Systems Analysis at National Guard Health Affairs - King Abdulaziz Medical City in Riyadh

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Performed at
National Guard Health Affairs - King Abdulaziz Medical City
Riyadh, Saudi Arabia

In partial fulfillment of the requirements of the Master of Health Informatics
Program
Dalhousie University
HINF 7000 Internship
Summer 2012/2013

Report of Internship for the period June 4 – September 5, 2012

Date submitted: July 13, 2012

Acknowledgment and Declaration

I would like to extend my deep appreciation to Reem Al Sayed, Ahmed M. Mahmoud, the IPPM and CIMS teams at NGHA for all of their assistance and knowledge throughout my internship. Without their help, this learning experience would not have been possible.

Finally, This report has been written by me and has not received any previous academic credit at this or any other institution.

(signature)

Rana Makki

Executive Summary

Health Informaticians are facing a tough challenge these days to deliver innovative solutions to improve the way healthcare is delivered, especially in light of ever-increasing demands for health care services amidst stagnant or shrinking budgets.

King Abdulaziz Medical City (KAMC) in Riyadh is one of the largest health care providers in the Kingdom of Saudi Arabia and has been recognized for its world-class facilities, staff and services as well as its low mortality and morbidity rates among its patients. To maintain and increase KAMC's high level of patient care quality, National Guard Health Affairs (NGHA) is seeking leading-edge technology-based services that can be delivered in the most cost-effective manner.

Having expert Systems Analysts on staff is essential to delivering technology-based solutions within an organization. As well as facilitating ease of operations, Systems Analysts are the link between health care providers and Information Technology (IT). They provide clinical departments with ideas and IT solutions to automate and improve existing practices, and collaborate and assist departments in making and incorporating IT and related changes to improve the delivery of patient care.

The author was trained as a Systems Analyst during her internship at the Clinical Information Management Systems (CIMS) Department, which is responsible for the development and support of the EHR and QuadraMed's Computerized-Patient Record (QCPR) system to all National Guard Health Affairs departments and divisions. In 2004, National Guard Health Affairs automated and standardized all medical records documentation through a virtual knowledge system that is delivered by the QuadraMed corporation (formerly known as Misys).

Two projects were planned for the internship. The first project involved automating the adult electrolytes replacement protocol for the Intensive Care Unit (ICU). This project aimed not only to automate workflow but also to improve the workflow of electrolytes replacement order and solve existing conflicts among physicians, nurses and pharmacists. In order to accomplish this project, two important modifications in QuadraMed's Computerized-Patient Record system were required. After successfully implementing the modifications, the project was completed, with positive comments coming from ICU physicians, nurses and pharmacists.

The second project was the automatic recognition of sepsis in the Emergency Department. The aim of this project was to develop an automatic tool that would screen patients for severe sepsis and alert the nurse when there was a suspected case. Plans are currently underway to further extend this solution throughout the rest of the hospital. We hope that, by implementing this solution, sepsis recognition times will decrease and patient safety levels increase.

The author used the knowledge and experience she obtained from Dalhousie's Health Informatics program in the Systems Analyst role as well as in the work she completed during her internship. Overall, it was a great learning and work experience for the author.

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1. Introduction

When in it comes to the health field, Information Technology (IT) has consistently been shown to be an important component that can increase the quality of health care systems. The computerized physician order entry (CPOE), which replaces the handwriting procedure and allows physicians to enter their orders directly into a computer, is a relatively new Health Informatics technology that can significantly reduce the overuse, underuse, and misuse of health care orders. Moreover, studies prove that CPOE can decrease costs, medical errors and patient length of stay, as well as satisfy various institutional and government guidelines easier and better. Moreover, this technology can produce considerable benefits and also be an important platform for changing the future of health care systems. To that end, health care organizational leaders should support CPOE, as it is one of the few critical technologies that can improve health care quality (Kuperman & Gibson, 2003). In order to maximize CPOE's benefits, the unique workflows for different hospital departments need to be fully understood. Systems can then be built in such a way that workflow is improved and any present conflicts between and amongst stakeholders resolved. Stakeholders include physicians, nurses, pharmacists, ward clerks, and even the patients themselves.

At most health care organizations, including NGHA, the responsibility for carrying out this crucial task is usually assigned to a Systems Analyst, whose primary job description is to deliver technology-based solutions to the health care giver. As they often write user requests into technical specifications, Systems Analysts function as the link between health care provider and Information technology. They may be responsible for planning a system flow, designing a system, producing business documents, understanding software ability and limitations, designing various components of a system, and delivering technology-based solutions to the health care provider within pre-determined frameworks and limitations set by organizational budgets and information systems considerations.

The Systems Analysts in the CIMS department at KAMC are either from IT or clinical backgrounds. Consequently, Health Informaticians would be at a definite advantage in this environment because of their having trained in both specialty fields. This allows them to understand clinical and technical aspects of the position and to act as a liaison between the two groups who do not have this dual perspective.

The first project that was assigned to the author involved automating the adult electrolytes replacement protocol for the intensive care unit. This project aimed not only to automate workflow but also to improve the workflow of electrolytes replacement order and solve existing conflicts between and among physicians, nurses and pharmacists. The required modifications in the (QCPR) QuadraMed Computerized-Patient Record system was done using the criteria engine provided in the QuadraMed system, in order to generate the appropriate electrolyte order according to the patient conditions documented in the QCPR. The project was successful and resulted in positive feedback from the physicians, nurses and pharmacists. The second project was the automatic recognition of sepsis for the Emergency Department.

> Sepsis is a potentially life-threatening complication of an infection. [I]t's
> most common and most dangerous in people who are elderly or who have

weakened immune systems. Early treatment of sepsis, improves chances for survival. Most people recover from mild sepsis, but the mortality rate for severe sepsis or septic shock is close to 50 percent. (Mayo Clinic, 2011)

The aim of this project was to develop an automatic tool that would screen patients for severe sepsis and alert nurses to suspected cases.

Again, the criteria engine provided in the QuadraMed system was used to provide decision support criteria, and there is a plan to further extend this solution throughout the rest of the hospital. We hope that, by implementing this solution, sepsis recognition times will decrease and patient safety levels increase.

2. The Organization

"National Guard Health Affairs provides optimum healthcare to [Saudi Arabian National Guard and] SANG personnel, their dependants and other eligible patients. NGHA also provides excellent academic opportunities, conducts research, and participates in industry and community service programs in the health field" (National Guard Health Affairs, 2008-2012)

There are five medical cities under NGHA: King Abdulaziz Medical City in Riyadh; King Abdulaziz Medical City in Jeddah; King Abdulaziz Medical City in Dammam; King Abdulaziz Medical City in Al Ahsa; and King Abdulaziz Medical City in Al-Madinah. There are also a couple of clinics in Riyadh and Taif.

KAMC in Riyadh was founded in 1983. Since then, it has continued expanding and its bed capacity has increased to 690, in addition to 25 beds allocated for surgical operations and 132 beds for admission of emergency cases. NGHA is also a member of the Joint Commission of International Standards (JCI), underscoring the institution's belief in the importance of health care quality on an international scope. KAMC in Riyadh has continued its success by providing the lowest mortality and morbidity rates among the patient population (National Guard Health Affairs, 2008-2012) as well as becoming an internationally recognized center in twin-separation surgery. Indeed, it is considered to be the first center with a 100% successful rate in surgical twin-separation procedures (Khan, 2006).

Within this complex, the Information Systems and Informatics Department (ISID) is in charge of the development and support of computers and Information Technology for all NGHA departments and divisions. According to its stated goals, the ISID strives to provide the highest quality of technology-based services in the most cost-effective manner, to facilitate NGHA's mission and to maintain and increase their high level of health care service. Some of their main sub-departments are the Enterprise Resource Planning (ERP) Department, the Human Resources Management Department, the Knowledge Management Department, Laboratory Information Systems (LIS), Clinical Radiology and Imaging Systems (CRIS), and Clinical Information Management Systems (CIMS).

The author was trained under the Clinical Information Management System Department, which is responsible for the development and support of the EHR and QuadraMed's Computerized-Patient Record system to all NGHA departments and divisions. In 2004, the NGHA automated and standardized all medical records documentation through a virtual knowledge system delivered by the QuadraMed corporation (previously, the Misys corporation), which is one of the top five international companies in this field (National Guard Health Affairs, 2008-2012).

3. Work Performed

The author performed the duties of a Systems Analyst during the internship, as a part of the clinical Application Services team under the CIMS Department. CIMS is responsible for the development and support of the QuadraMed Computerized-Patient Record system to all NGHA departments and divisions.

There are many modules under the QCPR system. Each team in the CIMS Department is responsible for a single module and is tasked to perform all the duties related to any project associated with that module, including customizing the module according to client needs, producing business requirements documents, developing initiatives, performing system testing, training staff, writing workflow agreements, troubleshooting any reported problems, being a liaison among the vendors, health care providers and other staff working in the ISID, etc

At the beginning of the internship, the author focused mainly on the "Automate adult electrolytes replacement protocol" project, which was intended to improve the workflow of electrolytes replacement order and solve existing conflicts between and among physicians, nurses and pharmacists. In order to accomplish the technical requirements of this project, two important modifications in the QCPR were required. The first one was to build three new procedures in CPOE, and the second one was to build new clinical decision support criteria, using the criteria engine provided in the QuadraMed system. The purpose was to generate the appropriate electrolyte order according to patient conditions documented in the QCPR.

In the latter half of the internship, the electrolytes replacement protocol solution was in the testing phase and the author started working on the clinical decision support tool for automatic recognition of sepsis. Since the author was already trained in the criteria engine provided in the QuadraMed system in the first project, it was easier to use it in this second project to provide decision-support criteria. Plans are currently underway to further extend this solution throughout the rest of the hospital.

The following is a detailed look at the actual work

3.1 The "Automate Adult Electrolytes Replacement Protocol" Project

The work performed on this project was comprised of numerous steps. These are detailed in the following points.

3.1.1 The Work Process

3.1.1.1   Project Scope

The project will include only the following components for adult patients:
- Potassium replacement protocol
  - For patients without head injuries
  - For patients with head injuries
- Magnesium replacement protocol
- Phosphate replacement protocol

3.1.1.2   Workflow

Before starting the planning process of the project, it was essential to know the current workflow for electrolytes replacement order as well as the existing problems with this workflow. To obtain this information, meetings were held with various stakeholders in the Intensive Care department.

There are three electrolytes in this protocol: potassium, magnesium and phosphate. Depending on patients' parameters, the doctors will decide the dose of the electrolytes that must be given to the patient. Parameters include whether or not the patient has a head injury, whether he/she has a peripheral or central line, the results of a kidney function lab test, etc. If, from the lab results, a nurse determines that a patient needs an electrolytes replacement, a doctor must sign an electrolytes replacement order sheet, which shows all of the parameters that will determine what is the ideal dose for this patient's situation. An example of an electrolytes replacement order sheet can be seen in Appendix A. Then the nurse will start to investigate all of these parameters, checking them on the order sheet, after which the order sheet will be sent to the pharmacy. There, the appropriate medicine will be prepared and sent back to the ward to be given to the patient. Up to this point, there is no problem with the workflow except that it is paper-based and takes a long time.

The real problem with the workflow, however, was in following up with the patient. In electrolytes replacement, the nurse has to recheck the level of the electrolytes the patient is taking every couple of hours, depending on the electrolytes protocol. According to these results, the nurse will either have to change the dose of the electrolytes medicine the patient is taking, or keep it constant. And here come the real problem: if the dosage has to be changed, the new order must be done by a physician. Physicians are not present in the ward all of the time and cannot come every couple of hours to sign a new order sheet. Moreover, nurses are not authorized to give patients a medical order, and pharmacists will not change the dose of the electrolytes unless they receive an order from a physician. Through this project, we tried not only to automate the process but also to resolve these issues.

To make it easier for the various stakeholders to understand the workflow, the author used Microsoft Visio to produce the BPMN (Business Process Modeling Notation) diagram for the workflow. BPMN is a UML activity diagrams that can show in very clear detail who does what, where, and in what sequence. By visually representing how the tasks are being completed, this process can improve the understanding of the workflow (Benson, 2010).

3.1.1.3   Assumptions

In order to automate the workflow electrolytes replacement protocol, the following were assumed:
- Once a physician decides on electrolytes replacement therapy for a patient, he/she orders it through CPOE.
- The order goes to the nurses' work list, where a nurse documents it according to different parameters as well as the patient's condition, all of which determines the electrolytes dosage.
- The system will automatically trigger the appropriate electrolytes order according to the parameters documented by the nurse.

When clinically decided, the physician must discontinues the electrolytes replacement order in the CPOE.

3.1.1.4   Required Computerized-Patient Record System (QCPR) Modifications

Based on the project scope and the electrolytes replacement protocol, two technical modifications in QCPR were required:
- Building three new procedures in the system:
  - Potassium replacement procedure
  - Magnesium replacement procedure
  - Phosphate replacement procedure

- Building new clinical decision support using the criteria engine provided in the QuadraMed system. This will automatically generate the appropriate electrolytes order according to the conditions documented by the nurse.

3.1.1.5   Criteria Engine Overview

The QuadraMed Computerized-Patient Record solution is supported with a Criteria engine table, ^nt ("ce"), which was used in the electrolytes project to build the clinical decision support criteria. The criteria engine table, ^nt ("ce"), is used to define the criteria evaluated by the system and the action that takes place when the criteria is evaluated as true.

The criteria evaluation engine (CEE) is the evaluation tool that allows patient data to be evaluated when it is documented in real-time, rather then in a retrospective mode. This allows an action to take place as soon as the criteria definition is evaluated as true.
Multiple actions can be performed by the system when the criteria definition evaluates as true, such as:
- Place an entry in a work queue
- Send an electronic mail message
- Generate an order
- Evaluate secondary criteria definitions

The criteria definition consists of "OR"/"AND"/"OR" conditions defined in a hierarchical format. Only one "OR" condition is needed to be evaluated as true in order for the system to begin evaluating the "AND" condition/conditions. Therefore "OR" conditions should be prioritized so that the "OR" condition least likely to be evaluated as true displays last. Each "OR" condition can consist of one or more "AND" condition. Also, each "AND" condition can consist of one or more lower "OR" conditions. The arrangement of "OR"/"AND"/"OR" conditions is important to the outcome of the evaluation as well as to the speed of CEE processing. The top and lower "OR" conditions should be arranged from the most likely to come to the least likely. This arrangement is used because the system stops at the first "OR" condition that is evaluated as true and ignores all of the remaining "OR" conditions. The arrangement of the "AND" conditions is not as important, since the system must evaluate all "AND" conditions before it perform the responding action.

It was important to the author to understand all of the details associated with the criteria engine table, ^nt ("ce"), criteria evaluation engine (CEE) and the criteria definition in order to be able to write the expression that is related to the electrolytes project.

Each one of the patient parameters in the electrolytes replacement protocol was defined uniquely in the criteria engine table, ^nt ("ce"), after which the "OR"/"AND"/"OR" conditions in the criteria definition and the criteria evaluation engine (CEE) were used to evaluate the patient parameters and trigger the appropriate electrolytes order.

The new solution was first tested by the project team to make sure there were no technical problems. Then training sessions were given to the health care provider in the ICU department. Finally, a workflow agreement document was generated and prepared to be signed by the various stakeholders.

The new workflow of electrolytes replacement protocol became the following:
A physician enters the electrolyte replacement protocol using the order set in CPOE. The physician can choose one or more options from the three electrolytes replacement protocol (i.e., potassium, magnesium, and/or phosphate). Also, she/he has to choose whether the patient has a head injury or not. Once the order is submitted by the physician, it will go to the nurses' work list (see figure 1 below).

Number: 2005281	Location: 0106S2	Gender: **Female**	Attending: **Salim,Faha**
Visit Number: 2005281-1	Cmt Loc:	Age: **32Y**	Primary Insurance: **Letter of Exception**

Work List

#	Date/Time	Procedure	Status
1	p r n	Potassium Replacement Protocol	scheduled
2	p r n	Magnesium Replacement Protocol	scheduled
3	p r n	Phosphate Replacement Protocol	scheduled

Figure 1: Nurse's Work List.

A nurse must then document all patient parameters that are in the electrolytes replacement protocol (see Appendix A). The system will automatically generate the appropriate electrolytes order

according to the documentation done by the nurse and the order will be sent to the pharmacy modules in QCPR, where the pharmacy will dispense the medication according to their workflow. The order will stay active until the physician discontinues it (see figure 2 below).
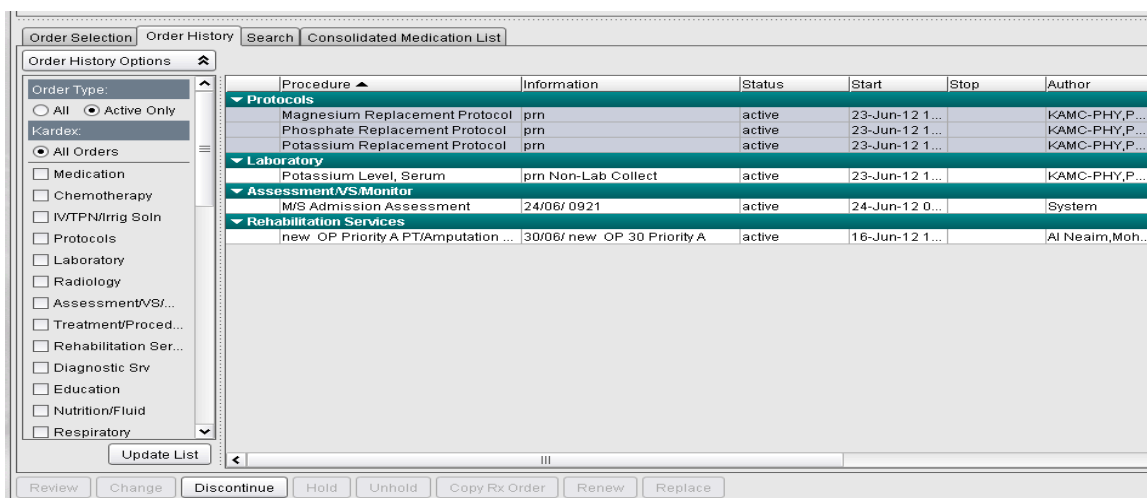

Figure 2: Patient's Order History

The reason for this consideration is to solve the conflict that used to arise in the manual workflow. Under this new system, when the parameters of the patient change and the nurse enters the new parameters, a new appropriate electrolytes order will automatically be generated by the system and send it to the pharmacist. Thus, the doctor does not have to come to the ward and make a new order for electrolytes replacement every time there is a change in patient parameters.

3.2 The "Severe Sepsis Automatic Recognition" Project

The work performed in this project involved several steps. These are detailed in the following points.

3.2.1 The work process

3.2.1.1 Project scope

The tool will be activated only in the following locations:
- Emergency department:
  - Triage
  - Adult care area
  - Critical care area

3.2.1.2 Assumptions

In order to automate the early recognition of severe sepsis, the following were assumed:
- When a patient is admitted to a certain area in which the sepsis screening tool is activated, the system will generate an order to activate the tool

- Once activated, the system will scan certain parameters with each new entry
- If the condition is met, the system will generate a "severe sepsis alert"
- This alert will go to the nurse's work list
- The nurse will response to the alert and page a physician
- The physician documents a response to the alert
- The tool will be reactivated/deactivated according to the physician's response

3.2.1.3   Workflow

Before starting the planning process of the project, it was essential to know the current workflow for suspected severe sepsis cases at the ER department. To obtain this information, meetings were held with various stakeholders in the department.

A very basic part in the step was to know the patient parameters that will trigger the alert. These parameters were given by medical staff at the ER department, and are based on the guidelines they follow.

Patient parameters are divided into two groups. The first group is called "SIRS" (systemic inflammatory response syndrome) and includes four parameters:
1. Temperature ≥ 38 or ≤ 36
2. Pulse ≥ 90 bpm
3. Respiratory rate> 20 bpm
4. White blood cell count >12,000 or < 4,000

The second group is called "Organ Dysfunction" and includes nine parameters:
1. Glasgow Coma Scale < 12
2. Systolic blood pressure (SBP) < 90
3. Mean arterial pressure (MAP) <65 mmHg
4. Saturation of peripheral oxygen (SpO2) < 90% of room air or on supplemental O2
5. Creatinine >200 µmol/L
6. Bilirubin >35 µmol/L
7. Aspartate transaminase (AST) > 90
8. Alanine transaminase (ALT) > 90
9. Platelet count < 100x109/L
10. Lactate > 2 mmol/L

If a patient has two or more SIRS criteria and one or more organ dysfunction criteria, then a severe sepsis case is suspected.

3.2.1.4   Required Computerized-Patient Record system (QCPR) modifications

Again, the criteria engine was used in this step to build a tool based on the severe sepsis recognition guidelines. Since the author already used the criteria engine in the first project, she was familiar with it while working on this project.

The parameters were defined in the criteria engine table, ^nt ("ce"), and the "OR"/"AND"/"OR" conditions and the criteria evaluation engine (CEE) were used to evaluate the patient parameters and trigger the alert when the severe sepsis conditions is met.

Training sessions about the new tool were given to health care providers in the ER department. This project is still in the testing phase.
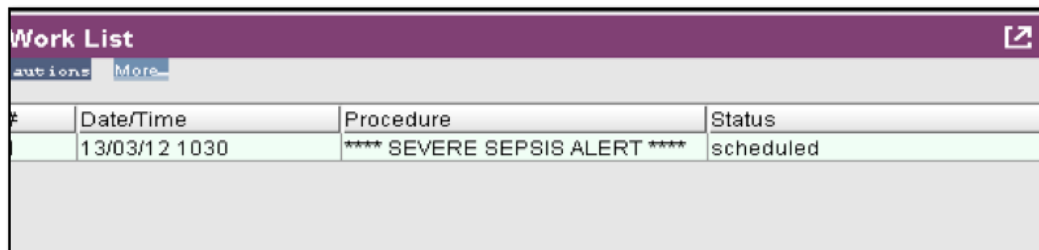
Once the testing phase is done, the new workflow for a suspected case of severe sepsis is assumed to be the following:

1. Severe Sepsis Screening Activation

    a. This will happen automatically once the patient is admitted.
    b. An order for "sepsis screening" will be generated automatically.
    c. The nurse should document the patient parameters in the system as usual.

2. Severe Sepsis Alert Activation

    a. If the conditions for severe sepsis are met, the system will generate a "Severe Sepsis Alert".
    b. This alert will go to the nurse's work list.
    c. The nurse will then write a documentation for this alert.
    d. Next, she has to page the number indicated on the alert screen and document that (see figures 3 and 4 below).
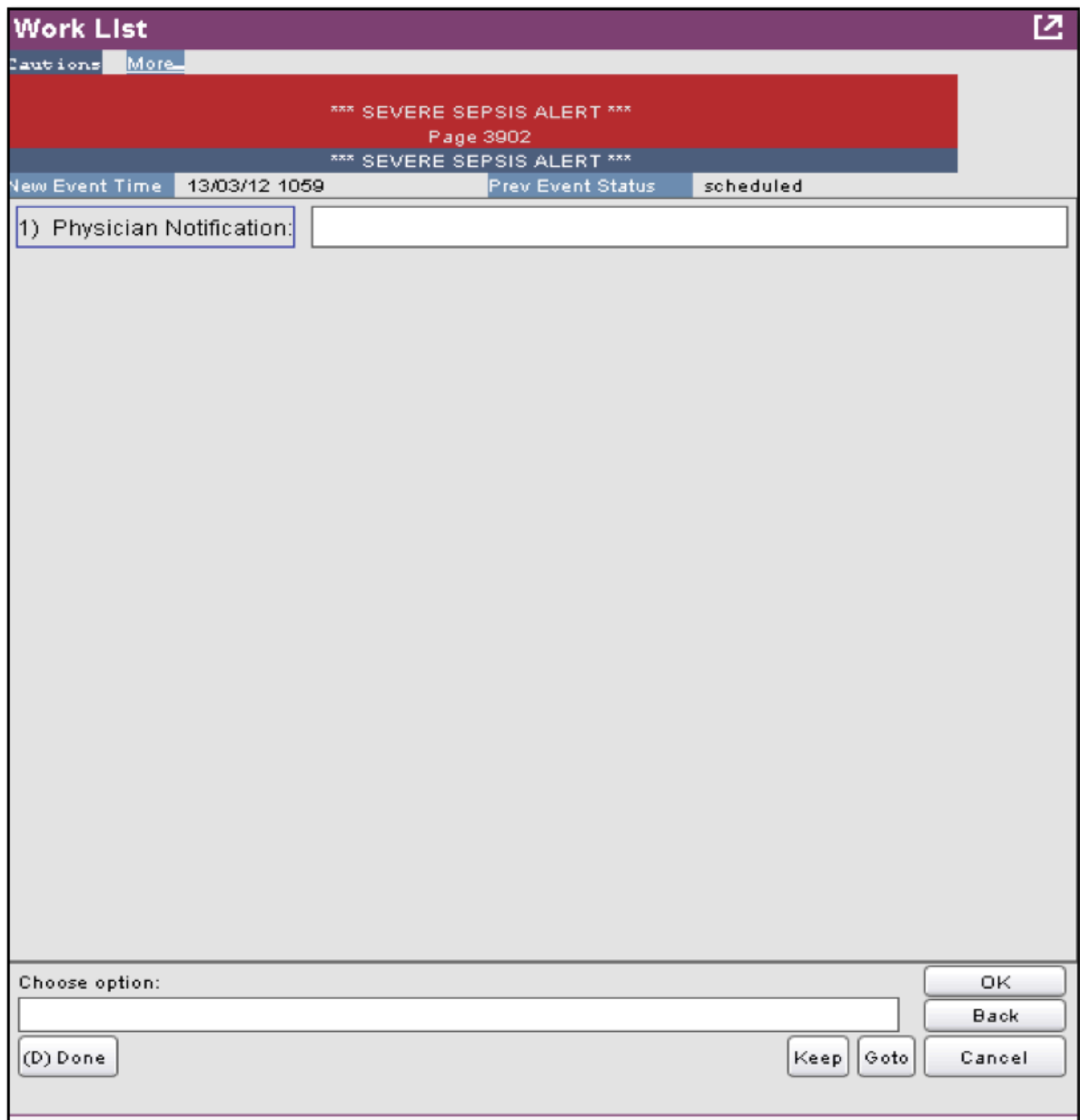

Figure 3: Nurse's Work List

Figure 4: Nurse's Work List

3. Severe Sepsis Screening Deactivation

Once the physician is informed by the nurse about the alert, he/she has to respond to the Severe Sepsis Alert by choosing from the following given options in severe sepsis management:

    i. Patient has confirmed/suspected infection (this will deactivate the alert for 48 hours).

    ii. Patient has no infection (this will deactivate the alert for 24 hours).

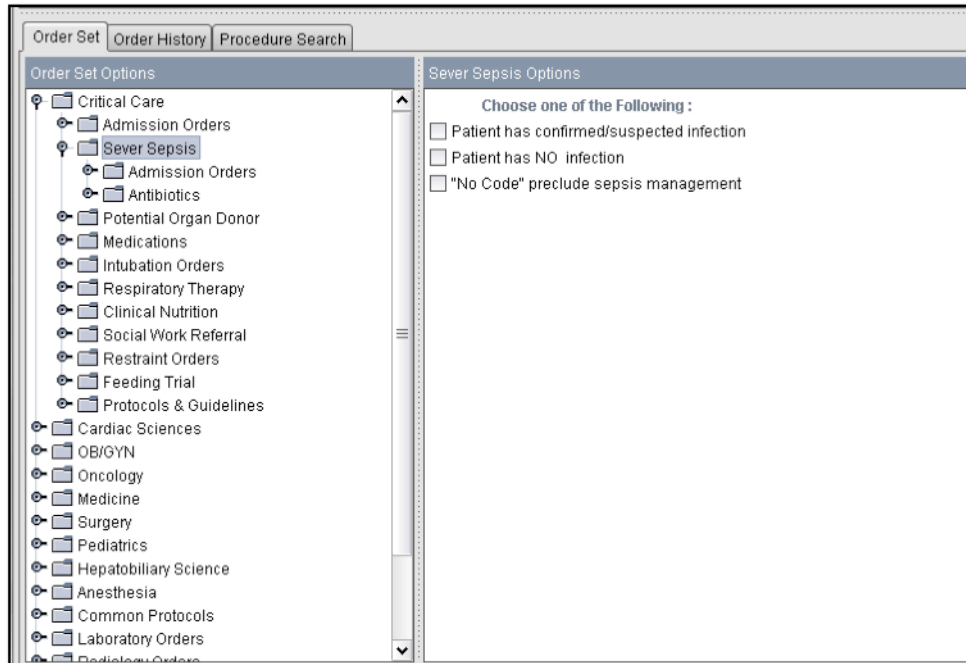   iii. No Code Status precludes sepsis management (this will permanently deactivate the alert).

Figure 5: Patient's Order Set

4. Internship Relation to Health Informatics

Many of the Dalhousie University Health Informatics program courses were valuable for the author during her internship as Systems Analyst.

A successful Systems Analyst must have four essential skills: analytical, technical, managerial, and interpersonal. Analytical skills are important for evaluating and understanding the organization and its functions, which helps the Systems Analyst to identify opportunities, to analyze, and to solve problems. Technical skills are important to understand the capability and the limitations of information technology and the information system. Management skills help in managing projects, resources, change and risk. Interpersonal skills are essential, as Systems Analysts serve as the liaison between different stakeholders such as health care providers, other IT staff, and vendors. The Dalhousie Health Informatics courses helped the author obtain these necessary and useful skills.

Additionally, having a solid foundation of information systems and computer applications is necessary when working as a Systems Analyst. As was outlined in detail earlier in the report, technical skills were useful in both projects to understand the issues and successfully move the projects forward. Health Informatics courses such as "Information Flow and Standards", "Information Systems and Issues" and "Networks and the Web" helped the author to better understand how the different information systems in the hospital work, to understand the workflow, to use VISO software to be able to visually represent the workflow, to be able to build the decision support criteria, and to effectively deal with the technical issues in both projects. Likewise, the "IT Project Management" course provided the author with the Management skills required to manage the projects successfully. Having the ability to link and communicate with all of the various stakeholders of the project was essential in this internship.

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As well, many of the Health Informatics courses provided the author with the skills required to feel comfortable and confident to liaise with others and to be able to face and solve any problems she might face when working in a team or with other stakeholders. During the Health Informatics program, the author learned to work with classmates from different disciplines, as the program was multidisciplinary and included students from different background. Specifically, some were from solely computer backgrounds and some were from solely medical backgrounds. Being able to navigate between the two 'sides' was very helpful as, in both projects, the author had to deal with team member and stakeholders from different backgrounds such as physicians, nurses and IT staff.

Furthermore, the "Knowledge Management for Health Informatics" course exposed the author to innovative Health Informatics solutions that can be used to solve different issues in health care sectors such as how to automatically capture explicit knowledge and represent it in a way that can improve health care delivery and quality. This can be seen in both projects. For example, in the second project, the author captured the knowledge from the sepsis guideline into the QCPR system for rapid identification of sepsis cases.

5. Critical Analysis

5.1 The "Automate Adult Electrolytes Replacement Protocol" Project

Large and complex health care facilities such as KAMC treat an enormous number of patients daily. Hence, these facilities require time-saving, innovative solutions like CPOE that can decrease high work loads while increasing quality of patient care.

In the first project, the main problem with the electrolytes replacement protocol was in following up with the patient. As mentioned previously, in electrolytes replacement therapy a nurse has to recheck the patient's electrolytes level every couple of hours, according on the electrolytes protocol. Depending on these results, the nurse will either have to change the dose of the electrolytes medicine the patient is taking, or keep it constant. If the dosage has to be changed, the new order must be made by a physician. At KAMC, physicians have a very high workload and cannot return to wards every couple of hours to sign a new order sheet.

The solution to this problem is to automate the electrolyte replacement protocol at KAMC in such a way that will solve this issue without increasing the workload for any of the medical staff. In addition, it is essential that this solution decrease costs and comply with the other HIS at KAMC. The QuadraMed's Computerized-Patient Record system is a powerful CPOE solution that has already been purchased by NGHA. One of its features is that it can be customized, to a large extent, to meet the clinic's requirements. Hence, it can serve as a viable solution to this problem. The criteria engine provided with the system is very useful in, for example, writing expiration rules and building decision support. These features and others were used to improve the electrolytes workflow and solve existing conflicts between and among doctors, nurses and pharmacists.

Moreover, The QuadraMed Computerized-Patient Record system, which is used in NGHA, incorporates many different departmental systems into one. The QCPR solution is more helpful in collating the data and producing useful reports then collating the data from multiple information

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systems. However, the problem with having single systems is that they cannot fulfill all of the requirements for each department, and sometimes they have to implement subsystems that can meet their requirement. Theses issues can cause a range of problems, from interproability between systems to increased costs and increased duplication of effort.

5.2 The "Severe Sepsis Automatic Recognition" Project

Early detection and diagnosis of sepsis is very important for the outcome of the treatment and can greatly impact mortality rates (Mayo Clinic, 2011) (National Institute of Health, 2009). When reviewing the literature, we discovered numerous research projects that aimed to develop methods to decrease time of sepsis recognition (National Institute of Health, 2009).

A Health Informatics solution that can decrease the detection time of sepsis is found in an automated tool that can screen patients for severe sepsis based on the specific guidelines a hospital is following. With regards to NGHA, QuadraMed's Computerized-Patient Record system can be built easier and without the added cost of purchasing new system. The author used her experience as a Health Informatician to build the alert and the automatic recognition for sepsis cases using the criteria engine provided with the QCPR system.

Some of the issues the author faced with this project are as follows. First, in order for the tool to perform accurately, nurses must document the patient parameters immediately. However, this was not always the case. Sometime, due to their high workload, the nurses used the paper chart to document the patient parameters and then, at the end of their rounds or shift, entered the parameters in the system. In cases like this, the tool will not work as it is intended to.

Moreover, during training sessions, we tried to educate the nurses about the importance of entering parameters immediately into the systems. While our efforts were met with some resistance (the nurses claiming it took too much time to constantly update the system), this problem can also be solved by using a Health Informatics solution. For example, a tablet can be provided to the nurses which they can use in the patients' rooms to record the parameters. This tablet can be directly connected to the QCPR system. The monitoring of patients can also be directly connected to the system, so that whenever there is a new reading in the monitor, it will automatically go to the QCPR system. This innovation will save the nurses a lot of time and might also increase the performance of the automatic tool for severe sepsis screening.

Part of a Systems Analyst's role is to find innovative solutions to meet the requirements of different departments in an organization. Being able to find innovative solutions and being able to work around the system to meet the departments' requirements will reduce the need of implementing new subsystems.

The role of Health Informaticians is incredibly vital and growing daily, mainly because they have knowledge in both IT and clinical areas. Although a Systems Analyst does not have to be an expert in the IT or clinical fields they are working within, it would be advantageous for them to have at least basic knowledge.

6. Conclusion

Health Informatics is a growing and promising field, especially with increasing demands for health care services and decreasing budgets. Indeed, the complexities of today's health care systems demand new technologies that can offer interoperability and ease of management, solutions that can readily be found in Health Informatics technology.

Even though the duties of a Systems Analyst can be difficult and very demanding, they are also fascinating and rewarding. Every hour of every day brings a new challenge, along with new opportunities to learn. Being a part of this profession is therefore not only a privilege but a pleasure.

The first project the author worked on ("Automate adult electrolytes replacement protocol") was accomplished successfully, with only positive feedback about the new solution coming from all levels of stakeholders.

During her internship, the author took time to investigate and analyze problems with the existing workflow. More time was then spent in finding a solution to improve the workflow using features of QCPR. A great deal of time was also invested in learning about the criteria engine and how it can be used in both projects.

Overall, the author found it very interesting to learn about technical procedures and assist in building new solutions. As the author comes from a clinical background, many of the courses that were taken through the Master of Health Informatics program at Dalhousie University contributed to her successful internship, especially the courses "IT Project Management", "Knowledge Management", "Networks and the Web" and "Information Flow and Standards".

In conclusion, the position of Systems Analyst is a challenging job that connects and combines Information Technology and clinical information. It is a promising and vital area of research, as the services provided by Health Informaticians can significantly increase the quality of health care delivery.

7. Recommendations

Although the first project, "Automate adult electrolytes replacement protocol", has been successfully completed, a couple of ideas, if implemented properly in the solution, can further increase the efficiency of the solution. For example, the results of patient lab tests can be sent directly from the LIS (Library Information System), instead of manual entering it in the system by nurse, which would reduce human error and decrease workload for the nurses. Also, an alert could be connected to the solution. In this way, when a lab result indicated that the level of electrolytes for a patient must be changed, a message could be delivered to the nurse to alert her about the new situation. This would increase the quality of health care delivery by improving accuracy and decreasing wait times and workloads.

For the Severe Sepsis Automatic Recognition project, performing an observational before/after

study to evaluate the impact of the new tool on the detection of severe sepsis specifically, and on patient heath care quality in general, is recommended.

8. References

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9. Appendix A

An example of electrolytes replacement order sheet

National Guard Health Affairs
King Abdulaziz Medical City - Riyadh

INTENSIVE CARE DEPARTMENT
ELECTROLYTES REPLACEMENT ORDER SHEET
FOR PATIENTS ON HEAD INJURY PROTOCOL

Exclude:
1) Hemodialysis and continuous veno-venous hemodialysis patients
2) Patients on total parenteral nutrition
3) Patients who weigh <50 kilograms

(A) K Replacement in Patients with Urine Output greater than 40ml/hour or Creatinine less than 115 mmol/l.

SERUM K$^+$ (mEq/L)	Oral or Intravenous potassium chloride		LABORATORY
	☐ PERIPHERAL LINE	☐ CENTRAL LINE	
3.6-3.9	10 mEq orally or per nasogastric tube	10 mEq orally or per nasogastric tube	
3.2-3.5	20 mEq in 250 ml of normal saline over 3hours as IV infusion	20 mEq in 100 ml of normal saline over 2 hours as IV infusion	
2.9-3.2	40 mEq in 500 ml of normal saline over 4hours as IV infusion	40 mEq in 100 ml of normal saline over 2 hours as IV infusion	Check K level 2 hours post infusion
less than2.9	40 mEq in 500 ml of normal saline over 4hours IV infusion+ Oral 30 mEq potassium Chloride (1 dose) stat and call physician	40 mEq in 100 ml of normal saline over 3 hours as IV infusion+ Oral 30 mEq potassium Chloride (1 dose) stat and call physician	Check K level 1hour post infusion

(B) K Replacement for Patients with Renal Impairment (Urine Output less than 40 ml/hour for 2 hours or Creatinine greater than 115 mmol).

SERUM K$^+$ (mEq/L)	Oral or Intravenous potassium chloride		LABORATORY
	☐ PERIPHERAL LINE	☐ CENTRAL LINE	
3.4-3.9	10 mEq orally or per nasogastric tube	10 mEq orally or per nasogastric tube	
2.5-3.3	20 mEq in 250 ml of normal saline over 2 hours as IV infusion	20 mEq in 100 ml of normal saline over 2 hours	Check K level 2 hours post infusion
less than2.5	Call physician		

(C) MAGNESIUM REPLACEMENT

SERUM MAGNESIUM	REPLACEMENT WITH MAGNESIUM SULFATE
0.61 – 0.8 mmol/l	3 grams in 100ml of normal saline over 2 hours
0.5 – 0.6 mmol/l	4 grams in 100ml of normal saline over 3 hours
less than 0.5 mmol/l	4 grams in 100ml of normal saline over 3 hours and Call physician

(D) PHOSPHATE REPLACEMENT

SERUM PHOSPHATE	REPLACEMENT WITH SODIUMPHOSPHATE
0.71 – 0.9 mmol/l	15 millimole in 100 ml of normal saline over 4 hours
0.5 – 0.7 mmol/l	20 millimole in 100 ml of normal saline over 4 hours
less than 0.5 mmol/l	30 millimole in 100 ml of normal saline over 4 hours

Physician's Name: _____   Badge Number: _____

Signature:_____   Date and Time:_____

(02/2009 "rev")