

DEVELOPMENT OF AN ELECTRONIC MEDICAL RECORD SYSTEM FOR THE UNIVERSITY OF NORTH CAROLINA WILMINGTON SCHOOL OF NURSING

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Abstract - *The purpose of this project was to develop an electronic medical record (EMR) system for use by the University of North Carolina Wilmington's School of Nursing (SON) faculty and student nurses in their new medical practice simulation laboratories. This system was designed to educate faculty, beginning practitioners at the undergraduate and graduate levels, and staff in Southeastern North Carolina to develop new skills and augment current skills in health care technology. The implementation of this EMR system required the development of a database and user interface according to the client's specifications.*

Presently, the EMR system is live and being used by the School of Nursing (SON) faculty and students in their instructional laboratory meetings. The goal of this project was to build the foundation for the SON's EMR system. Future work includes further development of the system's capabilities and functionality.

Keywords: electronic medical record (EMR) system, nursing, education software, databases.

1 Introduction

The use of electronic medical record (EMR) systems in medical facilities has become a standard practice in the medical care industry. On February 17, 2010, President Barack Obama signed *The American Recovery and Reinvestment Act of 2009* which included the restructuring of the nation's medical system by establishing "computerized medical records" in medical facilities nationwide; "Billions will be handed to companies creating these databases... to universities to incorporate patient databases 'into

the initial and ongoing training of health professionals" [1]. This new stimulus included the *Health Information Technology for Economic and Clinical Health (HITECH) Act*, which "authorized expenditures of at least \$20 billion to promote the adoption and use of EHR [electronic health record] technologies that would ideally be connected through a national health information network" [2].

Not only is the implementation of EMR systems in health facilities projected to be an economically and medically beneficial reform, the application of education EMR systems would provide similar benefits. The incorporation of an EMR system that simulates electronic medical records would prepare future nurses for the use of modern day healthcare technologies in the workplace. EMR teaching tools are said to be able to train nursing students "to manage the complex challenges of documenting care, patient safety, compliance and hospital efficiency" [3]. Frank Mortimer, publisher for Nursing Education at Wolters Kluwer Health, Professional & Education revealed "Currently, there are more than 3,000 nursing schools in the United States, and only 1 percent of them provide student with access to EMRs." [3]. The adaptation of EMR systems in commercial and educational medical facilities nationwide assures to be promising, once various economic factors are addressed, such as the consistency, maintainability and networking of patient medical records between medical facilities.

1.1 What is the problem we are addressing?

Although electronic medical record systems have been available for decades, the use of EMR systems in medical facilities is still very limited. The most common reason is due to the cost of installation and maintenance. U.S. News Health revealed present day EMR systems are estimated to run as high as "\$20 million to \$100 million" [4]. The expense of actually having an EMR system is substantially greater than the resulting benefit, especially for smaller organizations [4].

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Another common reason for the limited use of EMR systems is a lack of product availability for institutions of all sizes. Specifically, many contemporary EMR systems are targeted toward large medical facilities. As a result of this market focus on large institutional clients, there exist few EMR systems designed for and available to the far more numerous small, private practice firms and public universities. Additionally, the EMR systems that are on the market do not always provide the functionalities needed for operational use by most medical clinics and facilities. In 2010, the President's Council of Advisors on Science and Technology reported to the Executive Office of President Barack Obama, "even the advanced systems geared toward hospitals and large healthcare providers lack capabilities that seem rather obvious, such as extensive clinical decision support, or the ability to easily exchange data with other providers who share responsibility for the same patients." [2]. Not only is the availability of EMR systems to public medical facilities very limited, *educational* EMR systems are even more scarce and expensive.

1.2 Project Motivation

In conjunction with the construction of the new School of Nursing (SON) building, the nursing faculty and administration at the University of North Carolina Wilmington desired to integrate an EMR system into their Simulation Learning Center. At the time, nursing students and faculty occasionally used the Wilmington area's New Hanover Regional Medical Center's live EMR system during very restricted time periods throughout the week for laboratory practices. After researching the potential cost of an adaptable EMR system for the SON, the nursing administration ran into a financial dilemma. Research showed that the cost of commercial EMR systems designed for educational use averaged around \$10,000 for a yearly license, as quoted by *emr-edu.com* [6]. Due to the high cost and lack of availability of an EMR system that met its exact needs, the Nursing Department searched for more efficient and economical means of acquiring an EMR system for their Simulation Learning Center.

1.3 Project Significance

The development of a tailored EMR system for the School of Nursing would not only benefit student nurses by familiarizing them with modern healthcare technology, it would also incorporate

various administrative features that would allow nursing faculty and administrators to monitor their students' work. Initially, the nursing administration expressed their interest in educational EMR systems similar to "EMR-EDU" [5], "Neehr Perfect" [6], or the present EMR system used at New Hanover Regional Medical Center. As a result, the design and development of this EMR system was modeled after some of these systems, with various adjustments made and additional features added that are required for educational purposes. A customized EMR system ensures that the software features are adaptable to the program's curriculum.

Incorporating administrative tools into the customized EMR system, similar to those of the learning platform Blackboard [7], allows faculty members and administrators to conduct lab practices more effectively. Furthermore, a centralized EMR system provides students with a shared learning platform throughout the nursing program. Because this system is adaptable to numerous nursing courses, students are able to develop and utilize healthcare technology skills across multiple courses.

2 EMR System Design

2.1 Patient Medical Records Home Screen

The organizational structure of the foundation of this EMR system's user interface is comprised of the following components: a navigation bar, a patient banner, and a menu bar (refer to Figure 1). The patient banner displays biographical and vital medical information on a selected patient. The left-hand menu bar is used to navigate the various medical record forms by selecting the proper submenu item associated to a medical record form. Currently, four electronic medical record forms have been implemented: *Vital Signs*, *Minimal Data Set*, *Medication Administration Record*, and *Comprehensive Health History*. (Due to space consideration, all medical record forms will not be discussed in further detail).

2.2 Medication Administration Record Form

The Medication Administrative Record form is used by nursing students to record what and when specific medication(s) is/are administered



Figure 1. Patient Medical Records Home Screen

to a specific patient. The design of the MAR form consists of various functionalities for administrative users to that create a customized MAR for a standardized patient. (Further details on *standardized patients* are provided in section 2.4).

Administrative users have to ability to specify the start time for a MAR form, choose medication(s) to be assigned to the patient, and select specific administration times for a selected medication (refer to Figure 2).

Figure 3 shows the student view of the MAR form after an administrative user creates an MAR form for a patient. In the student view, medication administrators (student nurses) utilize this form by entering their initials whenever he/she administers a medication to denote the type, time, and by whom a medication was administered to a patient. Wherever a medication administration time is selected in the administrative view, the associated cell(s) in the student view contains textboxes, permitting medication administrators (aka student nurses) to

only administer a select medication at the specified time.

2.3 Form Expansion

Due to the complexity of some of the medical record forms, a special system was used to allow for future form expansions with minimal changes to the PHP pages and *no* changes to the database (refer to Figure 4).

Within each column, each checkbox is assigned a value to a power of two, beginning with 2^0 to 2^{n-1} ; n equal to the number of checkboxes associated to that field. For example, there are eight columns in the *Family History* form and 19 rows associated to each column. Therefore, to efficiently store this data into the database, the associated *CHHFamHist* table in the database consists of (an *id* field as the primary key and) eight fields associated to each of the columns (mother, father, brothers, sisters, etc.). The values assigned to the listed checkboxes below each column for the *Family History* form begins with *value="1"* ($2^0 = 1$) for the "Unknown" field to *value="262144"* ($2^{18} = 262144$) for the "Other" field. The sums of the values of selected

Family History
Select all applicable

	Mother	Father	Brothers	Sisters	MGM	MGF	PGM	PGF
Unknown	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Alive & Well	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Deceased	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heart Disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HTN	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stroke	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diabetes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Blood Disorders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cancer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sickle Cell Anemia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Arthritis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Allergies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Obesity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Alcoholism	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mental Illness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Seizures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Kidney Disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TB	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Enter Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Details:

Figure 4. Subsection of Comprehensive Health History form

checkboxes are stored into the database in their associated fields. This summation is equivalent to performing a bitwise OR across the array of checkboxes.

When the form is loaded, the stored value is decoded for each column using bitwise AND with a mask to determine whether the checkbox was checked. The mask is 2 to the power of the row number (starting with row zero). If the result is nonzero, this indicates the checkbox was checked; else, zero indicates the checkbox was not checked.

Although encoding a collection of bits with an integer conserves space, this was not the motivation for choosing this technique. The motivation was to allow flexibility in the number and names associated with a set of checkboxes,

until the number of checkboxes exceeds $11/\log_{10}2$ (~ 36).¹

2.4 Nonstandardized versus Standardized Patients

Nonstandardized patients can be created by any type of user. The patient's information and medical record forms can only be edited by the user who created the patient. (In exception, administrative users who have system overriding privileges can also have the ability to edit or delete any non-standardized patient).


Standardized patients can only be created by an administrative user but can be referenced or used in the EMR system by any user. (Note: Medication Administration Record (MAR) forms can only be created for standardized patients by an administrator.) The purpose of a standardized patient is to be able to create a patient template with default patient information settings that can be used by all students in a laboratory practice. Faculty can then view all students' work by searching the one standardized

patient.

2.5 Search for Students' Work

Faculty users have the ability to select any user or patient to display all medical records filled out by a selected student user, associated with a patient. This is a feature which is important for educational purposes not found in commercial EMR systems.

¹ The checkboxes were encoded in an *int11* integer field because this is the default integer size. Since *int11* can hold up to 11 decimal digits and a value of 2^n is required to store n checkboxes, a *int11* field can encode $11/\log_{10}2$ binary digit.



Welcome Admin!
Logout
Change Password

Home
Student Work by Patient
Student Work by Student
Create New User
Manage User Accounts
Manage All Patients
Medication Bank

Vital Signs

Student Work belongs to Student: **LILA BYRD**

- Byrd, Lila
- Jamison, Aaron
- Messina, Jessica
- Smith, Tabitha
- Tran, Admin
- Walsh, Kathryn

Patient: MURRAY, RUTH
DOB: 02/10/1931 Admit Date: 11/03/2010
MRN: 485970 Acct: 0526
MD: Dr. Goldblatt
Age: 80 Height: 155cm Weight: 101kg

Date: 04/28/2011 Room: 2007
Drug Allergies: SULFA
Nondrug Allergies: NA
Admitting DX: CVA, GERD, IDDM,PVD, COPD, HYPOTHYROIDISM, HTN, IDIOPATHIC HYPERKALEMIA, OA, CONFUSION

Minimal Data Set

- Byrd, Lila
- Craig, Tammy
- Feagan, Joan
- Jamison, Aaron
- Legrand, Kara
- Martin, Brittany
- Messina, Jessica
- Norton, Kristin
- Petasne, Lauren
- Sears, Allison
- Smith, Tabitha
- Walsh, Kathryn
- Winstead, Layne

VITAL SIGNS

Time: 07 : 00
BP: 130 / 76
P R: 80 / 16
Temperature: 98.7 °C °F
O₂Sat: 93 /
Notes: Pt. rated pain 4/10 on LRL.
Print

MAR

- Craig, Tammy
- Jamison, Aaron
- Messina, Jessica
- Petasne, Lauren
- Smith, Tabitha

Prev
Next

Figure 5. Display Students' Work

Figure 5 displays the *Display Students' Work* view which consists of a panel on the left-hand side that lists the students/patients associated to a specific form, a patient banner associated to the selected patient across the top, and the associated patient form populated with the entries submitted by the selected student.

For student' work displayed by patient:

- All students who created a form for this patient are listed in the left-hand panel by their names.
- The left panel is organized into the forms associated to this patient.
(i.e. All "Vital Signs" forms created for this patient are listed under the "Vital Signs" header in the left panel *by the students' names*).

For student's work displayed by student:

- All forms created by this student are listed on the left-hand panel by those patients' names for which the student created a form.
- The left panel is organized into the forms associated with this student.

3 Conclusion

Adoption of electronic medical record systems in medical facilities nationwide will greatly benefit our medical facilities' efficiency, accuracy and accessibility. The United States Department of Health and Human Services Secretary Kathleen Sebelius states, "Expanding the use of electronic health records is fundamental to reforming our health care system . . . Electronic medical records can help reduce medical errors, make health care more efficient and improve the quality of medical care for all Americans." [8]. Furthermore, Dr. David Blumenthal, National Coordinator for Health Information Technology explains, "With these programs, we begin the process of creating a national, private and secure electronic health information system... designed to help doctors and hospitals acquire electronic health records and use them in meaningful ways to improve the health of patients and reduce waste and inefficiency." [8]. In general, we can conclude that not only is the creation of new, adaptable EMRs economically beneficial to our nation, their creation will increase our medical facilities' consistency, maintainability, and networking of all patients medical records.

Electronic medical record systems are quickly being integrated into everyday use at various medical facilities. The implementation of the EMR system described in this paper allows the faculty and staff at the University of North Carolina Wilmington's School of Nursing to provide student nurses with hands-on experience working with EMR systems prior to entering professional practice. The system we built is a personalized EMR system for the students, faculty and staff at the School of Nursing that effectively matched their course curriculum and included features tailored to the faculties' specific needs.

3.1 Future Work

The result of this project merely built the foundation for the School of Nursing's EMR system. Plans are in place to expand the capabilities of the EMR system such as adding more medical forms to the system and possibly developing on some of the system's functionalities beyond simply data entry; for example, document image processing.

4 References

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