | 2   | 2   |     |    | 9.1           |
| Leading space(s)             | 3  | 4  | 25 | 3  | 9  | 0  | 44  |     |     |     |    |               |
| Preferred action not clear   | 1  | 0  | 2  | 0  | 1  | 0  | 4   |     |     |     |    |               |
| Cursor focus / Position not clear | 0  | 2  | 0  | 1  | 6  | 0  | 9   | 8   | 1   | 9   | 100 | 2.5           |
| Occlusion                    | 7  | 3  | 9  | 7  | 9  | 5  | 40  | 1   |     |     |    |               |
| TIP Persistence and occlusion| 1  | 1  | 6  | 1  | 8  | 5  | 22  |     |     |     |    |               |
| Problem Other                | 3  | 0  | 0  | 0  | 1  | 2  | 6   |     |     |     |    |               |
| Total                        | 115| 355| 171| 285| 315| 188| 1429| 107 | 18  | 14  | 139 |              |

The intent of providing users with field-specific data entry strategies was to reduce inefficiency. Optimal data entry strategies were used 77.6% of the time by users (combined results for medication/treatment, frequency, times and indication fields). On average, users completed these fields 5.5 seconds faster (22.9 seconds versus 28.3 seconds) when the optimal data entry strategy was used. Interestingly, the average user score for the strategy quiz was 88.3% correct responses, indicating that users’ demonstrated very good knowledge of optimal strategy use, but applied it less often.
3. Discussion

The development and deployment of CPOE continues to take place within the context of continuous information technology innovation. Even while the present study was underway, the next (Vista) version of Microsoft’s operating system had already been released, as had more sophisticated tablet PC hardware that added touch screen functionality. The order entry tasks completed by users in this study were very simple (in essence consisting of copy typing) and were performed under controlled conditions. Even so, a significant number of problematic navigational, data entry and system behaviours occurred, some of which were associated with very high error rates. This supports the need for rigorous and detailed usability evaluation of CPOE software. Although the functional requirements for CPOE software are being increasingly refined [12], and certification processes have been implemented [13], there is a need to routinely and systematically evaluate the performance of these applications.

The results of the present study demonstrate that users will adopt data entry strategies provided as part of application training, and that they are effective in improving efficiency. Further research is required in order to determine how the introduction and use of such strategies can further enhance the efficiency of CPOE use.

References

Mobile Phones As Mediators of Health Behavior Change in Cardiovascular Disease in Developing Countries

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Abstract. The global burden of cardiovascular diseases (CVD) is becoming a growing problem in developing countries. Successful self-management of CVD is dependent on a multitude of factors, including social support, communication with health care providers, careful monitoring, and other determinants. The growing market penetration and the communication properties of mobile phones create opportunities for innovation in promoting CVD self-management through support of lifestyle and behavior modification. Mobile phones support various modes of communication and interaction, have fewer adoption barriers, and are more prevalent than other available technologies in developing countries. However, mobile phone interventions are not without many challenges such as mobile infrastructure, electric infrastructure, access to mobile devices, and appropriate user interfaces for interaction. In this paper, we discuss current evidence as well as research opportunities to explore the role of mobile phones in supporting behavior modification in developing countries.

Keywords. cardiovascular disease, health behavior change, mobile technologies, developing countries

Introduction

Health information technologies (HIT), which include computers, mobile devices, and other technologies, have great potential to advance health care globally. The selection and development of technologies for particular medical problems in specific settings or geographic regions is dependent on the availability and access of the technology, as well as the extent to which the functionalities of the technology can support health intervention. The development and application of these technologies can be informed by the different elements of the interaction among technologies, health interventions, and individuals. Various factors influence this interaction, including human behaviors, the clinical domain, medium of the health intervention, barriers, and setting. The growing market penetration and the communication properties of mobile phones create opportunities for innovation in promoting cardiovascular disease (CVD) self-management through support of lifestyle and behavior modification. In this paper, we discuss current evidence as well as research opportunities to explore the role of mobile phones in supporting behavior modification in developing countries.

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1. Global Cardiovascular Disease Burden

CVD has been a health burden in developed countries, receiving widespread attention and awareness. However, the shift of demographics around the world is changing the distribution and prevalence of disease. As populations are gaining longer life expectancies, people are surviving into the older decades when CVD impacts can manifest. Trends of urbanization are also increasing the prevalence of environmental factors that influence lifestyle habits that increase risk of CVD, including tobacco addiction, reduced physical activity, and diets high in fat [1-3].

Populations in developing countries are also experiencing onset of CVD at younger ages, including working ages [2,4]. Limited resources and access to preventative and management interventions in developing countries contribute to this burden [2,4]. About 80 percent of the global burden of CVD death occurs in low- and middle-income countries, and the proportion continues to increase [3,5]. Driven by this increase, CVD is projected to be the leading cause of death in developing countries in 2010 [6], and the leading cause of death and disability around the world by 2020 [5].

2. The Emergence of Mobile Phone Use in Developing Countries

Most information and communication technologies (ICT) are only slowly being adopted in developing countries. The exception is that most people in developing countries have access to and use mobile phones, which are more prevalent than computers or internet access [7,8]. In Africa in 2004, there were approximately 82 million users of cell phones, with an average annual subscriber growth of 58% for the continent [9]. There are more mobile phones than fixed-line phones in sub-Saharan Africa [10].

The existing infrastructure and growing use of mobile phones emerges as a natural tool to explore as an intervention to promote health. Mobile phones can be a wide-reaching and effective mode of communication for populations in developing countries, particularly in rural regions. There are cost-effective and user-friendly advantages to utilizing mobile phones as a mode for intervention, but also limitations of data transmission, cost, language, and literacy demands [11]. Additional underlying factors for success are mobile infrastructure, electric infrastructure, access to low-cost mobile devices, and appropriate user interfaces for interaction [12,13]. However, all technologies present similar challenges, and the greater prevalence of mobile phones makes them a promising tool for health behavior interventions.

3. Lifestyle Modification for Reduction of CVD Risk Factors

Effective self-management of cardiovascular diseases can reduce the risk factors as well as alleviate the health impacts of CVD. Most of the risk factors for CVD can be attributed to modifiable lifestyle and behavioral patterns [5]. Behavioral risk factors that are most in need of targeting are tobacco consumption, hypertension management, physical activity levels, weight management, and diet [1,4,14]. While CVD can be preventable and treatable through modification of lifestyle practices and behaviors, there are a variety of psychosocial and environmental barriers to success. Modifying
behavior, and maintaining the modifications, requires emotional, social, and physical support.

Tailored communications that target the individual’s readiness to modify behaviors such as diet and physical activity have been proven to be effective for promoting behavior change [15-18]. These tailored interventions require individualized assessment and feedback and need to take into account the individual’s social and environmental context [19,20]. Tracking lifestyle and behavioral changes is also a long-term process, requiring monitoring of status, progress, and follow-up with healthcare providers or with counselors. Interactive communication that engages the individual in the health behavior intervention, such as collaborative goal-setting, and interpersonal communication that reaches the individual at an emotional level can also enhance the efficacy of behavior change interventions [20,21]. In addition to support and guidance from healthcare providers, individual social support networks are important pillars for achieving behavioral modification [22].

Interventions that support behavior change thus require communication tools that facilitate: 1) dynamic patient-provider interaction; 2) communication with support groups, family members, and friends; and 3) access to tailored information and feedback.

4. Mobile Phones in Health Behavior Change Interventions

The functionalities and affordability of mobile phones can be leveraged in a manner that augments the reach and effectiveness of behavioral interventions. Mobile phones support both two-way synchronous conversation (voice calling) and durable textual communication (short message service, or SMS) among geographically distant individuals, which can allow users to record and transit information, as well as communicate with health professionals, family members, friends, and other sources of information and support. Additionally, mobile phones are portable and support data entry and data storage, which facilitates monitoring patient activity and progress. The SMS feature supports data exchange, facilitating monitoring as well as delivery of tailored information [23]. Access to information sources, such as information hotlines or query by text message, can remotely answer patient questions and fulfill information needs.

A recent review of mobile-phone based health interventions revealed that mobile phones can be a positive means of promoting health outcomes, but most of these studies have been done in developed countries [11]. Mobile phone communication and functionalities are being used in behavior change interventions, such as for smoking cessation [24,25], physical activity [26], and dietary changes [27,28]. In one successful intervention, patients enrolled in a behavior management program received individualized diet and exercise plans. During a 12-week period, patients received weekly SMS messages about diet, exercise, and behavior modification. This intervention was able to help patients reduce weight, waist circumference, blood pressure, and other CVD risk factors [28]. Individuals living with HIV receiving tailored smoking cessation sessions by telephone were found to be more likely to have made a quit attempt, and to have a longer period of abstinence from smoking [25]. A preliminary study of a mobile phone-based fitness tracker that allows users to track daily walking steps and share their goals with other users is being further explored [26]. These interventions leveraged SMS messages, voice communication, and mobile
phone-based applications to deliver tailored communications and support monitoring of patient behaviors and progress.

5. Potential for Mobile Phones for Health in Developing Countries

There is also preliminary research exploring the potential of mobile phones as a potential intervention tool in developing countries. For example, findings from a survey of people living with HIV/AIDS in Peru suggest consumer enthusiasm for the potential of mobile device interventions in supporting HIV behavioral support in resource-constrained settings [29]. Another survey of patients enrolled in a CVD program in Santiago, Chile found that a majority of patients were willing to use telephone-based care for emotional support, and to receive telephone care management [30].

However, there are few large-scale studies exploring the use of mobile phones for health in developing countries. While there is potential to learn from existing studies in developed countries for implementation in developing countries, there are numerous differences in practice (e.g., the proportion of phones that are shared rather than personal) and other barriers which call into question the extent to which these studies generalize to developing countries [11].

There is continued research in monitoring and understanding the patterns of mobile phone use in developing countries, which informs how mobile phone interventions should be developed [8,10]. Some initiatives are exploring the development of mobile social software for developing countries [7]. There is also a growing community of researchers exploring the usability and interaction issues of using mobile phones in these countries [31]. A human-computer interaction research team in South Africa investigated usability and design issues of mobile phones, highlighting research needs such as exploring optimal use of small display screens such that they do not hinder performance and understanding [32]. There is also need to develop simple to learn and culturally relevant interactions and icons to promote usability and adoption of mobile phones for diverse populations in developing countries [31]. These types of initiatives can be leveraged to promote use of mobile phones to facilitate access to social support networks, disease monitoring, and delivery of tailored communications to promote disease self-management. Although this research is still in its infancy, they hold considerable promise that mobile phones may be an effective medium of health communication.

6. Discussion

There is both great need and great opportunity to reduce the growing physical, economic, and social burdens of CVD around the world and in developing countries in particular. The challenge of influencing behavioral and lifestyle changes for health promotion is unique to different communities. A range of environmental, economic, and social factors can impact the effectiveness of an intervention. Hence, local development of research, evidence-based guidelines, and patient education materials are necessary to promote the local relevance of interventions [33].

In order to facilitate the dissemination of technological interventions for CVD prevention, there is need to conduct assessments on feasibility and perceptions of both patients and providers. Additionally, understanding workflow and local capacity are
necessary to explore the feasibility and integration of technological interventions in clinical settings. There is also need for technical expertise and support for users, as well as the knowledge resources to create information hotlines or databases. As with any intervention, support and buy-in of vital stakeholders is critical – in this case, patients, providers, and mobile phone companies [11]. There would then be potential to design mobile phones with functionalities and display features that are more supportive of health promotion behaviors. The global research community is continuing to gather knowledge and resources, and has tools that with further development can meet the needs to reduce the growing burden of CVD. The research agenda can further explore the functionalities of mobile phones to be leveraged for support of other chronic illnesses, such as HIV/AIDS, diabetes, and tuberculosis.

HIT has great potential for advancing health worldwide. The growing market penetration and the communication properties of mobile phones create opportunities for innovation in promoting CVD self-management through support of lifestyle and behavior modification. While other technologies, such as land-line phones and computers, can also support interactive communication, there are a certain set of attributes unique to mobile phones that best support behavior change interventions. Communication properties and functionalities, including voice calling, data entry and data storage, mobility, and SMS messaging provide effective and efficient tools to support the communication needs of behavior change interventions, for healthcare monitoring, delivery of tailored communications, and access to social support.

References


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Ongoing Evaluation of Ease-of-use and Usefulness of Wireless Tablet Computers Within an Ambulatory Care Unit

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Abstract. This ongoing research is to assess user acceptance of wireless convertible tablet portable computers in their support of patient care within the clinic environment and to determine their impact on workload reduction for the information staff. A previous publication described our initial experience with a limited wireless environment. There, we tested the premise that wireless convertible tablet computers were equivalent to desktop computers in their support of user tasks. Feedback from users demonstrated that convertible tablet computers were not able to replace desktop computers. Poor network access was a weakness as well as the “cognitive overhead” encountered due to technical problems. This paper describes our further experience with a centre-wide wireless implementation while using a new wireless device. The new tablets, which have some unique functions that existing desktop computers do not provide, have been well received by the clinicians.

Keywords. wireless tablet computer, ambulatory care, iMPROVE, evaluation

Introduction

A recent publication in Medical Computing Reviews [1] described our initial experience with a limited wireless environment. We tested the premise that wireless convertible tablet computers were equivalent to desktop computers in their support of user tasks. Our evaluation methodology comprised a 68 item questionnaire using a 7-point Likert scale. One question was, for example, “I find the tablet easy to carry around in clinic.”

The questionnaire focused on three major issues: 1) the user’s perception of the technical properties of the tablet computer, 2) how well the tablet could be integrated into the clinic environment during patient encounters and 3) how well the tablet supported the user’s interaction with established Agency-standard software. The survey examined 8 separate domains that ranged from ergonomics to usefulness in clinical and on-clinical activities. Feedback from 13 users demonstrated that convertible tablet computers were not able to replace desktop computers. Poor network access was a weakness in addition to the “cognitive overhead” encountered with technical problems.
The tablets have functions such as viewing up-to-date dictations, lab information, images and guidelines with the patient and family in the exam room that existing desktops do not. This paper describes our further experience with a centre-wide wireless implementation in conjunction with a new wireless device. A brief summary of the iMPROVE project is provided.

1. Current State

We have had, since July 2008, a secure, non-broadcast wireless environment (802.11b/g) throughout the Cancer Centre using two Cisco 4402 Wireless LAN Controllers and 30 Cisco Aironet 1131AG LWAPP (Lightweight Access Point Protocol) Access Points. The access points are connected to the network with PoE (Power over Ethernet) switches. The network provides -50 to -60 dBm coverage on all three levels of the Cancer Centre. The wireless devices are HP Compaq 2710p convertible tablet computers with Windows XP Professional for Tablet installed. Standard Agency software includes the Cancer Agency Information System (CAIS), E Film, and Internet Explorer with additional software as required by specific disciplines, e.g., Radiation Oncology and ARIA®.

Each oncologist was assigned a tablet to use for all clinical activities and any optionally-desired non-clinical activities. They received a brief demonstration of the device’s features and were directed to the tutorials available on each tablet.

Expert users are available to demonstrate the use of technically demanding functions. They also solve network connectivity and user authentication problems.

2. Methods

The iMPROVE project collected data on chart activities during May 21 to 27, 2008. This was repeated during the pilot period of July 14 to 25, 2008, when the tablets were being implemented. Physicians were asked to complete a four-item questionnaire using a four-point Likert scale (strongly disagree = 1, strongly agree = 4).

The tablet questionnaire from the previous study was modified. A section was added on printer use. Managing authentication issues was added to the network section. Two questions, which were about the use of a chart or tablet before seeing the patient, were removed. A question, which was about the use of the tablet on the patient’s exam table, was added.

Questions regarding the Patient Manager (ARIA®) were added for the radiation oncologists. These questions were about its ease of access, where it would be used, and whether or not the it should be installed on tablet computers even though it is already available at certain desktop computers.

We enhanced the questions about non-clinical use by asking for which meetings the tablets were used rather than paper. After revision, the questionnaire contained 73 questions. In September 2008, it was sent out electronically using a Microsoft Word form. The domains and pertinent attributes of the questionnaire are shown in Table 1.
Table 1. Domains and attributes of the September 2008 study.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomics</td>
<td>Weight, portability, handling, configuration (tablet versus clamshell), ease of changing configurations</td>
</tr>
<tr>
<td>Graphical User Interface</td>
<td>Screen orientation (portrait versus landscape), screen brightness, desktop visibility, digital pen (ease of use as compared to a mouse and sub-menu), handwriting function, virtual keyboard, viewing desktop icons</td>
</tr>
<tr>
<td>Battery and Power</td>
<td>Battery strength during clinic, battery heat, use of the AC adapter, charge time</td>
</tr>
<tr>
<td>Network Access</td>
<td>Ease of logon, difference in logon between tablet and desktop, logon configuration (clamshell versus tablet), connection state, network accessibility, managing authentication issues</td>
</tr>
<tr>
<td>Printing</td>
<td>Printer setup, Reset default printer</td>
</tr>
<tr>
<td>Electronic/Paper Charting</td>
<td>Use of chart +/- tablet during patient encounters</td>
</tr>
<tr>
<td>Patient-Practitioner Tablet Interactions</td>
<td>Use of Windows Journal (note taking application using tablet and digital pen) during new patient interviews, access to needed information during various visit types, location of tablet computer (lap, counter tops, etc.)</td>
</tr>
</tbody>
</table>
| Application Use               | CAIS: Opening oncologist’s schedule, navigation, preferred configuration  
|                               | E Film: Screen orientation, download speed, screen resolution for various image types, comparing image series, navigation  
|                               | Internet Explorer: Access to the internet/intranet, web use and browser based calculators as compared to desktops  
|                               | Patient Manager: Access, location of use (ambulatory care, dictation room, patient review, etc.), need for application |
| Usefulness in Supporting Clinical and Non-clinical Activities | Equivalence to desktop in supporting clinical activities, some functions perform better with the tablet computer while in a patient exam room: reviewing images, labs, up to date documents, completing forms, printing prescriptions, patient education material, taking notes with Windows Journal. Could replace a desktop computer during clinical activities, supporting non-clinical activities such as meetings, journal club, etc. |

3. Results

The results are shown in Table 2 expressed as means with standard deviations. iMPROVE data is reported in time in minutes per chart spent printing or filing documents. Section scores are the sum of the means. The overall score is the sum of the section means. Location results from non-clinical activities and the Patient Manager are not yet reported. They await further input.

The iMPROVE pilot period observed a 1.14 minute/chart reduction (37%) in printing and filing information already available through CAIS. The oncologists scored a mean of 3.4 when asked if they had access to essential documents without printing to the chart. They scored 3.0 when asked if the tablets allowed them to practice at least as well as when documents were printed to the chart.

3.1. Demographic Statistics

Fourteen out of 25 (56%) participants returned the tablet questionnaire. The age range was 34 to 57 with a mean of 43.6. The group consisted of 8 medical and five radiation oncologists with one general practitioner in oncology. Six were female and 8 were male. Their self-assessed computing experience was: three - limited, 7 - intermediate and four - extensive. Seven current users participated in the previous evaluation.
Table 2. Survey results.

<table>
<thead>
<tr>
<th>Domains</th>
<th>Prior Study</th>
<th></th>
<th>Current Study</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Ergonomics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tablet weight is not an issue</td>
<td>5.1</td>
<td>1.2</td>
<td>4.7</td>
<td>1.4</td>
</tr>
<tr>
<td>The tablet is easy to carry around</td>
<td>4.4</td>
<td>1.7</td>
<td>5.5</td>
<td>1.2</td>
</tr>
<tr>
<td>The tablet is easy to handle</td>
<td>4.6</td>
<td>1.3</td>
<td>5.6</td>
<td>1</td>
</tr>
<tr>
<td>Clamshell configuration is easy to use</td>
<td>5.5</td>
<td>1</td>
<td>5.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Tablet configuration is easy to use</td>
<td>4.8</td>
<td>1.6</td>
<td>4.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Preferred configuration (Tablet = 1 Clamshell = 7)</td>
<td>3.5</td>
<td>2.2</td>
<td>5.0</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Score</strong></td>
<td>27.9</td>
<td></td>
<td>30.6</td>
<td></td>
</tr>
<tr>
<td><strong>Graphical User Interface</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landscape is easy to use</td>
<td>5.3</td>
<td>1.4</td>
<td>5.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Portrait is easy to use</td>
<td>5.2</td>
<td>1.2</td>
<td>4.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Preferred orientation (Portrait = 1 Landscape = 7)</td>
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<td>2.2</td>
<td>5.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Tablet screen brightness is satisfactory</td>
<td>4.9</td>
<td>1.6</td>
<td>5.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Brightness is equivalent to a desktop PC</td>
<td>3.3</td>
<td>2</td>
<td>4.7</td>
<td>1.4</td>
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<td>Tablet desktop is easily visible</td>
<td>4.2</td>
<td>1.7</td>
<td>4.3</td>
<td>1.9</td>
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<tr>
<td>It is easy to fix viewing problems</td>
<td>5.0</td>
<td>1.1</td>
<td>5.0</td>
<td>1.1</td>
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<tr>
<td>Tablet screen resolution is satisfactory</td>
<td>5.0</td>
<td>1.4</td>
<td>5.6</td>
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<tr>
<td>The digital pen is easy to use</td>
<td>4.6</td>
<td>1.4</td>
<td>4.8</td>
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<tr>
<td>The pen is easier to use than the mouse</td>
<td>3.8</td>
<td>2.1</td>
<td>3.4</td>
<td>1.2</td>
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<td>The pen submenu is easy to use</td>
<td>4.5</td>
<td>2</td>
<td>4.6</td>
<td>1.5</td>
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<tr>
<td>The tablet’s handwriting function is easy to use</td>
<td>4.2</td>
<td>1.9</td>
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<td>1.8</td>
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<td>The virtual keyboard is easy to use</td>
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<td>1.9</td>
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<tr>
<td>The Tablet’s desktop icons are easy to view</td>
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<td>1.3</td>
<td>5.5</td>
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<td><strong>Score</strong></td>
<td>62.1</td>
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<td>66.2</td>
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<td><strong>Battery and Power</strong></td>
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<td>The tablet’s battery strength is adequate</td>
<td>3.9</td>
<td>1.7</td>
<td>4.4</td>
<td>1.8</td>
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<tr>
<td>The tablet’s battery heat is bothersome</td>
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<td>1.7</td>
<td>2.5</td>
<td>1.5</td>
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<td>AC charging is used during clinic</td>
<td>3.6</td>
<td>2.6</td>
<td>2.2</td>
<td>1.3</td>
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<td>Charge time</td>
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<td>5/13 Continuous</td>
<td>10.6</td>
<td></td>
<td>9.1</td>
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<tr>
<td>3/13 &gt; 4 hours</td>
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<tr>
<td>3/14 Continuous &gt; 4 hours</td>
<td></td>
<td></td>
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<tr>
<td><strong>Network</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Tablet logon easy</td>
<td>4.2</td>
<td>1.6</td>
<td>5.4</td>
<td>1.3</td>
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<tr>
<td>Tablet logon is equivalent to a desktop PC</td>
<td>2.7</td>
<td>1.5</td>
<td>4.4</td>
<td>1.8</td>
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<tr>
<td>Preferred logon mode (Tablet = 1 Clamshell = 7)</td>
<td>5.5</td>
<td>2.1</td>
<td>5.6</td>
<td>1.8</td>
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<tr>
<td>The network is always connected</td>
<td>2.8</td>
<td>1.6</td>
<td>4.6</td>
<td>2.0</td>
</tr>
<tr>
<td>The network is accessible when needed</td>
<td>4.2</td>
<td>1.9</td>
<td>4.6</td>
<td>1.7</td>
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<tr>
<td><strong>Score</strong></td>
<td>19.4</td>
<td></td>
<td>24.6</td>
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<td><strong>Printing</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Printer setup is easy</td>
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<td>-</td>
<td>4.7</td>
<td>1.7</td>
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<tr>
<td>It is easy to reset the default printer</td>
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<td>-</td>
<td>4.5</td>
<td>2.1</td>
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Table 2 (continued). Survey results.

<table>
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<tr>
<th>Domains</th>
<th>Prior Study</th>
<th>Current Study</th>
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<td>Mean</td>
<td>SD</td>
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<tr>
<td><strong>Electronic/Paper Charting</strong></td>
<td></td>
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<tr>
<td>I use only the tablet while seeing patients</td>
<td>3.6</td>
<td>2.0</td>
</tr>
<tr>
<td>I use only the chart while seeing patients</td>
<td>4.1</td>
<td>1.8</td>
</tr>
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<td><strong>Score</strong></td>
<td><strong>7.7</strong></td>
<td><strong>5</strong></td>
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<tr>
<td><strong>Patient-Practitioner Tablet Interactions: Visits</strong></td>
<td></td>
<td></td>
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<tr>
<td>Use Windows Journal for new patient visit</td>
<td>2.7</td>
<td>2.4</td>
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<tr>
<td>Relevant information is there for new patient visit</td>
<td>5.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Relevant information is there for treatment visit</td>
<td>4.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Relevant information is there for follow up visit</td>
<td>5.0</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Score</strong></td>
<td><strong>17.8</strong></td>
<td><strong>16.2</strong></td>
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<tr>
<td><strong>Patient-Practitioner Tablet Interactions: Location</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy to use when on lap</td>
<td>3.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Easy to use when on counter in exam room</td>
<td>3.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Easy to use when on counter in dictation room</td>
<td>4.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Easy to use when the on exam table</td>
<td>-</td>
<td>-</td>
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<tr>
<td><strong>Score</strong></td>
<td><strong>11.4</strong></td>
<td><strong>12.7</strong></td>
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<tr>
<td><strong>Applications: CAIS</strong></td>
<td></td>
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<tr>
<td>It is easy to open a schedule</td>
<td>4.9</td>
<td>1.8</td>
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<tr>
<td>CAIS navigation is equal to that on a Desktop PC</td>
<td>3.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Navigation in CAIS is easy</td>
<td>5.1</td>
<td>1.7</td>
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<tr>
<td>Preferred configuration (Tablet = 1 Clamshell =7)</td>
<td>4.9</td>
<td>2.3</td>
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<tr>
<td><strong>Score</strong></td>
<td><strong>18.7</strong></td>
<td><strong>21.6</strong></td>
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<tr>
<td><strong>Applications: E Film</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preferred screen (Landscape = 1 Portrait = 7)</td>
<td>4.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Images downloaded satisfactorily</td>
<td>2.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Image resolution is satisfactory for X ray images</td>
<td>2.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Image resolution is satisfactory for CT images</td>
<td>3.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Image resolution is satisfactory for MRI images</td>
<td>3.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Comparing image series is equal to a desktop PC</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Navigation is equivalent to a desktop PC</td>
<td>3.1</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Score</strong></td>
<td><strong>22.2</strong></td>
<td><strong>24.8</strong></td>
</tr>
<tr>
<td><strong>Applications: Internet Explorer</strong></td>
<td></td>
<td></td>
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<tr>
<td>Internet access is equivalent to a desktop PC</td>
<td>5.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Internet use is equivalent to a desktop PC</td>
<td>5.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Use of oncology calculators is equal to desktop PC</td>
<td>4.1</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Score</strong></td>
<td><strong>15</strong></td>
<td><strong>15.7</strong></td>
</tr>
<tr>
<td><strong>Usefulness in Supporting Clinical and Non-clinical Activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tablets are as useful as desktop PCs</td>
<td>4.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Some tablet functions are better than a Desktop PC</td>
<td>4.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Tablet are useful reviewing images with patients</td>
<td>5.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Tablet are useful reviewing labs with patients</td>
<td>5.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Access web based knowledge sources</td>
<td>5.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Print patient education material</td>
<td>4.7</td>
<td>2.3</td>
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<tr>
<td>Access more up to date information on CAIS</td>
<td>5.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Print forms, prescriptions</td>
<td>5.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Use Windows Journal for notes</td>
<td>3.9</td>
<td>2.2</td>
</tr>
<tr>
<td>Tablets can replace desktop PCs</td>
<td>3.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Tablets are useful for non clinical activities</td>
<td>6.0</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Score</strong></td>
<td><strong>53.6</strong></td>
<td><strong>53.2</strong></td>
</tr>
<tr>
<td><strong>Overall Score</strong></td>
<td><strong>266.4</strong></td>
<td><strong>279.7</strong></td>
</tr>
</tbody>
</table>
4. Discussion

The iMPROVE project results suggest that a wireless system can reduce chart use significantly as more information becomes electronic. The cost savings in staff time could support the implementation of wireless systems in other cancer centers.

Improved network performance was observed when the scores of the two studies were compared. Comments from some users reflected the need for more training in and support for tablet use and digital pen configuration. A small cadre of expert users exploring additional functions have exhibited no significant resistance.

5. Conclusion

Overall, the tablets have been well received in the clinical environment. They have some unique functions and features that the existing desktop computers do not. Future studies could be conducted: 1) to analyze the perceptions of patients with respect to tablet use by physicians, and 2) to optimize the deployment of equipment.

References

Section 14

Telemedicine and Telehealth
Telematics in Acute Trauma Care

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Abstract. Each year, 20,000 people in Germany die because of a traffic accident. Altogether, yearly productivity loss caused by these injuries is estimated to be around 5 billion Euros. International and national studies revealed the trauma center level of the primary hospital as the major predictor for trauma related mortality. In 2006 the German Society for Trauma Surgery (DGU) called its members to form regionally based networks for the exchange of data among hospitals engaged in trauma care. In April 2008 the north-west region of Germany with 49 hospitals, three hospitals in the Netherlands, and local emergency services founded the “TraumaNetwork NorthWest (TNNW). The major goals of the TNNW are: 1) to shorten the time between accident and admission to the appropriate hospital, 2) to create effective means of communication, and 3) to implement common pre- and in-hospital standards for trauma care. Since the needed application software is not commercially available, a team of computer and medical specialists has been formed for its development. Once the software is in place, a pre- and post-analysis will be performed to study the consequences of the application on transportation time and injury-related mortality within the region. The project is recognized as a pilot project by the DGU and if it is successful is meant to be adapted across Germany.

Keywords. trauma, telemicine, teleradiology, emergency service

Introduction

Each year, 20,000 people in Germany die because of an accident. Altogether, yearly productivity loss caused by injuries is estimated to be around 5 billion Euros. International and national studies revealed the level of primary trauma care hospital as the major predictor for trauma related mortality.

As soon as someone calls 112, which is equivalent to 911 in the US, ambulances and or helicopters with trained emergency physicians are sent to the accident. After initial treatment at the site of the accident, the patient should be transported to an appropriate hospital with the necessary capacities, which is chosen by the local dispatch center. However, to find a matching hospital with available capacities, to date each needs to be called individually. In those cases reported, up to 3 hours have been spent solely in locating a hospital.

In 2006 the German Society for Trauma Surgery (DGU) called its members to form regionally based networks of hospitals engaged in trauma care [1]. Depending on its capabilities, each hospital engaged in such a network will be certified as a trauma centre with one of the following levels of trauma care:

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• Level 1: Capable of treating all kinds of trauma (including children) and capable of treating 2 or more trauma patients simultaneously.
• Level 2: Capable of treating most kinds of trauma (include head injuries).
• Level 3: Capable of providing basic life saving surgery for trauma patients.

The “TraumaNetwork NorthWest (TNNW)” was founded in April 2008. It serves 49 hospitals in the north-west region of Germany and 3 hospitals in the Netherlands as well as local emergency services, which include approximately 30 dispatch centers. The hospitals range from a 1,500 bed university hospital to small community hospitals. The TNNW serves approximately 5 million people in Germany and responds to an average of 3 life-threatening injuries per day.

The major goals of the TNNW are:
• To shorten the time between an accident and the ensuing admission to an appropriate hospital,
• to create effective ways of communication, and
• to implement common pre- and in-hospital standards for trauma care with continuous evaluation.

1. Methods

1.1. Decrease Pre-hospital Time

Most delays in pre-hospital trauma care are caused by looking for an appropriate hospital that has the capabilities to treat the patient. The dispatch agent is responsible for choosing the right hospital. However, he or she has information about only those hospitals within his/her district. Sometimes several calls must be made before an appropriate hospital can be found.

In order to accelerate the process of choosing the right hospital, each dispatch center needs to have information about all of the trauma hospitals within the network. It needs to know the capacities, the trauma-care levels, the departments and diagnostic capabilities (e.g., 24h CT-scan?) and telephone hotlines. We set up an Internet-based service which can be accessed by each member of the TNNW at any time. Each hospital provides its data that include the current capability of treating trauma patients. Local emergency services are then able to locate the site of an accident on a map and find the nearest (in terms of transport time under emergency conditions) appropriate hospital with free capacities.

In order to optimize this process even more, this information should ideally be available at the site of the accident to the local emergency physicians. However, this would require the localization of the accident site using a special GPS equipped device or by locating a cell phone.

1.2. Create Effective Ways of Communication

In acute trauma care, communication is especially important for a) the emergency physician or dispatch agent and staff of the admitting hospital and b) the treating physicians at those hospitals that transfer a patient. The emergency physician needs to talk to the trauma surgeon directly in order to inform him or her about the kind and the
degree of injuries. The emergency physician cannot waste time by being placed on hold. Hospitals have had to establish a hotline for trauma emergencies. If a hotline has not yet been established, a sponsored cell phone has been offered.

One of the most important aspects in a network of trauma hospitals is the exchange of X-rays and CT-scans. Often the pattern of injury is more complex than initially expected and level 2 or 3 hospitals must seek the advice of a level 1 trauma center. In an ideal world, the physicians of both hospitals would view the X-rays or CT-scans at the same time and discuss the treatment options over distance. The patient would then be transferred to the level 1 trauma center if necessary.

To facilitate the exchange of X-rays and CT-scans, hospitals should be able to exchange diagnostic data (e.g., CT-scans) securely via a fast internet connection and view the scans either on a radiology workstation or on an integrated viewer. Such an approach can be successful only if no additional software and hardware is needed (e.g. a web-based application [2]) and if the tool is compliant with federal security standards [3].

In 2002 video-conference tools were successfully used in southern Germany to exchange diagnostic data among 15 hospitals [4]. In the US, a few closed telemedical networks with common T1 lines have been successfully implanted, such as the Southern Arizona Teletrauma Program [5]. These networks profit from a relatively small number of hospitals and a shared T1 backbone. Unfortunately, each hospital in the TNNW has its own IT hardware and software. So we developed a new software that was independent of the existing IT-infrastructure. The result was a web application that any Internet browser can access. Each hospital can upload data, which might be X-rays or CT-scans conforming to the DICOM-standard or just simple jpg or pdf files, and send them to another hospital. There, the pictures can be viewed with the same web application, which also has the functionality of a DICOM-viewer.

1.3. Implement Standards and Evaluation

It is essential to have common standards in a trauma network. Each patient has a right to the same quality of care regardless of the hospital that provides the treatment. However, standards may be applied differently at different hospitals. While all hospitals agree to the content of the standards, implementation is a task left to the specific hospital.

While some internationally accepted standards exist in trauma care, such as ATLS®, most standards remain yet to be developed. Existing standards of level 1 trauma centers, such as the standard of cervical spine injury developed by the university hospital Münster, are provided to all hospitals. To develop additional standards, the members of the TNNW meet every two months in trauma conferences. Continuous evaluation is necessary to prove the success of the project and show its impact on trauma care. Data on the current status has been collected: the number of trauma patients treated each year in each hospital, the number of patients transferred to another hospital, the time needed for transportation to the hospital, and the number of times other physicians were contacted to exchange x-rays or CT-scans. Once the software has been implemented, another analysis will be performed to study the consequences of the new communication on transportation times and injury-related mortality within the region.
2. Discussion

While Germany provides a very high standard in emergency medicine, the quality can still be increased especially in time-critical emergencies such as with multiple traumas. The time needed for transportation to the right hospital and the rapid selection of an appropriate admitting hospital is a critical survival factor.

Germany is a densely populated country with a large number of hospitals. A hospital is never far away, especially if the patient is being transported by helicopter. However, less than 5% of the more than 2,000 hospitals in Germany are likely to qualify as a level 1 trauma centre and not all hospitals are engaged in trauma care. In the area of the TNNW around 100 hospitals are present. Only half of those hospitals offer services for trauma care and only four hospitals are likely to qualify as level 1 trauma centres.

The purpose of IT is “to provide the right information to the right people at the right time for the right price” [7]. Our dispatch tool will provide the right information (the nearest available and appropriate hospital) to the right people (the dispatch agent or the emergency physician) at the right time (just now). Hospitals will be able to exchange data like X-rays or CT-scans by Internet. It will no longer be necessary to send CT-scans from one hospital to another by taxi. We will be using IT to provide a faster and more secure way of exchanging information.

A potential problem is the maintenance cost of the tools. In order for these tools to be adopted, they need to be either free or inexpensive. While the development, testing and implementation of the tools are supported by grants, some way must be found to support the continuous improvement and maintenance once the implementation phase is complete. Several models of reimbursement need to be discussed. One reason for the slow start of teleradiology in Germany is the unsolved problem of reimbursement. As long as the reimbursement of a teleradiologic consultation is not resolved, teleradiology will not be successful in Germany [2].

The most important advantage of the tools is the rapid delivery of trauma care in its early phase. As the DGU has shown, the patient benefits from treatment in a level 1 trauma centre [1]. Unfortunately, not all patients can be treated in such a trauma centre. Some patients need to be transported to the nearest hospital in order to stabilize them and later be transferred to a level 1 trauma centre. Some patients may only be slightly injured and do not need the highest level of trauma care. Yet all patients have the right to expect the same standard of care in all hospitals and can expect their physicians to ask for a second opinion if their trauma exceeds his or her level of experience.

The formation of a network is an important step toward improving trauma care. But it is only the first step. As with a human relationship, a network must develop over time. For a relationship to develop, effective communication is essential. Any human relationship will falter if there is no opportunity to exchange thoughts. The same is true for hospital networks, be it in trauma care or any medical discipline. A trauma network provides a framework but it still must be filled with life. It must provide communication on different levels: personal communication during conferences, person-to-person communication using trauma hotlines, and the exchange of X-rays and CT-scans.

For communication to be successful a common language must be used and a protocol must be followed. The protocol in a trauma network is defined by standards which, although their implementation may differ from one hospital to another, are adopted by all hospitals.
All of the tools mentioned here are being developed by a pilot project in Germany to improve acute trauma care. However, these tools are neither limited to trauma care nor to Germany. While each medical discipline has its own priorities in emergency care, saving time in pre-hospital care is the most important common factor. If it is possible to find the nearest level 1 trauma centre it can be also possible to adapt this tool to, e.g., stroke emergencies and find the nearest available stroke unit. If these tools are successful in acute trauma care, more than just trauma patients may benefit from this project in the future.

References

Innovation in the North: Are Health Service Providers Ready for the Uptake of an Internet-based Chronic Disease Management Platform?

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Abstract. Remote and rural regions in Canada are faced with unique challenges in the delivery of primary health services. The purpose of this study was to understand how patients and healthcare professionals in northern British Columbia might make use of the Internet to manage cardiovascular diseases. The study used a qualitative methodology. Eighteen health professionals and 6 patients were recruited for a semi-structured interview that explored their experience in managing patients with cardiovascular disease and their opinions and preferences about the use of the Internet in chronic disease management. Key findings from the data suggest that a) use of the Internet helps to maintain continuity of care while a patient moves through various stages of care, b) the Internet may possibly be used as an educational tool in chronic disease self-management, c) there is a need for policy development to support Internet-based consultation processes, and d) while health providers endorse the notion of electronic advancement in their practice, the need for secure and stable electronic systems is essential.

Keywords. primary health care, CVD management, Internet consultation, chronic disease management

Introduction

Cardiovascular diseases (CVD) are the leading cause of death in the Western world [1]. In Canada, the budgetary drain from cardiac-related illnesses is growing at an astounding rate. Not only are 33% of Canadian deaths cardiovascular-related but CVD management now has an annual economic burden of approximately 18 billion dollars [1]. Four out of 10 Canadians in their 60’s report having some type of CVD (i.e., angina pectoris, myocardial infarction (MI), or hypertension) and the rate of prevalence continues to climb as people age [1]. Prevalence of CVD is expected to jump from 2.8 million to 4.2 million over the next decade as baby boomers enter their 60’s.

Remote and rural regions in Canada are faced with unique challenges in the delivery of primary health services. Barriers to health care in remote regions include
shortages of physicians and other allied health professionals. As well, accessibility to health services is impeded by geography [2]. Not only do some communities have limited access by road, but the long and harsh Canadian winters can restrict travel, including for health care. In British Columbia (BC) the Northern Health Authority (NHA) encompasses one third of the province yet serves only 7.2% of the total population of BC. Disproportionately, 13% of the population of the NHA has CVD but cardiac rehabilitation programs are unavailable to many of these patients. There are only 8 communities with populations over 10,000 people and over 60 smaller communities, predominantly First Nations, many of which are remote and isolated. These geographic and demographic features cause a shortage of human resources, infrastructure, and supplies for health care. Consequently, the need for innovation, integration of services, and collaborative approaches to deliver services in NHA are critical.

Recently, an infusion of Federal funding brought Internet access by satellite to remote and rural Canadian communities. This made innovative delivery of health services possible. The purpose of this study was to understand in what ways healthcare professionals and patients in the NHA could use the Internet to manage CVD.

1. Methods

The study used a qualitative methodology. Six physicians, five nurses and 7 allied health professionals were recruited for a semi-structured interview that explored their experiences in managing patients with CVD and their opinions and preferences about the use of the Internet in chronic disease management. Further, 6 patients were recruited to explore, by means of a semi-structured interview, their experiences in self-managing their CVD and their opinions and preferences about the use of the Internet in disease management. All participants were from the NHA. This data collection effort was part of a larger provincial study conducted by the British Columbia Alliance on Telehealth Policy and Research team.

1.1. Recruitment and Participant Characteristics

A total of 24 interviews were conducted. Six patients diagnosed with a CVD were recruited through flyers in medical settings and by word-of-mouth. Five out of the 6 patients were male, four were married and one was single. The sole female patient was married. All patients were 60 years or older. One patient lived in a community of more than 10,000 people; three patients lived within a 50 km radius of a community of more than 10,000 people, and two patients lived in communities of fewer than 5,000 people. All the patients had been diagnosed with CVD for at least one year. All patients were receiving cardiac care at a tertiary care centre in Vancouver, B.C.

Initially, physicians, nurses and allied health professionals in the NHA were selectively recruited based on their involvement in managing CVD. E-mails were distributed explaining the purpose of the study and requesting participants. Six physicians responded to the request and were compensated $100 for one hour of their time. Two in-hospital nurses responded to the initial request. Following these initial interviews, the interviewer would ask if there were any other health professionals that might be interested in participating. The rest of the participants were recruited by following up on the referrals (see Table 1).
1.2. Data Collection and Analysis

The data were gathered over four months. All the interviews were conducted by the same research assistant. Thirteen interviews with professionals were conducted at the interviewee’s place of business and five were conducted by telephone. Four patient interviews were conducted at the patient’s home; two were conducted by telephone. All interviews were recorded, transcribed and entered into the NVivo 8 software package for classification and organization of information. Analyses were guided by a grounded theory approach [3].

2. Key Findings

2.1. Current Electronic Use

In their daily practice, 16 of the allied health professionals used the Internet to keep their own education current. The two participants that did not use the Internet were a community-based physiotherapist and an exercise specialist. The participants who were using the Internet, visited sites that offered current disease-specific synthesized information. Up-To-Date, MD-consult Allnurses, Medline and E-Medicine were the web sites most frequently mentioned. All of the health professionals used e-mail (all health professionals were initially contacted by e-mail) but the amount of usage varied. Seven of the health professionals had forwarded educational web links to their patients. The physicians and one nurse regularly accessed the chronic disease management tool kit from the BC Ministry of Health. NHA has an electronic medical record (EMR) system so physicians had electronic access to their patients’ medical records and some lab tests and X-rays that were conducted in the NHA. All physicians appreciated being able to gain instant access to medical tests and all were optimistic that, within the NHA, they would be able to access more tests and X-rays online. None were aware if they could access medical tests ordered elsewhere in the Province but all thought that it would be beneficial. Some physicians had clinics with wireless capability and carried a laptop from room-to-room to access patient records. Four out of the 6 patients used the Internet at least once a week. Three patients and the wife of one patient used the Internet to find information about CVD. Two patients were not interested in using the Internet.

2.2. Facilitators for an Internet-based Platform

A common thread in all the interviews was the desire to have more information from other health professionals. As one physician reported, “The biggest gap is that, when

<table>
<thead>
<tr>
<th>Community size</th>
<th>Professionals interviewed</th>
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<tbody>
<tr>
<td>&gt; 10,000</td>
<td>1 internal medicine specialist, 2 family physicians, 2 in-hospital nurses, 1 community nurse, 1 exercise specialist, 1 physiotherapist, 1 systems manager, 1 chronic disease manager</td>
</tr>
<tr>
<td>5,000 &lt; &gt;10,000</td>
<td>1 family physician, 1 community nurse</td>
</tr>
<tr>
<td>&lt; 5,000</td>
<td>2 family physicians, 1 chronic disease manager/dietician, 1 community nurse</td>
</tr>
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Table 1. Distribution of health professionals.
people go south [to Vancouver], we do not get information that is useful. So, if [the Vancouver specialists] had a communication person [who] could make a phone call, e-mail, or FAX me [with] a sheet saying that a certain person has been discharged, [it would be helpful]. And, it would be helpful for me if they would write on the sheet when they want me to see [the patient].” To address the continuity of care, a health systems manager recommended an electronic system with the capability to automatically flag those patients released from a tertiary care facility and to supply the discharge summary with the contact names for the specialist and specialist nurses. Currently, the onus is on the patient to initiate all follow-up care. If a patient, after being discharged from tertiary care, does not make an immediate appointment with their family physician, the office staff of the clinic, who are unaware of the patient’s health status, may make an appointment booking for several weeks later. As one physician stated, “I would say the connection after discharge [from tertiary care] is loosey goosy and …a lot of times, discharge summaries are late, up to three months a lot of times. The only summary we’ll get is the one someone has in their hand, which is useful if it is legible, but we have no warning that they’ll come necessarily.”

An Internet-based platform provides the ability to quickly obtain patient information and share medical information with the patients. Physicians in NHA have access to the EMR system and the other health professionals see the benefit of having faster access to the input made by other professionals regarding patient care. One allied health professional said, “It would be helpful if there was an electronic patient chart that was accessible by the entire team of health professionals. As different health consults occurred, a chronological documentation of the patient/provider information would occur, making it easier for all to see what consult/lab tests, etc. occurred and what suggestions were made in the consultations.” Physicians thought more accurate information shared among professionals would be the result of such a system. It would be a more time-efficient system with less time spent by physicians sorting through the referral notes from other professionals.

Health providers stated that a virtual program would afford the health provider with the same access to information as the patients, “I have seen my patients that have come back from St. Paul’s on the congestive heart program and they seem to get extra education down there, but unfortunately, their education does not spread to me. And so, I am learning from what the patients are being told and not from anyone else. I think that either I am missing what is available to me, or I just have not been told what is available, or where to access that stuff but I think that there should be more education for me as well…I think that there needs to be more education for the physicians in the periphery because they are such a long way away from [the tertiary care setting].”

2.3. Barriers to an Internet-based Platform

The primary barrier, as voiced by all participants, to an Internet-based virtual care program was concern about security and privacy. Health providers differed on the emphasis they placed on security. Their level of concern ranged from acknowledging that security was a key issue to “until you have guaranteed me with 100% certainty that no hacker can access the information, that the web site management will not be sold to the highest bidder; patient information will not be sold to a third party, I will not use a virtual care program.”

Lack of time and lack of training to learn a new system were also key reasons not to use a virtual care program. The current EMR system of the NHA could be a possible
solution for these concerns; there were no negative comments about the current system and some physicians made reference to the large cost that was involved in implementing their current electronic system. A virtual program that mimics the current system or piggybacks on the current NHA EMR system may eliminate the time and learning needed for yet another system.

3. Limitations

The limitations of this study reflect the nature of qualitative methodology. First, recruitment of health professionals was mainly accomplished electronically. Hence, the experiences of interviewees may not have accurately represented the entire population of health providers in the NHA. A further limitation to qualitative methodology is that there may have been something fundamentally different about those individuals who chose to participate as opposed to those who chose not to. These limitations must be taken into account when, as with this study, investigators are interested in examining the motivations for embracing change.

4. Discussion

The present study provides support for the idea that health providers can utilize an Internet-based disease management platform as a tool to maintain continuity of care for the patient. Previous research has shown that patient outcomes are significantly better when collaboration exists among various health professionals to deliver health care needs [4]. However, in the NHA, there are no cardiologists, which means that many patients who have a cardiac-related illness must travel out of the region to receive specialized care. This study found that when patients require tertiary care, the primary care providers may experience a delay in receiving information about their patients. Delayed communication between tertiary care centers and primary care centers may be detrimental to positive health outcomes [5].

The present study found that remote providers supported an online co-management model of care. Patients might receive better care as they moved through the health system. An on-line chronic disease management platform could mean that all providers would have access to current patient information. These findings support previous research in which it was found that a web-based standardized communication system between the emergency department and family physicians improved continuity of care [6].

With increasing accessibility to the Internet, it is realistic to use an Internet-based platform to provide collaborative chronic disease management options. This study found that while health providers endorse the notion of electronic advancement in their practice, the need for secure and stable electronic systems was essential. Health providers surmised that the uptake of technology would be most successful when new systems were compatible with their current electronic systems. Disparities in Canada between rural regions, such as northern BC where there is a lack of health care accessibility, and urban regions continue to grow [7].

The findings of this study have implications for the future delivery of Internet-based chronic disease management in northern, rural, and remote areas of Canada. Human resources, service delivery, and geography comprise the largest challenges in
The need for innovation, integration of services and collaborative approaches to northern remote health services is critical. Advancing Internet technology allows for the possibility of innovative delivery of health services, which can alleviate the human resource shortage and close the geographic gap between rural patients and urban services. The urgency in developing and implementing viable co-management practice models becomes apparent when recognizing that remote and rural regions are challenged with personnel shortages, overburdened health providers and higher CVD rates. An interdisciplinary team working to their highest skill level using an Internet based platform may be a more efficient use of monetary and human resources and may enhance patient care.

References

Abstract. We describe an application of a computer-based system and telehealth approach for support of the continuous positive airway pressure (CPAP) treatment for obstructive sleep apnea (OSA). A conceptual framework is introduced that has four major components: patients’ education and communication, measurement of patients’ adherence, CPAP unit test, and CPAP treatment evaluation. The measurement and evaluation processes are based on a fuzzy logic approach and they use a set of predefined fuzzy rules. The rules are utilized for the calculation of patient’s adherence and treatment effectiveness using patients’ records, self-reported adherence data, and automatically downloaded data from the CPAP machines. Further, we discuss the need for a telehealth support system for OSA patients in the rural communities and small cities of British Columbia.

Keywords. continuous positive airway pressure treatment, treatment support, telehealth support system, obstructive sleep apnea

Introduction

Obstructive sleep apnea (OSA) is a serious respiratory disorder associated with significant risk for hypertension, congestive heart failure, coronary artery disease, and stroke. OSA is a common disorder afflicting approximately two to four percent of the general population. The standard treatment for patients with moderate to severe OSA is the application of continuous positive airway pressure (CPAP). The CPAP therapy is effective in relieving OSA symptoms; however, CPAP has a low level of acceptance and patient compliance (only 50 to 75% of patients continue CPAP treatment after the initial three months) [1,2]. Adherence to CPAP treatment is compounded by several factors: biomedical (severity of the disorder, CPAP side effects), psychological (anxiety, claustrophobia), the patient’s perception of the seriousness of the disorder, belief that the therapy will be effective, patient’s understanding of the CPAP therapy process), social (family support), technological (simplicity of the procedure, selection of CPAP device, appropriate air pressure), and economical (cost and insurance...
coverage). On the other hand, numerous studies have demonstrated that adherence can be significantly improved by a comprehensive support program, therapy follow-ups, and timely interventions by health professionals [1-3].

We identify two significant problems affecting patient adherence. First, OSA patients, in general, obtain limited support during their CPAP treatment from specialized clinics and CPAP providers. Second, the patients living in rural areas of British Columbia have limited access to specialized respiratory clinics and CPAP providers which are located exclusively in larger cities. We address these two issues by 1) creating a comprehensive conceptual framework to define support activities during the CPAP treatment and 2) developing a telehealth-based system, which applies this framework.

The proposed conceptual framework is composed of four major support components: 1) education and communication, 2) measurement of the patient’s adherence, 3) measurement of the therapeutic equipment, and 4) evaluation of the effectiveness of CPAP treatment.

In this paper, the authors describe the four components of the framework and propose a telehealth-based system. First, the authors describe the education and communication support for patients. Second, they discuss the process of measuring the patient’s adherence. Third, they describe a system for testing the CPAP equipment. Fourth, the authors provide an overview of the rule-based system for the evaluation of the effectiveness of CPAP treatment. Finally, the authors describe the results from a pilot project and discuss future work.

1. CPAP Therapy

The standard treatment for moderate and severe OSA is continuous positive airway pressure (CPAP). The CPAP device prevents the upper airway from collapsing by creating positive pressure in the pharynx during sleep. The patient wears a nasal mask connected via plastic tubing to an air pump. CPAP therapy is not curative, and patients must use the mask regularly to significantly decrease the number of breathing pauses and sleep fragmentation. The CPAP therapy should result in reduced daytime sleepiness, increased arterial oxygen saturation, decreased hypertension, reduced depressive moods, and improved quality of life. Although CPAP is a highly effective therapy, the level of acceptance and patients’ adherence is low [3,4]. Compliance and treatment effectiveness are influenced by factors such as selection of the appropriate equipment corresponding to patients’ needs, absence of side effects, and acceptance by family members.

Patient compliance is measured by the number of hours of CPAP use per night. On average, CPAP treatment requires at least 4 hours of CPAP use per night [4]. The number of hours is measured by two methods: objectively, by downloading the data from the CPAP device and subjectively, by recording the hours of use reported by patients.

Since OSA is a chronic condition, patients require ongoing support for their treatment in terms of education (individual sessions, group sessions, education of the family members, educational materials), ongoing communication with the clinic (phone calls, in-person visits, electronic mail), and treatment interventions (mechanical, psychological, and lifestyle interventions) [5,6]. Furthermore, an effective treatment
protocol requires mechanisms for measuring patients’ adherence, testing the CPAP equipment, and evaluating treatment outcomes.

2. Conceptual Framework

The conceptual framework for the support of the CPAP treatment has four components: education and communication (EC), measurement of patients’ adherence (PA), CPAP unit test (CT), and treatment evaluation (TE). The framework uses two databases: 1) the patients’ database containing patients’ records and their treatment data and, 2) the rules’ database containing fuzzy-logic based rules for measuring acceptance and evaluating effectiveness of the treatment.

2.1. Support for Education and Communication, EC

The component for the support of education and communication, EC, is based on two premises: demonstrated effectiveness of educational interventions and treatment follow-ups and the need for early identification of patients at risk for low adherence. Several studies have demonstrated improvement in the adherence to CPAP therapy by introduction of various educational interventions: oral explanations, written explanations, videos, home visits, phone calls, tutorial groups [7,8]. Furthermore, many studies have shown that significant increases in CPAP use can be achieved when close follow-ups are provided by the health practitioners [7]. Even with the improvements, patients’ adherence to such a difficult treatment regime as CPAP is also influenced by several physiological and psychological factors: the initial severity of OSA, side-effects, coexisting depression, and self-efficacy. Even the fact that the referral was initiated by the family member rather than patient could be a significant determinant of future adherence.

The EC has two functions: assessment of the informational and educational needs of the patients and their families, and analysis of the risk factors for non-adherence to the treatment. These functions use a set of predefined rules to identify patients’ requirements for early educational interventions and close follow-ups. The patients are classified according to their educational needs and risk level for non-adherence into four categories: low, average, high, and extremely high.

2.2. Support for Measuring the Patient’s Adherence, PA

The component for measuring patient’s adherence, PA, comprises four mechanisms: 1) collection of data on side effects and problems with the CPAP machine, 2) collection of subjective data on daily CPAP use reported by patients, 3) collection of objective data on daily use downloaded from the CPAP machines, and 4) analysis of patients’ CPAP adherence. The PA component uses an inventory of side effects and CPAP-use problems. The inventory was created by the authors to standardize and quantify the factors influencing CPAP adherence. The inventory includes eleven side-effects (nasal congestion, rhinorrhea, rhinosinusitis, nose bleeding, skin abrasion, conjunctivitis, aerophagy, sinus discomfort, sleep fragmentation, anxiety and, claustrophobia) and six CPAP-use problems (the level of air pressure, mask leaks, proper mask type and fit, quality of air, machine noise, and problems with hygienic care of CPAP unit). We have defined two dimensions for the CPAP side effects: frequency and severity. Similarly,
we have defined two dimensions for the CPAP-use problems: frequency and level of inconvenience. All dimensions are measured using a Likert-type scale from 0 to 4. Each side-effect and CPAP-use problem is assigned a score, which is calculated by multiplying the values for both dimensions. For example, an occasional (frequency = 1) minor sinus discomfort (severity = 1) will be assigned a score of 1 (score = frequency × severity), whereas, frequent (more than 4 times per week) and very severe nose bleeding (severity = 4) will be assigned a score of 16.

The PA component uses fuzzy-logic based rules to calculate patient’s adherence to CPAP therapy as low, average, high, and extremely high.

2.3. Support for CPAP Equipment Testing, CT

The component for testing CPAP equipment, CT, measures response and sensitivity of a particular CPAP unit to specific airflow obstruction events. These events are simulated using as a base typical breathing patterns observed in OSA patients. The test is done automatically using the pharyngeal simulator and it provides an independent behavioral profile of particular CPAP device. Behavioral analysis can further be performed to match patient’s needs with a specific type of a device. The pharyngeal simulator is a dynamic device developed to enable testing of auto-titration CPAP devices. It has adopted a Starling resistor model for generating airflow obstructions simulating a sleeping patient. The simulator is connected to a fully functional CPAP device which is configured to support a particular OSA condition. By generating predefined air flow obstructions events, responses of CPAP to those events are recorded in real time. A collection of consecutive air flow obstruction events creates a test scenario that can be replayed many times for the same model of CPAP device or another device. Results then can be compared and differences identified to establish behavioral expectations.

2.4. Support for CPAP Treatment Evaluation, TE

The component for treatment evaluation, TE, supports the respiratory therapists, who monitor the patients and initiate necessary treatment interventions, such as applying different types of CPAP units, changing the air pressure, and increasing communication with the patient.

The treatment effectiveness is calculated using three factors: changes in symptoms, CS, patient’s adherence level, PAL, and patient’s profile, PP. The changes in symptoms are calculated based on nocturnal oxygen desaturation (ΔNOD), excessive daytime sleepiness (ΔEDS), and hypertension (ΔHTN). The NOD is measured using nocturnal pulse oximetry. The EDS is measured by the Epworth Sleepiness Scale – a self-administered questionnaire rating sleepiness on a scale of zero to three in eight situations. The HTN is based on the measurement of blood pressure. The TE component calculates the direction and the significance of change for each factor, for example: increase in NOD (ΔNOD↑) decrease in HTN (ΔHTN↓). The significance of the change is defined as small, medium, significant, and large. Patient’s adherence level, PAL, is evaluated by the PA component as low, average, high, and extremely high. Patient profile, PP, includes baseline data at the start of the treatment (age, gender, baseline body mass index, BMI, and OSA severity) and characteristic that can vary over the course of treatment (ΔBMI).
The TE component uses IF-THEN fuzzy rules (stored in the rules’ database) to calculate the effectiveness of the therapy, \( T_{\text{EFF}} \), as one of the three values: low, medium, and high.

For example, a rule based on three factors \( CS, PAL, PP \), evaluates treatment effectiveness, \( T_{\text{EFF}} \), as high. The changes in symptoms, \( CS \), are defined as a significant reduction of nocturnal oxygen desaturation, a significant decrease in excessive daytime sleepiness, and a significant decrease of hypertension. The patient’s adherence level, \( PAL \), has been evaluated by the PA component as high. The patient’s profile, \( PP \), is as follows: an older female patient (age > 65) with morbid obesity (BMI > 40), severe OSA, and a small drop of BMI during the treatment. Thus the complete fuzzy rule is defined as follows:

\[
\text{IF } (\Delta \text{NOD} \downarrow = \text{significant} \text{ AND } \Delta \text{EDS} \downarrow = \text{significant} \text{ AND } \\
\Delta \text{HTN} \downarrow = \text{significant}) \text{ AND } \text{Patient}_-\text{Adherence} = \text{high} \text{ AND } \\
(\text{BMI} = \text{morbid} \text{ AND } \text{age} = \text{older} \text{ AND } \text{gender} = \text{female} \text{ AND } \\
\text{OSA} = \text{severe} \text{ AND } \Delta \text{BMI} \downarrow = \text{small } ) \text{ THEN } T_{\text{EFF}} = \text{high}.
\]

### 3. Telehealth-based Support System

The conceptual framework for support and evaluation of CPAP treatment has been created as the first step towards the development of a comprehensive telehealth system to support the CPAP treatment for patients from rural areas and small cities in British Columbia. This province covers an area of 944,735 km\(^2\), but has only six specialized clinics located in the major cities. Thus many patients must travel hundreds of kilometers for OSA diagnosis and treatment. These patients do not have walk-in access to the respiratory clinics or the providers of CPAP machines. Therefore, a telehealth support for the treatment of a chronic and serious disorder such as obstructive sleep apnea is a necessity rather than an option in healthcare.

The proposed telehealth system provides five service modules: 1) a Web-based interface for patients’ education and communication via the Internet, 2) a Web-based interface for remote data acquisition and centralized storage in a database server, 3) an analytical system for testing of the CPAP equipment, 4) an analytical system for measuring patients’ adherence, and 5) a computerized rule-based system for the evaluation of the effectiveness of CPAP treatment.

We have designed a system called CPAP-T*MONITOR based on open source software: Java Server Pages (JSP), PHP, Apache Tomcat Server, and MySQL as a DBMS system. Using a modularized approach, we have prototyped two components: a Web-based module supporting CPAP education and communication and a Web-based module for remote testing of CPAP machines. Currently, we are working on a rule-based system for patients’ adherence and treatment evaluation. The initial set of rules has been derived based on the experience of specialists from the Respiratory Therapy Clinic at Thompson Rivers University and on medical literature. However, for further use, the rules must be evaluated. The evaluation process will be based on large sets of treatment data. Up to now a prototype version of rule-based fuzzy inference system has been built. We are planning to evaluate the rules based on statistical analysis and data mining.
4. Conclusions and Future Work

In this paper, we presented a conceptual framework which is necessary for the development of a support system for the treatment of obstructive sleep apnea. Furthermore, we stressed the need for a telehealth approach, which will support the patients living in rural communities and small cities, the respiratory specialists operating in specialized clinics, and the general practitioners working in remote rural areas. The major purpose of the system is to maximize CPAP treatment benefits by improving patients’ adherence, introducing early interventions, and optimizing the use of treatment equipment (matching the patients’ breathing behavior with a particular type and model of CPAP device).

The authors have been working on the computer-based systems for OSA diagnosis and CPAP treatment since 2005, and we have tested several computational approaches and developed four prototypes of the Web-based modules [9,10]. Our preliminary tests have verified our hypothesis that the fuzzy logic approach will provide good representation for the complex and imprecise nature of the CPAP evaluation process. However, based on our experience, the development of a comprehensive and fully automated rule-based system for CPAP treatment support requires collaboration between a larger group of researchers and developers.

References


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Section 15
Terminology, Classification and Standards
Optimizing Standard Patient Management through Order Sets – Impact on Care (Blood Cultures)

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Abstract. We show that order set design and support must be thoughtful to result in improved quality of care and reduced waste and that order set use should be monitored to confirm expected impact and detect unanticipated consequences.

Keywords. clinical decision support, order sets, order entry, hospital information systems

1. Introduction

The value of a Clinical Information System is said to be highly dependent on Clinical Decision Support (CDS) including Computerized Physician Order Entry (CPOE) [1]. A common form of CDS is the use of order sets (OS). A well-designed order set is effective because it:

1. is non-intrusive into workflow (in contrast to alerts),
2. makes ordering more efficient,
3. guides the user to order the most important interventions by implicitly reminding them of those interventions and bringing forward to the point of ordering relevant, timely and patient-specific information,
4. leverages known guidelines and best practices, and
5. reduces local area practice variation.

However, OS can deliver these advantages only if they are thoughtfully designed, users are effectively trained in their use and if the impact of their use is monitored. Optimal approaches include close attention to the elements of a set shown in Table 1.

We will show how monitoring the impact of a group of OS for blood cultures identified shortcomings in the initial design and implementation and how two interventions improved the outcome.
2. Setting

Our Region implemented an acute care Patient Care Information System (PCIS) for use at three urban adult care sites totaling 2000 beds and used by 2000 physicians. The functionalities of the system included:

1. Order entry and management all orders (CPOE)
2. OS and alerts
3. Electronic Medication Administration Record (eMAR)
4. Clinical Documentation: allergies, diagnoses, flowsheet data including vitals and fluid balance
5. Results: Lab, Diagnostic Imaging (DI) text
6. Transcribed documents

Activation was by “big-bang” at each of Hospital 1, 2 and 3 with a period of approximately two months between sites. The physician adoption rate, measured most objectively by CPOE Rate = Number of orders entered directly by physicians/All orders that could be entered by physicians, was high at all sites and has remained stable in the one and a half years since activation of Hospital 1. Specifically for medication orders which are often the most complex and have the greatest potential for benefiting from structured entry, the staff physician CPOE Rate measured monthly has varied between 74 and 76%. The system includes over one thousand OS. These sets fall into five types (see Table 2).

Table 1. Design elements of an order set.

| Content | a) Priority driven by need. OS should be implemented earlier and with greater care if they will be frequently used, address common clinical conditions, reduce risk of common clinical errors or represent clearly more efficient and intuitive approaches to creating electronic orders.  
  b) Allow best practice sets to be embedded in other order sets to reduce high variability in areas with known quality and safety impacts. |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Design  | a) Designed by clinicians who can represent the ultimate users in collaboration with experts in the clinical area and in set design on the specific platform used. 
  b) Incorporate accepted best practice and evidence. 
  c) Address known inappropriate variations from best practice. 
  d) Are efficient to order with. 
  e) Are intuitively named and easy to locate within a large collection of sets. 
  f) Are designed in accordance with a style guide that helps users leverage their familiarity with some sets when using an unfamiliar set. 
  g) Includes all information needed to make decisions within the set to reduce need to navigate elsewhere to find this information. |
| Training| a) Gives users a solid start in optimal use of OS to benefit care and for ordering efficiency. 
  b) Alerts users to sets that lead to significant changes in clinical practice. 
  c) Alerts users to new sets or major changes to existing ones. |
| Maintenance| a) Mechanisms to gather feedback on sets requiring changes in content or format and to schedule timely review of content and clinical guidance. 
  b) Decision process for changes and implementation. 
  c) Monitor order set utilization stratified by role of ordering clinician and other factors. 
  d) Monitor impact on care and outcomes. |

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Design of approximately 60 High-impact pan-departmental OS was led by multi-specialty clinical committees. The convenience sets were designed by a hospitalist informatician with extensive experience with order entry design and in consultation with relevant departments. The remaining OS were designed by physicians designated by each clinical department with the support of clinical informatics specialist nurses, all of whom received additional training and education specific to the design and implementation of order sets. These parallel activities of sets design were driven by time constraints and allowed for an efficient process but did not directly encourage cross-departmental decision making or review by performing departments like Laboratory and DI, nor allow for formal review by existing Quality Improvement committees and the Pharmacy and Therapeutic Committees.

This paper focuses on the use and impact of OS for blood cultures. In addition to a small number of OS that are specifically and only for blood cultures, blood cultures are a common element of 54 other adult OS. Commonly used sets with embedded blood culture orders include ICU admission, ED shock/sepsis, Fever NYD. The only simple way to order blood cultures is via an order set (rather than a single order (called an order item in our system) because the design is meant to support two sequential ones (i.e., paired cultures, except in the case of three for suspected endocarditis) as recommended in the literature [2]. Although there are some non-order set ways to order blood cultures to manage manual requisitions from some outpatient areas or to address unusual needs (e.g. when Lab needs to re-draw a sample because the original was mislabeled or broken or a requisition was lost) these pathways are not part of standard workflow for the average user.

These 55 OS were used to enter a total of some 61,000 blood cultures over 15 months. Three of these 55 sets were responsible for the majority of blood culture orders. Since each set was designed by a different physician and because direct laboratory oversight of set design was not possible, there was a wider range of design variability than ideal. We did not appreciate this variability until after activation. The motivation for this study was early evidence that suggested that inappropriate single cultures were ordered too often.

### 3. Methodology

The total number of blood cultures is $P + S$ where $P$ is the number of blood cultures ordered as a pair, i.e., two cultures and $S$ is the number of single blood culture orders, i.e., one culture. SBCR, the single blood culture rate is then defined as $SBCR = S/(P+S)$. SBCR data was initially available from the Regional laboratory. Later, data were extracted from the PCIS database using an SQL query for orders entered for blood cultures. This later data included:

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<th>High-impact pan-departmental for very high-risk conditions or interventions noted by Safer Healthcare Now (anticoagulation, myocardial infarction, surgical site infection prevention and diabetes management)</th>
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<tbody>
<tr>
<td>Phase-of-care-related (e.g., Laboratory and EKG tests in emergency department (ED); Hospitalist admission)</td>
</tr>
<tr>
<td>Condition- or intervention-related sets (e.g., Adult endocarditis blood culture; Standard vaginal delivery).</td>
</tr>
<tr>
<td>Convenience (e.g., lab orders for Mondays and Thursdays for three weeks).</td>
</tr>
<tr>
<td>Diagnostic Imaging (DI) test requiring preparation (e.g., CT scan with contrast)</td>
</tr>
</tbody>
</table>
1. Name of the order set from which the order was entered.
2. Patient location at time of order.
3. Date and time each order was entered (allowing determination of whether a pair of blood cultures was ordered essentially simultaneously).
4. Role of entering provider (Physician or nurse).

These data were further analyzed by Excel spreadsheet. In addition, documents relating to blood culture were reviewed which contained:
1. Initial set design.
2. Redesigned set.
3. Communications with ED providers regarding optimal ordering practice.
4. Date of interventions.

4. Results

4.1. Step 1. Order Set Redesign Due to High SBCR Based on Lab Data.

Following activation at the Hospital 1, the Laboratory staff recognized, based on lab information system data, that SBCR was very high (32%). In response to this clinical issue, a Review Panel was formed to improve ordering behaviour by identifying the reasons for inappropriate blood culture ordering and standardizing these orders. The panel consisted of an infectious disease consultant who was also a member of the laboratory, a clinical informatician, clinician designers and PCIS analysts who worked in collaboration with each department set owner. This panel suspected that the high rate of single blood cultures was due to PCIS implementation and specifically the result of suboptimal design. However, to be more certain, they recommended a parallel data acquisition from PCIS that allowed much more detail of ordering practices. This analysis identified situations where single orders were, in fact, appropriate (e.g. where the single order was to draw the second culture if the first was not paired; where single orders were a short time, say minutes, apart). The PCIS data with each order also included the name of the order set used to enter the order, the location (department or ward of the patient) and the role of the person entering (nurse or physician).

Despite having only the lab data available initially, the panel concluded that redesign was required urgently, i.e., before this more detailed data became available. On reviewing the order set designs, several weaknesses were identified and are illustrated in Figure 1.

1. There was no explicit guideline in the sets to remind users that two cultures were the optimal number (except an implicit suggestion for three when endocarditis was suspected).
2. It was easier to select a single culture (one click) than two (two clicks).
3. All four circumstances in which blood cultures could be ordered were in a single set even though each was for a very different setting.

We separately analyzed inpatient and Emergency Department (ED) data for several reasons:
1. On inpatients, physicians order most blood cultures whereas in ED, nurses do so independently by protocol.
2. ED staff tend to use a different set (EDRN Common Lab/CV) to order blood cultures from that used by most staff on inpatient units (Blood Culture – Adult).

3. Communication regarding best practice is different in these environments, coming from ED leadership in ED and from Infectious Disease staff on inpatient units.

4. ED staff are much smaller in number and easily accessible for interviews.

**Figure 1.** Simplified screen shot of original 4-part blood culture without pre-selected pair. For legibility and clarity, we have converted all screenshot to a graphic that captures the fundamental structure of the sets. To order, the clinician needs to click in the box to the left of any order and then click the “OK” button.

**Figure 2.** Simplified screen shot of redesigned order set. The endocarditis and pediatric sets were moved to their own OS.

**Figure 3.** New order set design when embedded. This is the commonly used set in ED patients. Note that, as in all other embedded sets, cultures are not pre-selected and there is explicit advice for paired cultures.
4.2. Step 2. Trends After Redesign Show Single Cultures Not Reduced Enough in ED, So Educational Efforts Were Added.

A key difference between Blood Culture – Adult and all other blood culture sets is that the former has blood cultures pre-selected while none of the latter do. This allows us to compare the impact of pre-selecting on ordering behaviour. Two adult blood culture sets (Blood Culture – Adult and EDRN Common Lab/CV) account for 83% of blood culture orders Sep 2006 through Jan 2008 shown in Table 3. We focus our analysis on these two because the number of orders arising from each of the other sets is relatively much smaller (from 15 to 1,288 pairs of orders each).

Looking at the detailed ordering behaviour for the two most common sets in ED, orders fell into three groups as shown in Table 4. The results in Table 4 suggest that in ED, the majority of cultures (87%) were ordered appropriately as a pair in a single session of computer use. Of the remainder, roughly half (6%) were eventually (after a period of one second to 17 hours) ordered as a pair. We were interested mostly in understanding the reasons for the number of single orders (7%) and in reducing this towards zero.

The results in Table 5 suggest that redesign with pre-selecting had a small effect, resulting in a lower rate of single cultures (4.8 with pre-selecting versus 6.6%).

**Table 3.** Number of all blood culture orders from source order set by patient location 2006 Sep 9 to 2008 Feb 29.

<table>
<thead>
<tr>
<th>Patient location</th>
<th>All (ED+Inpatient)</th>
<th>ED</th>
<th>Inpatient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Culture – Adult</td>
<td>32,160 (50%)</td>
<td>1,231 (6%)</td>
<td>30,929 (72%)</td>
</tr>
<tr>
<td>EDRN Common Lab / CV (embedded)</td>
<td>19,435 (30%)</td>
<td>18,529 (87%)</td>
<td>906 (2%)</td>
</tr>
<tr>
<td>Other order sets (embedded)</td>
<td>4,488 (7%)</td>
<td>961 (5%)</td>
<td>3,959 (9%)</td>
</tr>
<tr>
<td>Non-order set</td>
<td>7,609 (12%)</td>
<td>496 (2%)</td>
<td>7,113 (17%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>64,124</strong></td>
<td><strong>21,217</strong></td>
<td><strong>42,907</strong></td>
</tr>
</tbody>
</table>

**Table 4.** For adult ED patients, the number of blood cultures ordered from OS including embedded sets 2006 Sep 9 to 2008 Feb 29.

<table>
<thead>
<tr>
<th>Group</th>
<th>Blood culture orders</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Paired entered at the same time</td>
<td>18,438</td>
<td>87</td>
</tr>
<tr>
<td>2</td>
<td>Paired entered at different times</td>
<td>1,292</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Single</td>
<td>1,487</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>21,217</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.** SBCR in adult ED patients cumulative 2006-2008. Note these data related to blood culture orders after 2006 Nov when all order sets had been redesigned so that Blood Culture – Adult had both cultures pre-selected and EDRN Common Lab / CV had neither pre-selected. Both order sets included a message that two cultures are to be ordered.

<table>
<thead>
<tr>
<th></th>
<th># Blood cultures</th>
<th># Single blood culture</th>
<th>SBCR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Culture – Adult</td>
<td>1,224</td>
<td>59</td>
<td>4.8 %</td>
</tr>
<tr>
<td>EDRN Common Lab / CV</td>
<td>17,962</td>
<td>1,179</td>
<td>6.6 %</td>
</tr>
</tbody>
</table>
Regarding the incidence of single blood cultures, the results in Figures 4 and 5 show a rapid reduction after the set redesign in Oct 2006 followed by a gradual reduction over time. In addition, in ED, there was a further reduction in the incidence of such inappropriate ordering after an Aug 2007 ED memo but this is not seen on inpatient units.

![Figure 4](image1.png)

**Figure 4.** Impact of pre-selecting on % rate of single blood culture orders.

![Figure 5](image2.png)

**Figure 5.** Timeline of interventions (PCIS activation across sites, redesign and formal communication).
5. Discussion

This study showed an unacceptably high rate of single blood culture orders following implementation of a new CIS. Several reasons may be postulated. First, unfamiliarity with a new information system may negatively influence clinicians, perhaps because they are focusing on the mechanics of using the system rather than ensuring that their clinical decisions are sound. It is this risk that encourages implementers to achieve good design, effective training and high levels of clinician support in the early days after activation. Second, the design of the CIS may be inadequate either because the configuration designers did not consider the various clinician behaviours or because the system’s technical design is limited. Finally, training and support may have been inadequate.

In our organization, we initially assigned blame to the configuration design. The clinical impact of missing bacteremia was considered too high a risk to await further data acquisition that would have helped us distinguish between system unfamiliarity alone and a design flaw.

As more detailed data came available, we recognized that this may have been an overly simplistic view. As Figures 4 and 5 suggest, the formal communication in Aug 2007 reduced single cultures even further. We have no insight into the influence of less formal communication that may have influenced ordering behaviour over the course of this study. Also, as Table 5 suggests, pre-selecting is somewhat useful but we felt that the PCIS version at the time was technically too unreliable to allow embedded sets with unselected individual orders, when selected, to force automatic selection of groups of orders.

A more recent insight resulting from our inability to reduce single cultures to zero has been a misunderstanding between clinicians and Infectious Diseases that paired blood cultures can be drawn simultaneously and, unless a particular vascular site is the suspected source of bacteremia, that both cultures can be drawn from the same site. Following a change in policy and appropriate communication, we plan to assess the impact of this work process redesign on single cultures in ED and subsequently throughout the organization.

In more general terms, this study demonstrates several aspects of CDS:
1. Timely electronic, person- and time-stamped, structured data allows robust analysis.
2. Design, however well considered, requires periodic re-evaluation.
3. Analysis is necessary to identify unintended consequences and to confirm benefits.
4. Design by itself is insufficient to solve all CDS challenges. Leadership, education, review of best practice and policy as well as communication are often also required to achieve clinical goals.
5. The rapidity with which ordering behaviour can be changed is critical in a complex environment where standards of care may change quickly.
6. Effective cross-departmental coordination of CDS development is important.

As Cockerill et al suggest, reducing single blood cultures to zero should result in improved care and outcomes. In addition, this would reduce the work of phlebotomists (nurses in ED and lab technologists on inpatient units) by avoiding repeat blood cultures after the single had been noted. Finally, lab quality assurance effort is
decreased because they have traditionally contacted the units with alerts that one blood culture is insufficient.

There are several limitations to this study. Antibiotic timing data is not available in ED so we cannot assess the clinical impact of delay in second culture. This is especially so in Group 2 where the delay was sometimes in hours. As in most informatics evaluations of large CIS, it is difficult to assign causes to effects because the system is in constant flux due mostly to growing user familiarity but also due to post-implementation training and communication and support, clinicians exchanging ideas and “tricks”, process “work-arounds” and non-CIS changes in care and processes.

Acknowledgement

We wish to thank Ms. Jen Bohach for her careful data analysis.

References

Use of Case Mix Tools for Utilization Management and Planning

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Abstract. An aging population, new technologies and drugs, and tightening constraints on financial and human resources have placed increased demands on hospitals to meet health care needs. Canadian hospitals, health regions, and ministries are placing a high priority on the evaluation of appropriateness and efficiency of medical care and on the proactive and targeted reduction of inefficiencies. The CMG+ grouping methodology is a case mix tool produced by the Canadian Institute for Health Information (CIHI) to analyze the acute-care inpatient population in Canada. CMG+ methodology can be applied, for example, to utilization management. The expected length of stay (ELOS) indicator can be used as a benchmark for assessing the length-of-stay distribution of various subgroups of patient activity. It can also be used to compute potentially conservable days and to identify those patient subgroups where gains in efficiency may be realized. We describe CMG+ utilization management using this and other examples.

Keywords. case mix groups, utilization management, efficiency of medical care, health indicators

Introduction

Case mix grouping and indicators provide a basis for making meaningful comparisons within and among hospitals. The mix of patients seen can vary greatly within and among departments, facilities and jurisdictions. It is critical to consider the case mix profiling to bring meaning and understanding to our health information statistics.

Case mix systems exist to reduce the nearly infinite combination of diseases, interventions and clinically relevant information that hospital sector clients exhibit, into a reasonable number of clinically-relevant and resource-similar groups. Case mix grouping and indicators are used for monitoring, assessing patient safety, and decision-support. They also provide information for accountability agreements, interprovincial billing rates, and population based funding models.

Canada’s current acute inpatient grouping methodology is Case Mix Groups+ (CMG+). The CMG+ methodology was released in 2007 and introduced several new intervention-based factors. The new grouping factors were introduced as associated cases are linked to increased resource consumption. The addition of these factors, has however, resulted in a more complicated indicator methodology. With over 500 unique indicator values possible within a selected CMG, a simple look-up table structure for indicator assignment is unmanageable. As a result, the resource indicators are assigned at the base (non-factor) CMG and age group-specific averages. (Each case is assigned to an age group and CMG.) A much smaller portion of cases are affected by the CMG+
factors. For the factor cases, which constitute approximately 21% of annual inpatient data, additional multiplicative factor-specific lookups are required to adjust the resource indicators for the presence of the factors. Approximately three percent of cases have multiple factors. Additional interaction terms are also used to adjust the resource indicators for the interactions among factors. Client feedback, since the implementation of CMG+, has identified the need for higher level summary statistics than are currently available in the CMG+ resource indicator documentation and guidance on how to use this information for meaningful informed utilization management (UM).

1. CMG+ Grouping

CMG+ identifies 21 major clinical categories (MCCs), with 557 CMGs. CMG+ is an ICD-10-CA/CCI-native grouping methodology that replaces the ICD-9/CCP-based CMG/Plx methodology. The complexity (Plx) overlay in CMG/Plx was replaced in CMG+ with a comorbidity-based factor and three intervention-based factors: fourteen flagged interventions (such as chemotherapy, mechanical ventilation and tracheostomy), a count of intervention events (OR/intervention suite visits for significant interventions) and three out-of-hospital interventions. In addition, the number of age groups within CMG+ has been expanded. The prevalence of these factors explains considerable variation in resource consumption.

The grouping methodology uses the most responsible diagnosis (MRDx) to assign an MCC to a case. If qualifying interventions are observed, the intervention ranking highest in the hierarchy is selected for CMG assignment. In the absence of an intervention, the MRDx is used to assign the CMG to a diagnosis based CMG. Other data such as interventions, diagnosis and clinical information are used to refine CMG splits.

There are exceptions to the CMG+ high-level business logic, including MCC 8 - musculoskeletal diseases and disorders, MCC 14 - newborns and neonates and MCC 16 - infectious disease and disorders. The intervention partition of MCC 8 is split by oncology diagnoses to keep MSK oncology cases separate from non-oncology MSK cases. The newborn and neonate MCC includes all cases under 29 days old. Newborn and neonate CMGs are refined by delivery gestational age, birth weight as well as additional intervention and diagnosis codes. HIV cases are included in MCC 16 - Infectious disease and disorders. While the MRDx of HIV is used to group these cases to MCC 16, the manifestation diagnosis is used to group the case to a HIV CMG within MCC 16.

As cases are assigned to MCCs by the MRDx, and intervention CMGs based on the most resource-intensive intervention observed, it is possible for cases with similar interventions to be spread over many different CMGs. Take for example a patient with a knee replacement intervention. If the knee replacement is associated with a trauma MRDx, these cases will be grouped to a CMG within MCC 19 - Trauma and complication of treatment. If the knee replacement is associated with an MRDx of degenerative knee disorder, then the case will be assigned to an intervention CMG in MCC 8 - musculoskeletal diseases and disorders. If the knee replacement is associated with an oncology diagnosis, then the case will be grouped to a different oncology intervention CMG within MCC 8. If the knee replacement is performed at the same time as a higher resource intervention, say a hip replacement, then the case would be
grouped to the hip replacement CMG instead of the knee replacement CMG, as higher resources are required for hip replacement interventions. If however, there are complications and the patient is kept in hospital for a long period of time awaiting placement in a sub-acute bed, the MRDx will eventually become awaiting placement, and this case would then be assigned to MCC 20 - Other reasons for hospitalization. For this reason, CMGs are not as effective in identifying all of a particular type of intervention case. This is an important limitation of the CMG+ grouping methodology. This refined CMG grouping methodology does, however, improve the clinical and resource similarity by assuring that cases within CMG are as similar as possible.

2. CMG+ Indicators

There are two main CMG+ indicators, expected length of stay (ELOS) and resource intensity weights (RIW). The indicator values are updated annually with the most recent indicator data sources to reflect annual changes to the grouping methodology. Approximately four million acute inpatient records, that is, two years of acute inpatient cases, are included in the calculation of ELOS statistics. ELOS values are the factor-adjusted average acute LOS of acute inpatient typical cases. Transfer, death, sign-out and long stay cases are excluded from ELOS statistics as these cases have either an interruption to their service profile or an exceptionally long LOS when compared to similar CMG-factor specific cases. While ELOS is assigned to all cases, meaningful comparisons can only be made with typical cases.

Alternate level of care (ALC) days are purposely excluded from ELOS methodology as ALC days are ideally not expected. The distribution of ELOS statistics is heavily skewed. The average ELOS is approximately five days while the median ELOS value is three, indicating that the bulk of cases have three days stay, but there are many cases with much larger LOS values, that result in a higher average ELOS value. An ELOS minimum of one and maximum of 100 are applied.

Associated with ELOS measures are the CMG-factor-specific trim points. Cases with a LOS beyond the trim point are identified as long-stay cases, with a separate RIW methodology. Trim points are identified as the extreme end of the LOS distribution where the LOS exceeds what is reasonable expected. These cases are identified separately for two main reasons: to allow for more accurate ELOS statistics calculation and to identify these cases for a separate RIW calculation process and mitigate the resource burden these cases can have. The overall portion of cases that are long stay is set to approximately 4.5 percent of all cases.

The RIW values are cost weights that are relative to the average typical inpatient cost. The RIW values are calculated using service recipient cost data for a subset of the acute inpatient cases with approximately a million patient-based cost cases for each annual RIW calculation. While ELOS uses a single regression model for computing ELOS statistics, there are separate RIW statistics produced: the typical RIW values, the per diem RIW, and long stay per diem RIW. The typical RIW values are the average relative resource indicators, the per diem RIW is the average relative daily cost rate, and the long stay per diem RIW is the hoteling or ALC relative per diem value.

These three RIW statistics are used to calculate RIW for the main atypical types. Typical cases are assigned the CMG factor-specific average values in a process similar to ELOS calculation. Atypical cases are assigned RIW based on the per-diem value multiplied by the observed LOS, and adjusted for factors, atypical status and the LOS.
Per diem estimates represent the daily costs and are calculated as the RIW divided by ELOS. Long stay case RIW are assigned as the typical factor adjusted RIW plus the difference between the LOS and ELOS, multiplied by the long stay per diem rates.

The RIW calculation process includes the hospital-specific relative value or HSRV methodology, an iterative process of averaging to adjust for systematic variations in the raw cost data by facility, CMG and fiscal year. The HSRV methodology is used to adjust for facility-, fiscal year- and CMG-specific trends observed in the raw cost data and translate the raw costs to relative measures. The RIW values are also adjusted for observed differences in the LOS reported on the service recipient and national ELOS values.

3. Introducing CMG+ Use and Understanding 2009

To facilitate client use and understanding of CMG+ grouping and indicators, CIHI’s Case Mix department will be releasing a new publication in the summer of 2009: “CMG+ Use and Understanding.” This document will include a high-level review of both the CMG+ grouping and indicator methodology. CMG+ users will still require access to the details in the CMG+ Directory and DAD RIW & ELOS documentation for comprehensive details on CMG+ grouping and indicators. This document will provide a high level review of grouping and indicators to ensure that the issues pertinent to CMG+ interpretation are available in a simplified format.

The document will also outline the CIHI standards for using CMG+ information for utilization management and planning purposes. One of the fundamental ways that resource indicators are used is to estimate resource consumption. By using retrospective case mix grouping and indicators, predictive resource models can be built. CIHI currently endorses using the Canadian Management Information Systems Database (CMDB) cost per weighted case (CPWC) statistics to convert the relative RIW measures to dollars. CPWC statistics are available at the facility, region, provincial and territorial, and national level. Determining which CPWC statistic to consider needs to be evaluated carefully in order to assure that the proper CPWC statistic is used. There are also instances when using the CPWC statistic, especially at the facility level, should be used with caution. This documentation will define the standards for using CPWC to convert RIW to dollars and what the expectations to use are.

To further meet client demands for high-level summary information, the document will include several appendix tables with summary statistics to assist in decision-making. These tables will be produced by jurisdiction, peer group, hospital, diagnosis-intervention partition, MCC, and CMG. In addition to standard indicator statistics such as averages, percentiles, market share, and rankings, the tables will include rolled-up atypical distributions portions and new statistics that have been derived from CMG+ grouping and indicators specifically to facilitate CMG+ use and understanding.

For example, it is standard utilization management practice to compare observed LOS values with national and peer standards. There is, however, variation in how the comparisons are made. Some jurisdictions use ELOS as the national standard for LOS measures whereas others use the reported 25th percentile value of LOS.

All inpatient days of stay are not created equally. Intervention cases have higher costs and per diem values and tend to consume more resources, particularly in the early portion of the stay. While it may seem intuitive that reducing LOS reduces costs,
intervention-based cases with extremely short stays must absorb the admission and intervention costs over the shorter stay, resulting in more resource intensive days, or higher cost per diems. As LOS increases, the resource consumption declines although less dramatically after the first several days of stay. LOS values that are already shorter than the reported ELOS represent resources conserved as the stays are costly.

4. Strengths and Weaknesses of Using Case Mix Measures for UM

Case Mix grouping and indicators are an integral component of UM. The CMG+ grouping and indicators represents a detailed, complicated, yet elegant methodology. It is easy, however, to misuse and misinterpret trends and results. There are many grouping and indicator details that must be considered when evaluating the data. For example, the grouping methodology and indicators are updated each year to include more recent data in indicator estimates, address modifications to the underlying data coding systems, and further refinements the grouping and indicator methodology. Comparisons of data across multiple methodology years can often lead to erroneous data interpretation. To perform meaningful trending analysis, the data needs to be grouped according to a consistent methodology by the process referred to as “historical regrouping.” Historical regrouping ensures that regardless of underlying changes in methodology, clinically similar cases are grouped and assigned indicators in as comparable a way as possible. Without historically regrouped data, observed differences could either be real differences or differences resulting from shifts in methodology over the years.

Another common example of CMG+ indicator misuse would be inclusion of atypical and long stay cases in the evaluation of conservable days with ELOS statistics. While ELOS values are assigned to these cases, ELOS is calculated excluding atypical and long stay cases on purpose, as by definition, atypical and long stay cases are not expected to exhibit a typical distribution of LOS. Any evaluation of conservable days including atypical or long stay cases in the calculation of conservable days is inaccurate and inappropriate.

For these very reasons that CIHI’s Case Mix department will be concentrating its efforts on providing support for these processes and documenting the potential pitfalls. By releasing the CMG+ Use and Understanding document in 2009, CIHI will help clients understand how to appropriately use case mix information for UM and address client needs for high level summary statistics necessary for making meaningful data evaluations.
A Standard Operating Protocol (SOP) and Minimum Data Set (MDS) for Nursing and Medical Handover: Considerations for Flexible Standardization in Developing Electronic Tools

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Abstract. As part of Australia’s participation in the World Health Organization, the Australian Commission on Safety and Quality in Health Care (ACSQHC) is the leading federal government technical agency involved in the area of clinical handover improvement. The ACSQHC has funded a range of handover improvement projects in Australia including one at the Royal Hobart Hospital (RHH), Tasmania. The RHH project aims to investigate the potential for generalizable and transferable clinical handover solutions throughout the medical and nursing disciplines. More specifically, this project produced an over-arching minimum data set (MDS) and over-arching standardized operating protocol (SOP) based on research work on nursing and medical shift-to-shift clinical handover in general medicine, general surgery and emergency medicine. The over-arching MDS consists of five headings: situational awareness, patient identification, history and information, responsibility and tasks and accountability. The over-arching SOP has five phases: preparation; design; implementation; evaluation; and maintenance. This paper provides an overview of the project and the approach taken. It considers the implications of these standardized operating protocols and minimum data sets for developing electronic clinical handover support tools. Significantly, the paper highlights a human-centred design approach that actively involves medical and nursing staff in data collection, analysis, interpretation, and systems design. This approach reveals the dangers of info-centrism when considering electronic tools, as information emerges as the only factor amongst many others that influence the efficiency and effectiveness of clinical handover.

Keywords. clinical handover, standardized operating protocol, electronic tools

Introduction

“Standardise. What is standardisable?...Hospital leaders often complain that our physicians won’t accept any standardisation of practices. But when you look at what the hospital is trying to get physicians to do, you find that they’re being asked to follow detailed protocols .... These pathways attempt to standardise too much, are too complicated, and are legitimately resisted by physicians as ‘cookbook medicine’ in many instances.” [1]
Clinical handover has been defined as “the transfer of professional responsibility and accountability for some or all aspects of care for a patient, or group of patients, to another person or professional group on a temporary or permanent basis” [2]. It is widely recognized that good handovers do not happen by chance and that they require significant structural and organizational efforts. There needs to be leadership, time commitment, human resource commitment, and proper structures in place for effective clinical handover to occur [2]. Due to changing work hours within many hospital settings, clinical handovers have become a task of increasing relevance [3]. A major high risk area where improved clinical handover solutions are urgently required is in shift-to-shift medical and nursing handover. A major factor inhibiting improvements are issues related to the lack of basic understanding of the clinical handover process and the lack of common structure for clinical handover [4]. Clinical handover is clearly a highly complex process affected by many different factors [5]. As a recent review of handover literature has highlighted, clinical handover is very important to ensuring continuity of patient care within healthcare settings; the lack of adequate handover often leads to poor patient outcomes [6].

Research has been aligned with these discussions on the role of electronic tools and/or systems to improve clinical handover [7,8]. While information and communication technologies have real potential to enhance the quality and safety of health care, beyond the successes of some clinical diagnostic and treatment technologies, there continues to be a disjuncture between this “promise” and the reality of ehealth [9,10]. From an information systems perspective, an analysis of IT failures reveals the prevalence of techno-centric and/or info-centric assumptions about how IT benefits can be achieved [11]. Also, despite increased awareness of the need to “engage users,” this continues to be very hard to do at a practical level and there remain a limited number of case studies on clinical handover addressing how to: (i) generate insights into the range of socio-technical factors and their inter-relationships; (ii) how to engage end-users; and, (iii) how to translate these insights into an IT tool and/or system design that involves clinicians as co-participants [12-14].

1. Aims

This paper examines an ACSQHC funded clinical handover improvement project conducted at the Royal Hobart Hospital (RHH), Tasmania, Australia. This project aims to investigate the potential for generalizable and transferable clinical handover solutions across the medical and nursing disciplines. More specifically this project produced minimum data sets (MDSs) and standardized operating protocols (SOPs) for nursing and medical shift-to-shift clinical handover in general medicine, general surgery and emergency medicine. The project was also able to generate an over-arching MDS and SOP incorporating a “flexible standardization” approach that recognized the importance of engaging users in each clinical area. The over-arching MDS consists of five headings: situational awareness, patient identification, history and information, responsibility and tasks and accountability. The over-arching SOP has five phases: preparation; design; implementation; evaluation; and maintenance.

This paper provides an overview of the project and the approach deployed. It explores the implications of standardized operating protocols and minimum data sets for developing electronic clinical handover support tools. This paper aims to contribute
to the field of patient safety and medical error management through on-going work on clinical handover improvement.

2. Methods

The over-riding methodological framework deployed in this project involved an holistic socio-technical approach to understanding and improving clinical handover. This approach integrated clinical and information systems expertise with qualitative field techniques and user-centred education and training in an iterative feedback loop. At a practical level, the research team expended considerable effort from the outset of the project to engage stakeholders at all levels in the hospital. A range of techniques were used to “build trust and rapport,” alongside conventional qualitative field observation sessions, interviews, participant observation and analysis of handover messages (between 50 to 100 messages). These included informal chats and team members being active participants in informal gatherings and social activities prior to the beginning of formal data collection. Based on this in-depth engagement process, it was possible to optimise understanding of the clinical processes in the different clinical areas and across the different disciplines.

Based on this data collection, analyses and interpretations of individualized MDSs and SOPs were developed for medicine and nursing across the three areas (i.e., 6 sets in all). These were then used to stimulate further feedback from participants, which resulted in further revisions. The research team then engaged in further analysis to explore differences and commonalities among these MDSs and SOPS. This analysis led to the development of an over-arching minimum data set and over-arching standardized operating protocol. The research team also developed education and training manuals to support the transfer of skills and knowledge. Building on the iterative feedback approach, those insights generated as the project matured were fed back into further revisions of the MDS and SOP, education and training materials, and protocols for engaging stakeholders.

3. Results

This project has developed transferable standardized operating protocols incorporating minimum data sets for medical and nursing shift-to-shift handover in General Medicine, General Surgery and Emergency Medicine at the Royal Hobart Hospital. It has generated the associated manuals and training materials. Significantly the approach also supported the development of an over-arching minimum data set and over-arching standardized operating protocol to provide a coherent framework for supporting transferability of clinical handover improvement initiatives in different clinical settings. The remainder of this section outlines the over-arching MDS and SOP.

From the analysis of the MDSs across the three clinical areas and two disciplines (medicine and nursing) it is evident that there are significant differences. These differences are partly related to the different disciplines, communication methods and settings used in clinical handovers (e.g., bedside handover involving patients versus formal handover in separate meeting rooms). However, following detailed analysis an over-arching MDS was able to be generated that achieved a standardization of minimum content for the transfer of information, responsibility and accountability
during shift-to-shift clinical handover. The over-arching MDS is structured in five sections:

1. Situational and Environmental awareness
   a. Alerts and safety
   b. Advanced notice (especially high risk patient movement)
   c. Attention (to sick/deteriorating patients)

2. Patient identification and demographic details
   a. Textual identification (at least surname)
   b. Numerical identification (hospital unique identifier or date of birth)
   c. Wrist band check or other demographic data

3. History, evaluation and management
   a. History (presenting problem, relevant past history and current issues)
   b. Evaluation (physical examination findings, investigation findings and current diagnosis)
   c. Management to date

4. Responsibility, risk management and action plan
   a. Tasks to be completed (including the tasks and recommendations)
   b. Outstanding or abnormal results and observations (include a list, as well as actions and recommendations)
   c. Risk management

5. Accountability to ensure patient safety
   a. Patient (code status, MET status, other relevant information)
   b. Profession and colleagues (treating and responsible doctors, charts and clarifications)
   c. Organization (discharge planning)

Similarly, the over-arching SOP was generated from an analysis of data from the six SOPs developed across the three clinical areas. Importantly, however, this SOP was also developed in a manner that recognized the fact that any standardized solution will require the capacity to be adapted to local circumstances in order to ensure integration to achieve safer clinical care. The over-arching SOP is comprised of five phases: preparation; design; implementation; evaluation; and maintenance. Each phase has a number of individual steps described in terms of background issues, objectives, framework, local considerations and tools and guidance. It is recommended that all five phases be considered by individuals or groups who are interested in improving the clinical handover processes. Critically the “flexible standardization” of this over-arching SOP aims to achieve the following objectives:

1. a standardized solution which allows seamless integration into the local clinical context to improve clinical handover.
2. a standardized solution which will provide tools to clinicians and managers interested in the area of clinical handover to implement clinical handover improvement initiatives within their local clinical services.
3. a standardized solution which will reduce communication gaps for patient care.
4. a standardized framework which allows for national learning from local adaptation and implementation of the standardized operating protocol.
5. a standardized framework which will enable evaluation of information tools and communication processes for patient safety.
4. Discussion

“The challenge of patient safety is not only clinical, but also organizational. To succeed, patient safety initiatives must be designed and executed using change management principles such as congruent changes targeting multiple components, specific change management roles for different participants in the care-delivery process, implementation through dedicated support structures and multiple tactics, and institutionalization through enhanced workforce capabilities and opportunities for continuous learning. [15]”

The sections above describe the ACSQHC project at the RHH in Tasmania. This section of the paper explores the implications of this approach and its outputs for developing electronic clinical handover support tools [11].

At the broadest level, systems designers, by taking user engagement seriously, are presented with the challenges of how to maintain responsiveness to the diversity of user requirements and how to balance the variety of needs versus wants articulated by different users. Users as co-participants in solution development usually have different levels of knowledge on the phenomena being researched as well as the potential of IT tools/systems to assist. Critical in this process is the need to manage expectations while maintaining an incentive for change that will assist with adoption and usage of any IT tools/systems built. At a more practical level, this research highlights that designers may need to curtail their own desires to build “state of the art” features and functionally complex tools as these may not be appropriate for clinical work practice or the users’ conceptualizations of the handover problem being addressed. The tendency of IT designers to see clinical work practices as primarily information problems may account for the high percentage of IT health project failures. As this research project has illustrated, clinical handover is highly complex and involves a dynamic set of inter-relationships among socio-cultural, communicative, organizational and technical factors. To reduce this to merely a problem of information flow is to marginalize the very rich user insights generated through the co-participation process. In considering the role and development of electronic tools to support clinical handover, a sustainable system needs to ensure:

- Identification of, engagement with, and support from all stakeholders (either directly or indirectly);
- Direct acknowledgement of differences between what participants do and what they say they do and their knowledge of these differences;
- Engagement with clinical change champions;
- Direct acknowledgement of all views but also expectations management of what is achievable within the tools/systems and what will remain aspect of the protocols for handover (i.e., a support tool rather than a replacement for good work practice);
- On-going processes for refinement and change over time (i.e., the tools must not be conceptualized as ‘finished’ rather they are part of a dynamic system requiring subsequent modification as work practices evolve); and
- Mechanisms for on-going feedback.
5. Conclusion

This paper has provided an overview of the RHH clinical handover project and the approach deployed and briefly considered the implications of the standardized operating protocols and minimum data sets for developing electronic clinical handover support tools. This work is on-going and the ACSQHC has recently invited the Tasmanian project team to engage in further work on the branding, marketing and extension of the over-arching SOP and MDS. The team are also examining options for extending the initial electronic handover tool built [11].

References


Managing Terminology Assets in Electronic Health Records

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Abstract. Electronic Health Record (EHR) systems rely on standard terminologies and classification systems that require both Information Technology (IT) and Information Management (IM) skills. Convergence of perspectives is necessary for effective terminology asset management including evaluation for use, maintenance and intersection with software applications. Multiple terminologies are necessary for patient care communication and data capture within EHRs and other information management tasks. Terminology asset management encompasses workflow and operational context as well as IT specifications and software application run time requirements. This paper identifies the tasks, skills and collaboration of IM and IT approaches for terminology asset management.

Keywords. EHR, terminology asset management, data mapping

Introduction

Now that electronic health records (EHRs) are replacing antiquated methods of storing health data, there is a compelling need for terminology asset management within healthcare organizations. According to McClure et al [1] this approach creates the infrastructure required to implement, utilize and maintain encoded concepts within computerized systems. From a health information management perspective, terminology asset management is a required element for all EHR systems. Standard health terminologies are a prerequisite to functionality.

The infusion of technology into record-keeping suggests a promise of improved patient safety and quality of care, cost control and richer sources of data for clinical research. To make all these promises come true, a solid terminology foundation is required to ensure interoperability between systems and data integrity.

This research paper confirms the need for terminology asset management as a critical component in the health record of the future. Terminology services represent functions necessary to manage, search and access terminology content [2]. Organizations adopting standard terminologies are recognizing that the existing and future HL7 (Health

1 The term Electronic Health Record is used in this paper to describe a health record created and stored using electronic media. Use of the term in this context does not express specific functionality or care setting attributes.

2 This paper represents the opinions and view of the authors listed and does not necessarily reflect any endorsement or position of listed affiliations.
1. Evaluating Clinical Terminology Systems for the EHR

How are terminologies used for selected parts of the health record evaluated and deemed “fit for purpose”? Health care is delivered at the local level but the data derived from the service are required for regional and national use. This requirement for shared data underscores the significance of the application of useful terminologies, expressed as code systems, essential to overall system reliability. As health record content requirements are developed, the importance of terminology oversight is evident and the need for evaluation is revealed. Within HL7, a code system is defined as a collection of uniquely identified concepts with associated designations, associations and meanings. To meet the requirements of a code system, a given code must correspond to one and only one meaning. At a minimum, Code Systems have the following attributes:

- An identifier that uniquely identifies the code system (id)
- A name that the code system is normally referred to (localName)
- A name that is the official name of the code system as assigned by the terminology provider (fullName)
- A description that describes the Code System (Description). This may include the code system uses and intent.
- Copyright information pertaining to the Code system (copyright) [2]

Requirements and specifications are acquired through detailed interviews and observations with individuals and/or departments involved. Some terminologies are used locally while other core terminologies such as Systematized Nomenclature of Medicine, Clinical Terms® (SNOMED CT), Logical Observations, Identifiers, Names and Codes® (LOINC), or The International Classification of Diseases, (ICD) are normally used across health care enterprises and business partners.

Interface terminology systems facilitate ease of use for clinicians at the point of care. Rosenbloom et al [4] provide a model for evaluating interface terminologies. In order for SNOMED CT® to be implemented, EHR vendors require a clear business case for deployment in their systems [3]. Measurable attributes include concept coverage, term accuracy and expressivity required by the use case. Multiple system terminology asset management is conducted in a team environment to establish broader input and diverse perspectives [1]. Membership in this team is institution specific and includes both clinical and EHR vendor partner expertise. Team assessment and participation in evaluation is critical to make sure all needs are met.

For example, in preparing the Canadian French translation of SNOMED CT®, the team created subsets using input from projects to be implemented. At first only a subset of concepts is to be translated. The first subsets are based on business needs of Quebec and additional translation will occur at a later date following evaluation. According to Fabry, the translation team has encountered difficulty finding adequate concepts to express in French. The primary challenge involves missing logic surrounding the terms so the actual use of the term is necessary to select the correct map [5]. Methods and examples must be used in combination to properly evaluate terminologies to assure they are fit for purpose.
2. Linking Terminologies for Data Management

When data maps for a specific use case are necessary how is this accomplished and what is the best process for data map maintenance?

Data maps create a bridge between information expressed in one terminology to its equivalent in a different terminology somewhat like the translation from the French language into English.

When a clinical reference terminology is linked to a classification system, data maps increase efficiency in the system by re-purposing captured data [6]. Once medical information is captured using an interface terminology, it can be mapped to terminologies with formal representations [7]. Maps are available from commercial terminology service providers, government agencies and standards development organizations [8]. Specialized associations between terminologies require attention from expert human review or a combination of machine maintenance with human oversight [9]. Guidelines and heuristics for creating maps must be detailed to enable reproducibility [10].

An illustrative example of clinical input and vendor collaboration for terminology equivalence is found in product offerings of Ocean Informatics via the Ocean Knowledge Studio (OKS) employing clinical knowledge models and terminology subset tools. These applications enable clinical terminology experts to visually define queries linked to SNOMED CT® or other standards. The resulting output of the OKS authoring environment provides a means to have standardized, adaptable, and portable information. Software tools, coupled with terminology service integration, provide a powerful environment to support dynamic healthcare business needs [11]. The storage and reuse of archetypes in a collaborative environment saves both time and money for everyone using the standards [12]. Creation of mappings, regardless of methods or tools used to create the map, is likely to suggest ways to improve the vocabularies on both sides of the map [13]. Terminology asset managers should coordinate revision requests to the appropriate standards development organization to foster maturity in the systems.

3. Implementation in Electronic Health Records

What critical factors must be considered for controlled terminology systems implementation and subsequent use in electronic health record components and which organizational units in a health care enterprise must be involved in strategic planning for implementation and use projects?

Impact of terminology use depends on the penetration of the system involved. The content accessible within the EHR is as important as the record itself [14]. Core terminology (e.g., SNOMED CT®, LOINC®) requires user collaboration, ongoing oversight and scheduled maintenance for successful results. The Canada SNOMED CT® translation team has found a number of defaults from the fusion between the SNOMED and READ codes. In some cases there are redundant or ambiguous concepts and spelling errors which can potentially cause problems. Since the team is only at the translation portion of the project, they do not know how these issues will impact the user. Improvement to the terminology is ongoing but impossible without use in the clinical environment. Input from early adopters will be helpful to overall terminology asset management [5].
A collaborative partnership must exist between organizations and their technology vendors and/or terminology service providers for a smooth EHR implementation. An implementation checklist is useful and questions that must be addressed include:

1. Which software applications will use the terminology data files, the terminology services, or terminology system?
2. What departments use the terminology system?
3. What key individuals or groups are impacted?
4. What existing terminology maps are available (with preference to those produced by authorities or official sources)?
5. Is mapping to any other terminology or classification system required?
6. If additional data maps are required, who will develop them?

Maintenance plans must be established and the process managed to sustain the value of organizational terminology assets. Issues to address include determination of what standards development organization owns the terminology and at what intervals the terminology will be updated. If a terminology service provider has not been contracted to manage updates, a maintenance budget allocation and assignment of responsibility by internal staff is required [15].

4. Identification of User Groups

What methods are used for identification of users and stakeholders requiring terminology use orientation and training?

Training is needed to understand clinical terminologies and how to use them correctly. Clinical reference terminologies can be complicated and both implementers and end users require a good understanding of terminology architecture and terminology rules.

Educational requirements can be separated into primary and secondary approaches. Primary users include individuals or department that educate others or have “hands on” interaction with the terminology. Secondary users include organizational management, clinicians affected by the use of the terminology, financial interests impacted by terminology covering administrative interests, software vendors and other business associates. Secondary users are frequently involved in workflow and depend on or are otherwise affected by the terminology [16].

Canada Health Infoway has created a Standards Collaborative Education and Training Task Force to inform identification of affected groups. They have developed a survey to determine participants’ level of involvement and knowledge, to inform the education and training needs. Survey results are expected to be available by December 2008 [17]. Needs assessment surveys are a good example of a method used to confirm identification of user groups for specific content areas. In the United States activities are underway to prepare for the migration of ICD-9-CM to ICD-10-CM and ICD-10-PCS. An initiative of this magnitude requires audience segmentation for optimal education and training plans, Checklists and tool kits have been created to inform the large stakeholder groups [18]. New classification systems have special challenges for education of groups since today’s healthcare delivery system involves numerous and diverse user groups resulting from ubiquitous use of electronic data sharing and health care claims transactions.
5. Educational Approaches for Terminology Orientation and Training

Which methods of education are offered to users concerning terminology access, management and use?

Each identified user group usually requires a different approach for learning. Approaches to education may be viewed from three perspectives:

1. Unique needs (Formal education/certification, Technical training, Heightened awareness).
3. Specific needs and learning level of instruction required [16].

A variety of educational sessions are available to meet identified needs. There are a number of Health Information Management (HIM™) and HI degrees and diploma programs available. Université de Sherbrooke in Canada offers two graduate level microprogrammes. Both programs provide formal distance or on site education in terminologies in both English and French[19,20]. The Canada Health Infoway Standards Collaborative provides sessions in HL7 v3, SNOMED CT® and also in Introduction to Vocabulary, LOINC® & pan Canadian Laboratory Observation Code Database (pCLOCD) [21].

In the United States, educational offerings are available from universities and colleges offering informatics degrees and certificates and through many professional associations, including the American Health Information Management Association (AHIMA). Government sponsored outreach activities and commercial firms with educational programming are also available.

Our research identified that a variety of different methods and venues exist to meet unique needs in the management of terminology assets to ensure appropriate coverage and understanding of the role of these important components in health care delivery. For educational programming, using terminology content is more effective when offered in computer enabled environments since the technology supports simulation of terminology use, workflow and reporting results.

Conclusion

Managing terminology assets in Electronic Health Records is an emerging role that requires thoughtful consideration in strategic planning and implementation project execution. Without dedicated resources to evaluate candidate systems, link them to existing or other new terminologies, guide implementation to meet electronic health records requirements, and identify and educate user groups, the investments in these important resources will be wasted.

Interface terminologies used at the point of care to facilitate linkage between local clinician-friendly terms, patient-friendly terms and additional secondary data uses are important to multiple business requirements. In order for an EHR to deliver on promises of improved patient safety, quality of care and greater efficiency, additional attention to infrastructure and terminologies is critical. This research sets the stage for the next generation of health records using standard terminology foundations. Future efforts will ensure data sharing between providers and consumers. Now is the time to be engaged in expanding the expertise required, learning what tools and models are already available to
take electronic health record to the level providers and patients expect for intelligent, integrated, interactive care and beyond.

References

Normalization of Reported Lab Results

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Abstract. It is possible for physicians to review electronic lab results in the format of the sending lab and, as well, to see them using advanced visualization techniques. When lab results for a particular patient are reviewed by a physician, they must be integrated with other lab results and other issues of the patient. Viewing the results can present a number of difficulties. One problem relates to normal ranges that can change over time and can be different when sent by different labs. This is not an issue when results are printed but when the results are graphed with their normal range displayed, distortions often prompt questions from patients who are shown the results. There are also situations were it is important to review a cluster of four or five different tests to properly understand the clinical situation. Tests in the cluster, however, can have interrelated result values that differ by orders of magnitude. Normalization, which can be used to scale the graphs, has been proposed in the past but not gained any popularity. The benefits of this approach are discussed.

Keywords. lab test results, normalization, visualization, graphing

Introduction

Coiera \cite{1} has stated that to achieve the oft cited and demanded “reform” required to ensure “health care is to flourish in the coming setting of diminished resources and increased demand, then it will do so because we have explicitly designed and implemented new systems of care that are fundamentally sustainable. Given the likely enormity of that task, it may require nothing less than the reinvention of health care.” He also discusses the cognitive load on physicians. Our paper, which describes a functionality related to graphing lab results, was prompted by the needs expressed by Coiera.

Chronic Care Model as described by Bodenheimer et al \cite{2} is predicated on the innovative use of informatics and information and communication technologies. With the rising interest in chronic disease management and the increasing understanding of disease trajectories it is of increasing importance to see and understand trends based on laboratory results. Physicians have traditionally viewed lab results printed on paper. Consequently, various data formats and standards have been developed for this medium. With the electronic delivery of lab results and the ability to use computers to view the results, new ways of presenting the results are possible and the viewing parameters can be set by the user.

The interpretation of laboratory test results is becoming increasingly complex. It is now difficult for any one person to remain abreast of current developments in the whole of laboratory medicine. The availability of computer based lab results allows for
the manipulation of those results. Results that were typically delivered on paper had a
fixed format defined by the facility delivering those results. Even when a lab delivers
electronic results, it continues to be careful about formatting those results because of
concerns related to their misinterpretation. With computer based applications, however,
it is possible for end-user applications to manipulate the display of the results and to
use the results in different contexts such as graphs and clinical decision-support
applications. Blois stated that “The cognitive problem facing the physician is how to
take the available clinical data in a given case, which are disparate in kind and
reliability, and wring from them in the light of personal knowledge the appropriate
conclusions, whether they pertain to diagnosis, treatment choice, or case management”
[3].

Factors, such as age, sex, sampling procedure, concurrent drug therapy, biological
variation and so forth, have varying effects depending on clinical circumstances and the
testing technology. These factors must be taken into account for a correct
interpretation of results. It is becoming more evident that there is an interplay between
numerous variables rather than just a solitary interaction between two things [4]. It
makes sense to provide the person, who views the test results, with tools that assist in
the visual integration of multiple variables.

The way that electronic lab results are currently delivered hampers the ability to
exploit the capabilities of computers to display lab results. Electronic results have the
advantage that they can be stored for many years and later be displayed longitudinally.
When viewing a particular test with results that span several years, shifts in the normal
range become evident. This shift in the normal range can add to the difficulty in
interpretation. When results are thus displayed to the patient, the patient often requires
an explanation why nothing was done in the past even though the lab result then was
just as high as it is in the present.

The defined normal range will be different when the same lab uses different
methods or instruments to do the tests. The differences in normal ranges may also be
evident when results are from different labs. Results from several labs may be
interspersed when one looks at several years’ worth of results. These problems were
identified in the past with the test for prothrombin time (PT). Results from multiple
labs were different enough to cause difficulties for clinicians to manage patients on
anticoagulants. As a result of this, the labs decided to switch from reporting the actual
PT result to reporting an International Normalized Ratio or INR. This is now the
standard way that PT results are reported.

The typical graphs used in EMRs or electronic medical records applications show
only one parameter. If a second or third parameter is of interest, additional graphs are
displayed. If cholesterol results are being reviewed, the total cholesterol, LDL, HDL,
TG and CK are all of interest. If a patient has liver problems or kidney problems, the
clinician is interested in how a number of different test results interrelate and how they
are influenced by medications. In the information visualization domain, there are ways
of displaying 6 or 10 or 1,000 different lab tests with thousands of data points on a
single screen. Normalization of lab results would facilitate the creation of more
comprehensive displays. The difficulty with grouping clinical lab results as mentioned
above is that the numeric ranges for the different results can be very different. For some
tests the range could be from 0 to 10 while for another test in the same group the range
could be from 0 to 600,000. Normalization would rescale these results to fit a range of
0 to 100. A small number of authors have given presentations and published papers in
support of the concept of normalization of lab results. Powsner and Tufte published
their landmark article on graphic reporting, which included a graphic prototype of a single laboratory measurement [5]. Surprisingly, there has been almost no subsequent implementation in applications that are used to display lab test results [6,7]. In the paper by Henry[6] he notes that:

In Cleveland’s second work, visualization as the process in which information is encoded on graphic displays is deemed critical to data analysis of graphs. In it, he further asserted that graphs are powerful tools provided that the information contained within can be decoded visually with relative ease; this enables clinicians to examine graphs of data and, based on their experience, come to a more accurate and prompt conclusion.

Spackman and Beck also emphasized the importance of effective communication in laboratory reports, both printed and computerized, with the need for improvements. We concur with their assessment that there is a substantial "risk of information overload" and that an inordinate amount of time is required for clinicians to review unimportant results for the most critical values amidst less relevant information. They also called attention to the need for well-organized and readable results, with easy-to-follow trends and highlighted critical values so that both the magnitude and direction of deviation are evident to the reader.

For some tests, the clinical significance increases even with small changes while for others the results may have to be an order of magnitude different to achieve the same clinical significance. Clinicians understand that, if the potassium level is even slightly above normal, attention needs to be paid yet if a platelet count triples it does not raise the same level of concern. This suggests that normalization should not be a blind procedure. The laboratory variables are “individual” with different statistical properties and clinical interpretations. Consequently, they also require different normalization formulas [7].

Considerable effort would be needed to create individualized normalizations for the over 30,000 different laboratory tests. There are a few tests that are done with great frequency. These tests are done on many patients and physicians review these tests on a daily basis. Many patients have these tests done repeatedly. Groups or panels of these tests are described in the next section.

Transformation of lab results to normalized values can facilitate their in clinical decision-support. The numeric value is not so much of interest, rather, it is the clinical significance of the result that is of interest. Having normalized results could make the creation and maintenance of decision support rules easier to maintain.

1. Methodology

In using a range of 0 to 100, low normal could be defined to be 40, high normal to be 60, critical low to be 20, and critical high to be 80. The starting point would be the actual result and the transformation would be based on the values that sent for LL, L, H and HH. This would provide a clinically appropriate scaling in spite of very different values. If it is not possible to the values for LL and HH then some assumptions would have to be made regarding the scaling of the results.

The entire range cannot be normalized with a straight line relationship because the clinical significance may not follow a straight line. The laboratories already have
values that they use to flag critical high levels and critical low results. If these values were sent with the result then the transformation could be done in a way that was clinically reliable. In situations where the values are not available it should be relatively easy to review each of the following tests and create normalization curves for each.

2. Suggested Panels of Tests

The meanings of the following abbreviations are well known to people who use them daily.

- Basic Metabolic Panel: Na, P, Cl, CO2, BUN, Cr, glucose, Ca
- Hepatic function: Total Protein, Albumin, Total Bili, Alk Phos, ALT, AST
- Hematology Panel: Hgb, MCV, MCHC, HCT, WBC, neutrophils, platelets
- Lipid Panel: Total Cholesterol, LDL, HDL, TG, CK, GGT, ALT, AST

With this small number of test types would be relatively easy to develop a consensus on the scaling of the numeric values against the ordinal or Y-axis for clinical significance. When the four or five parameters in a single panel are graphed it would be easy to notice whether one parameter was out of synchronization with the others or if all of the parameters were changing in the same direction. Figure 1 shows number of lab test results where most of the values are at the bottom of the graph; it is hard to see whether or not other parameters are changing with line “A.” Figure 2 clearly shows the other parameters changing with Line “A.” The normal range in Figure 2 is between 40 and 60.

Figure 3 shows another group of lab test results. Here CK has an obvious peak while the other parameters are pushed to the bottom. Figure 4 shows the same results after normalization and it is clear that the TC and the LDL lines show a decline after the statin is started. After a period of time the CK values increase and the statin is discontinued. After this it is clear that the LDL and the TC begin to rise again.

3. Conclusion

The concept of having graphs of lab results that display normalized results is only one aspect of functionality that can be developed to take advantage of what computers can do to facilitate the interpretation of lab results. Other aspects of functionality could relate to the user being able to easily select the parameters that are to be displayed, the ability to vary the time scale from many years to a few days. It is also possible to generate graphs that display results of all the patients in the practice. These features and the integration of graphical displays with dynamic queries and direct manipulation of databases would also provide a great deal more sophistication than is typically provided to physicians reviewing laboratory results [8]. While the paper by Card was published12 years ago most physicians using computer based medical records applications have yet to see the level of sophistication described in that paper.
One challenge that physicians face when managing patients is to help them achieve increasingly strict clinical targets. Clinical practice guidelines specify increasing numbers of tests to be done and physicians are faced with having to review an increasing number of lab tests and trying to assess the effect of treatments on their patients. One way to reduce the cognitive load on physicians would be to present the user with more information displayed in a way that it is quick and easy to arrive at the correct conclusion. Although there are thousands of lab tests, there are a few that are commonly performed and inter-related, which are often considered in groups or panels. These tests measure functions that interact or that are influenced by treatments. Designing a method to allow the physician to quickly assess the clinical situation by viewing a single graph would speed up the process. By grouping tests and normalizing lab results as we have suggested, the physician could more easily consider a greater number of variables at a glance.

To achieve the lofty goals of increased efficiency, effectiveness and economy that have been achieved in other major sectors of our economy, the application of sound
informatics practices such as normalization are required. Computers can enable physicians to process information more quickly and accurately. Normalization will help this process by enabling

- user-defined formatting of data presentation to eliminate cognitive clutter,
- development of new information discovery techniques, and
- clinical decision support and critical alert implementation.

References

Medical Text Analytics Tools for Search and Classification

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Abstract. A text-analytic tool has been developed that accepts clinical medical data as input in order to produce patient details. The integrated tool has the following four characteristics. 1) It has a graphical user interface. 2) It has a free-text search tool that is designed to retrieve records using keywords such as “MI” for myocardial infarction. The result set is a display of those sentences in the medical records that contain the keywords. 3) It has three tools to classify patients based on the likelihood of being diagnosed for myocardial infarction, hypertension, or their smoking status. 4) A summary is generated for each patient selected. Large medical data sets provided by the Institute for Clinical Evaluative Sciences were used during the project.

Keywords. medical search, free-text analysis, EMR

Introduction

There is a vast number of electronic medical records (EMR) available for medical research since many medical professionals have moved their patient records from paper to computers. Traditional database management systems can provide effective retrieval and management functions for well-structured EMR data. However, most progress notes and consultation letters are free text. A challenge faced by medical professionals is to effectively and efficiently retrieve useful information from large stores of semi-structured data. Without proper tools, the rich information buried in health records is inaccessible to clinical research and decision-making.

The objective of our research is to develop text analytics tools that are capable of parsing clinical medical data so that predefined search subjects that correspond to a list of medical diagnoses can be extracted [1-3]. In addition to this particular core functionality, it is also desired that several important assets should be present within the text-analytics tools in order to improve its overall ability to be used as recommendation tools.

In this research, we worked with research scientists at the Institute for Clinical Evaluative Sciences (ICES) in Toronto and examined a number of techniques for structuring and processing free text documents in order to effectively and efficiently search and analyze vast numbers of medical records. We implemented several powerful medical text analytics tools for clinical data searching and classification.

For data classification, our tools sort through a great number of patient records to identify the likelihood of a patient having myocardial infarction (MI) or hypertension (HTN), which are two common diseases in Canada, and classify the patients
accordingly. Our tools can also identify the likelihood of a patient being a smoker, previous smoker or non-smoker based on the text data of medical records.

This paper is organized as follows. An integrated tool with a graphical user interface (GUI) is presented in Section 1.1, a free-text search tool in Section 1.2, three classification tools in Section 1.3 and a summary tool of each patient in Section 1.4. In Section 2, the data set and the evaluations are described. Finally, the conclusions are drawn in Section 3.

1. An Integrated GUI-based Tool

1.1. An Integrated GUI-based Environment

Since the advent of the graphical user interface, the majority of the users of consumer software have become reliant and comfortable within the confines of a point-and-click environment. Consequently, a text-analytic tool, as shown in Figure 1, has been designed. Clicking the button of the ICES search tool, we can start the free-text search. Clicking the button of the ICES summary tool, we can use three classification tools to summarize the records of each patient.

![Figure 1. An integrated GUI-based interface.](image)
1.2. A Free-text Search Tool

A free-text search tool based on keywords is designed to retrieve records based on keywords such as “MI”. The search results display the key sentences in the medical records containing the keywords as presented in Figure 2.

![Figure 2. A free-text search tool.](image)

The textboxes are used in order to retrieve user input on the encounter file using the patient ID. The free text uses keyword, such as “MI”, with additional free text search options like “part of word”, a limited search by data range, and any single search term that is to be sought after within the entirety of the PieceInfo text file. The three buttons, namely “Search MI Patients”, “Search Smokers” and “Search HP Patients”, are exhibited functionalities. The button of Clear All works for clearing the information displayed. Three text fields take up most of the program window. On the left panel there is the complete list of every event/visit/encounter so that any of the particular encounter data fragments can be displayed in full in the right panel, in the middle panel, the results of the search can be found, indicating either the presence or absence of myocardial infarction for the given patient.

1.3. Three Classification Tools

Three classification tools are presented as Figure 3 to classify patients based on their likelihood of having MI or hypertension, or on their smoking status.

In Figure 3, we load the PieceInfo file, the BasicInfo file and the ProfileInfo file into their locations. Then there are three buttons to show the classification of MI or
smoker or HP. As an additional option, a limited search by date range can be set. Taking the button of “Show MI” as an example, the patients IDs, the MI sentences and the detailed data are shown in the three panels. The middle panel displays that the text surrounds each matched instance for myocardial infarction, and is itself highlighted in blue. Just above these panels there are a series of removable tabs which are MI patients, Possible MI, No MI and Family MI History. The tabs enable the user of the tool to select the particular classification that they wanted to view the patient lists for. The buttons of “Show Smokers” and “Show HP” are used as the same way as the button of “Show MI”.

1.4. A Summary Tool

A summary of each patient with regards to their MI and hypertension diagnosis and their smoking status is provided, which is shown in Figure 4. Furthermore, two methods of saving and printing the results of the text-analytics search are available at the summary tab level. The saved data exists in a HTML format and encompasses all of the records for a single patient ID. Continuing the example in Figure 3, Figure 4 shows us the panel of the summary tabs, where the accumulated results and detailed results for a patient are presented.
2. Data Sets and Evaluation

2.1. Date Sets and Format

All the data are from the Institute for Clinical and Evaluative Sciences (ICES). Currently, the data will be provided in three files which are the basic information file, the profile file and the encounter file. The formats of these three files are as follows.

1. Basic information file (basicinfo.txt) with the unique patient ID, date of birth, postal code, and physician information; there is ONE record per patient in this file; this file is mostly for database linkages, but the date of birth is important to calculate the age of the patient and only appears in this file.

2. Profile file (profileinfo.txt) with the unique patient ID and gender, along with several free-text fields including problem list, risk factors, personal traits, allergies, running treatment list; there is ONE record per patient; each physician tends to use these fields differently, some including personal information such as employment and relatives, while others stick strictly with medical information.

3. Encounter file (pieceinfo.txt) with the unique patient ID, date of the encounter, fixed-value vital signs, fixed-value lab results, free-text consult letters, and free-text progress and treatment notes; each dated encounter is not necessarily a patient visit, but can also signal the import of a lab report or a consult letter; there are MULTIPLE records per patient (linked back to that patient via unique patient ID).

2.2. Evaluation

The tool will be evaluated in two stages. One is against a professional clinical diagnosis using specially selected sample datasets that will be reviewed and scored by clinicians. The clinicians will score the records using the same parameters as the tool. For example, the clinicians will score patients records for current smoker/never smoked/previous smoker but not current smoker. Three clinicians will read each record and the majority opinion will be used for each record. The other one is against the entire dataset with random quality control.

3. Conclusions

In this paper, we have proposed and implemented a novel integrated GUI-based tool. This tool can identify the likelihood of a patient having myocardial infarction (MI) or hypertension (HTN) from very large scale ICES medical data sets. It can also identify the likelihood of a patient being a smoker, previous smoker or non-smoker based on the text data of medical records. The tool provides a promising avenue of constructing medical text analytics tool for search and classification, which are intelligent, flexible and adaptive. In the future, our work has the capability of making the text analysis tool a strong aid for medical professionals and can also define new projects which would be undertaken by further collaboration between York University and ICES.
Acknowledgements

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Evaluating the Effectiveness of Modeling Principles for Data Models

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Abstract. We evaluated the effectiveness of modeling principles intended to harmonize the information representation between terminology-ontology models and information models. Our study utilized dental clinical statements and sample dental record questions. We asked experts to define the equivalency (mapping) of these elements and measured their agreement. We modified the data elements and asked the experts to conduct subsequent mappings. We measured the agreement and compared the levels of agreement before and after changes, expecting that agreement would increase. The level of agreement (Kappa) before modeling was 0.3 to 0.4 and after was 0.5 (p<0.05). The difference was small but statistically significant. Our results suggest that the modeling principles improve information representation since agreement increased.

Keywords. information modeling, evaluation methods, data models, ontology, dentistry, dental informatics

Introduction

Improvements in clinical documentation and communications can lead to the reduction of medical errors [1]. Presently, electronic documentation of patient records builds on data models designed to convey information. Rector [2] and Tu et al [3] characterize three types of data models currently supporting the representation and communication of information in healthcare.

1. The Terminology-Ontology model “represents the relations between the types of information (“concepts”), e.g., SNOMED-RT’s compositional representation [4], GALEN’s Common Reference Model” [5,6] or SNODENT [7].

2. The Information-Data model maintains “the structure of how instances of different types of information may be related to each other in a data repository

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or message,” e.g., Health Level 7 Reference Information Model [8,9],
ISO/CEN Electronic Health Record Architecture (ECHRA) [10].

3. The *Inference-Problem Solving model* “describes what should be done in
highly defined situations taking into account a range of information”, e.g.,
Medical Logical Modules (MLMs) [11].

Traditionally, these models have been created by different groups, resulting in
discrepancies that can lead to misrepresentation and misinterpretation of information.
Additionally, adoption of such models makes their modification and proper integration
more difficult. Consequently, this creates potential for errors due to ambiguity or
duplication of information [2].

Several modeling principles have been proposed to reduce these discrepancies
[2,12,13]. These principles provide guidance by defining how information should be
represented and in which model. In other words, these principles assist in defining the
models’ mutual constraints and obligations in order to keep communication
unambiguous [2]. For example, “each type of information should be represented
uniquely in only one place in only one way.”

Regrettably, very few studies exist that have measured the effectiveness of the
proposed principles. A study by Qamar et al [14] showed that, by modifying the
information model, the data mapping accuracy (of open EHR data archetypes to
terminology concepts) improved from 64.7% to 80.5%. The result from this study
supports the idea that modeling improves the way information is represented. However,
it was unfeasible for us to measure the changes in accuracy were changes also applied
to the terminology model. This reason prompted our current study. We hypothesize that
the application of Rector’s modeling principles to both the information model and
terminology model, improves the representation of information.

1. Background

Dentistry, as with other branches of healthcare, is an information-intensive domain.
When it, however, is compared to medicine in general, the need for information
exchange is different. This has resulted in limited levels of clinical computerization
[15]. Consequently, terminology and information models have not been in much
demand. Although, by lacking in years of sophistication, this situation could be
considered a disadvantage, it does provide the opportunity to learn from previous
experiences in medical informatics.

The Center for Dental Informatics at the University of Pittsburgh is currently
pursuing two projects to develop clinical data models for general dentistry. The first
project is focused on the development of a terminology and ontology of dental
diagnostic concepts. The second addresses the creation of an information model for the
electronic dental patient record. These two projects are in an early stage of their
development and require the utilization of raw data from clinical sources. This early
status provides an excellent opportunity to evaluate the effectiveness of the modeling
principles [2] when applied to both models.

In order to reduce discrepancies, we believe that our two models should be
developed in parallel. Before choosing definitive development strategies, we decided to
determine how appropriate the modeling principles would be to our specific content
area.
2. Methods

In our study, we evaluated the effectiveness of the modeling principles proposed by Rector et al. [2] by using simple raw clinical statements that contained diagnostic information and sample dental record questions (items). We called both of these “primitives.” We asked experts to conduct mappings (or define semantic equivalency) using these primitives and measured their agreement. Then we modified the primitives using Rector’s modeling principles [2] and asked the experts to replicate the mapping process. After this, we measured the agreement and compared the levels of agreement before and after the modifications, expecting that agreement would increase. We proposed that the change in agreement provides evidence of the effectiveness of the modeling principles.

Formally, our hypothesis is that the level of agreement between clinicians increases as a result of an improved model harmonization caused by the application of the modeling principles.

3. Modeling principles

Alan Rector [2] established rules or principles that assist in the joint development of the terminology-ontology model and the information model. With these principles, Rector delineates how the information should be allocated and establishes the constraints and obligations for each model.

3.1. Terminology Ontology Model

In this study we evaluated the following rules that we chose to apply only to the terminology ontology model:

a) Separation between kernel and status concepts. The terminology-ontology should explicitly separate kernel concepts (a type of “atomic concept”) vs. status concepts (modifiers or qualifiers). For our experiment the modeling included parsing the statements and stating whether the resulting terms included kernel or status concepts.

b) Reduction of ambiguity by identifying semantic types. The semantic type guides the interpretation of a concept-term by providing a better context. For the modeling, we included the semantic type of the terms that were created in the parsing process, as described in the preceding paragraph.

3.2. Information Model

Concurrently, we evaluated the application of the modeling principles applicable to the information model. These focused on two aspects: ambiguity and structure. We chose and evaluated the following principles:

c) Separation of the multiple pieces of information embedded in a single information item. For example, “cheek biting/lip biting” was separated into “cheek biting” and “lip biting”.
d) Elimination of the generic information items. For example, “Are you aware of any problem?”, “Comments”.

e) Canonically renaming ambiguously named information items to enhance the intended purpose of the item. For example, “chewing” was renamed to “difficulty in chewing”.

f) Canonically grouping the synonymous information items together to prevent duplication of information. For example, “Do you get nervous before dental treatment?” and “Are you usually nervous during dental visit?”

g) Organization of the information items into meaningful categories and subcategories. For example, category “Previous dental care information”, subcategory “Surgical.”

By applying these principles we expect that experts will be able to better recognize when two data elements are equivalent. These include elements from terminology-ontology project and elements from the information model project.

4. Data Elements

We asked experts to evaluate the equivalence of elements from the following two sources.

4.1. Terminology-Ontology Model Project

The terminology-ontology model project has the goal of representing the diagnoses and findings used in general dental care. The original data consists of 5300 raw statements each ranging from a single word to a full sentence of clinical information. A dentist and a medical librarian, both knowledgeable in medical terminologies, extracted the statements from 80 patient records obtained from two dental schools. The statements will serve eventually as a source for developing a reference ontology-terminology. All of the statements are of diagnostic interest. Examples of statements include “broken tooth” or “mesio-distal caries on tooth number 14.” From the 5300 statements, we pre-selected 752 that would contain information pertaining to a patient’s dental history. From these, we randomly selected 150 for the first part of the experiment (training set) and four sub-sets of 40 for the second part (test set). We called these primitive dental statements.

4.2. Information Model Project:

The information model project has the goal of developing a validated and refined list of data elements/information items that will support the documentation (capture/store) and retrieval process of patient health information in the Electronic Dental Record (EDR). Examples include “Are any teeth loose? yes/no”, “dental anxiety: yes/no” or “frequency of brushing:”. The list of information items was developed using a bottom-up approach by extracting information items from a sample of 10 dental paper record formats (four from practicing dentists, two from dental schools, and four from commercial vendors) [16] and 10 documented patient charts from the School of Dental
Medicine, University of Pittsburgh. The list consisted of 70 information items pertaining to the “dental history” part of the overall model. We called these primitive information model items.

The raw data for both projects was collected independently.

5. Defining Equivalency (Mapping) before Modeling

For the first part of the experiment, two experts defined the equivalency of primitive dental statements with the primitive information model. We employed a dentist (PHC) and a senior dental student (JM) to conduct the mappings. The experts received a training set of 150 primitive dental statements and 70 primitive information model items.

The experts were instructed to read the first primitive dental statement and then decide whether any of the 70 primitive information model items would be equivalent, that is, could accommodate the meaning. If any of the items was fully equivalent in meaning, we asked them to mark the item(s) as providing a “complete” mapping.

When the primitive information model item could accommodate only part of the meaning expressed by the primitive dental statement, we instructed the experts to mark the mapping as “partial.” For example, the primitive dental statement “caries on tooth #8”, when mapped to the primitive information model item “presence of caries: yes/no” would be considered partial since the information model item cannot capture the anatomical information (“#8”). For partial mappings, we asked the reviewers to provide reasons for their rating.

If the primitive dental statement could not be accommodated by any of the primitive information model items, we asked the reviewers to indicate that there was no mapping (no equivalence).

6. Defining Equivalency (Mapping) after Modeling

For the second part of the experiment, we asked our clinicians to repeat the previous step of defining the equivalency of data elements, but on this occasion, they received modified data elements using the modeling principles described in Section 3. The modified data elements were presented in four sets of data. We presented them in sets in order to measure the effect that the different modeling principles would have depending on whether the changes occurred in the terminology-ontology model, the information model or in both. Additionally, we presented a fourth set with items similar to the first part of the experiment to control for learning. The four sets were as follows.

A. Primitive dental statements – modified information model items set - We asked the experts to map 40 primitive dental statements to 85 modified information model items. We expected that the experts’ agreement when mapping this set would be better than the training and the control set but less than the set that contains modifications to both the dental statements and information model items.

B. Modified dental statements – primitive information items set - We asked the experts to map 40 modified dental statements to 70 primitive information
model items. We expected that the experts’ agreement when mapping this set would be better than the training and the control set but less than the set that contains modifications to both the dental statements and information model items.

C. Modified dental statements – modified information items set - This set integrated 40 modified dental statements and 85 modified information model items. We expected that this set would generate the highest level of agreement among experts since it includes modifications to the dental statements and information model items.

Control set - This set was identical to the training set but with fewer primitive dental statements (only 40 instead of the original 150). The number of primitive information model items was 70. We expected that the experts’ agreement when defining the equivalency (mapping) of this set would be similar to the agreement found in the training set.

The number of information model items increased from 70 to 85 as result of applying the modeling principles. The categorization of the items changed from one all-inclusive Dental History category to six major categories and 18 subcategories. Data types which suggested the structure of information, e.g., binary, text, etc., were dropped because the experts made it clear that the “implementation level” of the information items clearly limited their ability to represent information.

The modification of dental statements was done independently from information model items by having two of the investigators, Torres-Urquidy and Acharya, work separately. Doing otherwise would generate the risk of creating a confounding factor in our evaluation.

7. Statistical analysis

We used Cohen’s Kappa [17] statistic to measure inter-rater agreement because it corrects for chance. We determined the agreement of the experts’ mapping for the five different sets, one set during the training and four sets during the second part. Our null hypothesis (Eq. 1) was:

\[ H_0: K_{\text{training}} = K_{\text{control}} = K_A = K_B = K_C \]  

where \( K_{\text{training}} \) is the level of agreement obtained by clinical experts when determining the equivalency (mapping) of the training set (no modifications); \( K_{\text{control}} \) is the experts’ level of agreement when mapping the control set; \( K_A \) is the experts’ level of agreement when mapping the primitive dental terms to the modified information model items; \( K_B \) is the experts’ level of agreement when mapping the modified dental terms to the primitive information model items and; \( K_C \) is the experts’ level of agreement when mapping the modified dental statements to the modified information model items.

For testing the hypothesis, we conducted two-sided pair-wise comparison using the confidence intervals obtained from the levels of agreement. We defined the level of statistical significance at \( p < 0.05 \).
8. Results

Table 1 shows the levels of agreement as well as the confidence intervals for the mapping process. The level of unweighted kappa for the training set was 0.3302 (0.95 confidence interval: lower limit 0.3025, upper limit 0.3579). The level obtained while using the control set was 0.4388 (0.95 confidence interval: lower limit 0.4084, upper limit 0.4691). The difference between these two kappa values showed that there was some external factor that caused agreement to increase.

Table 1. The table includes the levels of agreement and confidence intervals. The level of agreement reached when using set C was the highest and its difference was statistically significant.

<table>
<thead>
<tr>
<th>Data set</th>
<th>Dental statements</th>
<th>Information items</th>
<th>Kappa</th>
<th>Lower limit</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>150 (primitive)</td>
<td>70 (primitive)</td>
<td>0.3302</td>
<td>0.3025</td>
<td>0.3579</td>
</tr>
<tr>
<td>A</td>
<td>40 (primitive)</td>
<td>85 (modified)</td>
<td>0.4358</td>
<td>0.4084</td>
<td>0.4626</td>
</tr>
<tr>
<td>B</td>
<td>40 (modified)</td>
<td>70 (primitive)</td>
<td>0.4402</td>
<td>0.4102</td>
<td>0.4701</td>
</tr>
<tr>
<td>C</td>
<td>40 (modified)</td>
<td>85 (modified)</td>
<td>0.5041</td>
<td>0.4776</td>
<td>0.5306</td>
</tr>
<tr>
<td>Control</td>
<td>40 (primitive)</td>
<td>70 (primitive)</td>
<td>0.4388</td>
<td>0.4084</td>
<td>0.4691</td>
</tr>
</tbody>
</table>

The level of agreement for data set A (primitive dental terms and modeled information items) was 0.4358 (0.95 confidence interval: lower limit 0.4089, upper limit 0.4626). The level of agreement for data set B (modeled dental terms mapped to primitive information items) was 0.4402 (0.95 confidence interval: lower limit 0.4102, upper limit 0.4701). When comparing these two datasets to the training set, it was possible to perceive a statistically significant difference, showing an increment in agreement when modeling was used for at least one of the models.

On the other hand, the agreement from data sets A (K_A = 0.4358) and B (K_B = 0.4402) when compared to the control set (K_control = 0.4388) show that there was no statistically significant difference between them.

As mentioned above, the control set was similar to the training set in the sense that no modeling was used (i.e., it only included primitives). This indicates the possible presence of an external confounding factor that increased agreement artificially.

The level of agreement for the final data set which included modeled dental terms and modeled information model items was 0.5041 (0.95 confidence interval: lower limit 0.4776, upper limit 0.5306). When comparing to the agreement of the other four data sets, we can appreciate a small but statistically significant difference, showing that there was an agreement increment.

9. Discussion

The existence of different data models creates potential for erroneously expressing information. In order to reduce this potential for errors, it is possible to establish constraints and obligations between data models. Explicitly, these constraints and
obligations can be seen as modeling principles the objective of which is to determine the most proper way to allocate information.

Our study evaluated the effect of certain modeling principles by determining the change in clinician’s agreement before and after their application. The results suggest that when applying modeling principles, agreement increases. In other words, the clinicians found more information equivalencies after applying the modeling principles. Specifically, the level of agreement for the set in which the modeling principles were applied to both, dental statements (terminology – ontology model) and information items (information model), agreement increased.

On the other hand, our study had several limitations. First, because of the study design, we were able to detect a confounding factor since there was an increment in agreement between the training and control sets. This is possibly the consequence of a “carryover effect” [18]. Thus, our results should be interpreted cautiously. The second limitation could be that our study only used two experts. Further studies should have more experts participating in the mapping process. Additionally, this study addressed a limited conceptual area, that is, dental diagnostic concepts relevant to dental history. It is possible that in other conceptual areas the modeling principles perform differently. Finally, although the change in kappas was significant, the level reached suggests only moderate agreement [19]. This could be caused by the difference in levels of experience of our participant clinicians: one was a clinician with more than 20 years of experience and the other was a final year dental student. These levels of experience possibly create clinical interpretation differences that reduce agreement and hide the true effect of the modeling principles. Another element to consider is that possibly, the modeling changes helped one expert more than the other. Further analysis should explore this possibility.

Conversely, the highest level of agreement was reached when applying the modeling principles to the dental statements and information items. This difference was statistically significant suggesting that the early (during the development stage) and parallel (to both models) application of the principles facilitates the creation of enhanced data models.

In conclusion, we found that agreement between experts increased after applying the modeling principles proposed in the literature. This provides favorable evidence suggesting that applying such principles alone improves the representation of information.

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References


Boundary Objects in the Multidisciplinary Care Management of Chronic Conditions: Multiple Chemical Sensitivity

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Abstract. Chronic conditions such as Multiple Chemical Sensitivity (MCS) are a significant challenge to the health care system as they are poorly understood, poorly documented and lack accepted or standardized treatment strategies. Research has shown that the successful management of patients with such conditions requires a multidisciplinary team of clinicians and the comprehensive assessment of factors contributing to the ill health. Results from two studies that have shown reduction in health care costs and improvement in symptoms for patients with MCS are presented. We explore the use of a controlled clinical vocabulary as a boundary object in care documents to facilitate collaborative management of patients with MCS.

Keywords. chronic disease management, collaborative care, standardized vocabulary, multidisciplinary clinicians, boundary object

Introduction

The burden of chronic diseases has grown in recent years with an increasing proportion of the population having more than one chronic illness or risk factor for chronic illness [1]. The management of chronic conditions that have limited documentation or accepted treatment strategies is a challenge to the health care system since clinicians are left to devising care plans in isolation [2]. For many of these conditions there are no specific guidelines to treatment that have been shown to be successful. Multiple Chemical Sensitivity (MCS) is one such chronic condition in which multiple body systems [3] are affected and patients exhibit a wide range of symptoms from physical to psychological with overlapping diagnoses and symptoms in many body systems that often leave the medical practitioner mystified.

The quality and aptness of the care delivery for patients with conditions such as MCS depends on the collaborative operation of the multidisciplinary team of clinicians [4]. Failure to maintain accurate, explicable and structured flow of patient information could result in repetitive procedures, augmented health care costs and medical errors [5].

Research has shown that artifacts such as patient care documents, with a goal of increasing the understandability and offering information clarity for its end users are
the binding objects in a collaborative care environment [6]. Developing and maintaining a seamless flow of relevant and timely patient information when multiple care providers and disciplines are involved is a grand challenge in conditions such as MCS.

This paper explores the concept of boundary objects or collaborative artifacts to enhance the shared working environment among multiple care providers. A methodology to develop a boundary object for MCS is discussed.

1. Multidisciplinary Care Management Approach for Chronic Conditions: MCS

Adopting a symptom-based and patient-centred approach that encompasses all aspects of the patient’s health with a focus on self-management is coming to the forefront as the most effective way of managing patients with MCS [4]. In conditions such as MCS, the patients display symptoms that exist on a wide spectrum from purely physical to purely psychological. This feature is shared by other chronic conditions where addressing symptoms of varied nature is essential in facilitating the patient towards improved health [7]. The Nova Scotia Environmental Health Centre is a treatment facility for individuals with multiple chemical sensitivity, chronic fatigue syndrome and fibromyalgia. The care provided is individualistic and the care team is a multidisciplinary team of clinicians. A collaborative care management scheme is established with the multidisciplinary care team involved in the care. Members of the multidisciplinary team include physician, nurse, psychologist, psychotherapist, physiotherapist, rehabilitation coordinator and dietician. Presented in this section are two studies that have attempted to show the efficacy of this multidisciplinary approach.

In a cohort study on patients with MCS [8], the financial implications of a multidisciplinary care approach to standard treatment was assessed and compared to the costs incurred in the general population of Nova Scotia (NS). A total of 563 patients participated in the study. The results from the study showed that patients referred and managed by the multidisciplinary care approach showed a decrease in their health care utilization costs compared with their previous utilization patterns. The decline in the standardized average costs in three cohorts of MCS population (1998, 1999, 2000) and NS population is shown in Figure 1. The mean costs for the MCS population dropped close to the Provincial average in 2000, while the Provincial mean (general population) showed slight increase in costs over the years. Physicians’ visits for the MCS population by general practitioner and by specialists, emergency and hospital separations, and associated costs also showed a significant decline in the years following the consultation with the multidisciplinary care management approach.

In a second study on MCS [9], the impact of a symptom-based, team management approach was studied in a total of 183 active and 109 discharged patients. A detailed symptoms questionnaire was used to measure the outcome of this treatment approach. In the active patients, health changes at various time periods of follow up since commencement of treatment was measured (6 months, one to two years, more than two years).

Patients showed statistically significant improvement in their overall health, activities of daily living and in commonly reported symptoms such as health since ill; too ill to do housework; limited contact with people to avoid exposures (see Table 1).
Table 1. Improvement in symptoms measured at various time periods of follow up since the commencement of treatment.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>6 months p value</th>
<th>1-2 years p value</th>
<th>2+ years p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement in health since ill</td>
<td>0.05</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ability to do housework</td>
<td>0.05</td>
<td>0.008</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Social life</td>
<td>0.9</td>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0.01</td>
<td>0.003</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Headaches</td>
<td>0.9</td>
<td>0.004</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fatigue</td>
<td>0.5</td>
<td>0.3</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

The research information presented shows evidence of success in the management of patients with MCS through a multidisciplinary care approach. However, there are a number of impediments to the success of such management schemes. There is limited research on ways to improve the competency and collaborative functioning of the care teams. The collaborative discussions of healthcare professionals with varying clinical backgrounds and team discussions, whether face-to-face or virtual meetings, are the points of negotiation. Timely delivery of care depends on the information that exists in the common knowledge space.

2. Controlled Clinical Vocabulary as Boundary Objects

A boundary object, a concept introduced by Starr [10], refers to physical artifacts such as electronic health records, that serves as an interface between disciplines and communities of practice. A study by Araújo [11] explored the theoretical concepts of boundary object by using common symptom terminologies as mediating objects to
integrate the work among professionals dealing with fibromyalgia and somatic functional syndromes.

Reference clinical vocabulary offers a common position for clinicians, regardless of their disciplinary background, to share collaborative information. SNOMED CT® or Systematised Nomenclature of Medicine is a standardized clinical vocabulary that can be used by all computers and electronic health record information. The benefit of using concept-based reference vocabulary such as SNOMED CT® is that it provides a feasible platform for comparison and communication. A study by Elevitch [12], discusses the improvement in safety standards by using a reference vocabulary in anesthesia care. A study by Paterson [13] explored the enhancement of semantic interoperability of clinical documents for chronic conditions such as chronic kidney disease, hypertension and diabetes. In this study, a semantically interoperable discharge summary was generated as a boundary object by creating a standardization platform for the vocabulary used in the document from reference vocabularies such as SNOMED CT®.

3. Methodology to Develop Boundary Object to Enhance Collaboration Among MCS Care Providers

A study to enhance the shared working environment for the multidisciplinary care providers involved in the care of MCS is planned. The objective of the study is to develop and evaluate a controlled clinical vocabulary for the generation of MCS patient profiles using SNOMED CT® [14]. A question that will be posed as part of this research is whether the reference terminology, SNOMED CT®, is comprehensive enough to capture important concepts and terminology used in the classification of lesser known conditions such as MCS. Figure 2 is a schematic of the proposed plan of work to develop a methodology for creating a boundary object. In order to explicate the existing vocabulary in use in the generation of patient profiles for MCS, chart audits of MCS patients and structured interviews with MCS care providers is planned. Based on the information that is gathered, a knowledge base of the existing vocabulary consisting of commonly used terminology, phrases and concepts in the categorization of the MCS patients will be developed. This vocabulary will then be mapped to SNOMED CT® leading to compilation of exact matches, synonyms and no match grouping of the existing vocabulary for MCS. A controlled clinical vocabulary containing exact matches and synonyms for terminologies and concepts from the old vocabulary derived from SNOMED CT® will be developed.

Figure 3 shows the application of the boundary object, controlled clinical vocabulary in the generation of patient profiles for MCS. The multidisciplinary clinicians will use this boundary object to recode the existing patient profiles to test the new vocabulary. The study will obtain feedback from end users and experts in the field to determine the usefulness of this information as a shared negotiation artifact.

4. Conclusion

Maintaining the appropriate level of knowledge sharing and communication is an exigent task for health care providers and informaticians as care management for
patients with chronic conditions that have overlapping and multiple diagnoses may be distributed among multiple clinicians, disciplines and communities of practice. Clinical documents with standardized vocabulary act as boundary objects enabling clinicians and informaticians to exchange and share patient information in a timely manner with knowledge in the shared space being easily understood across disciplines and communities of practice.

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