10-2015

EEMI - An Electronic Health Record for Pediatricians: Adoption Barriers, Services and Use in Mexico

Juan Carlos L. Jarquin
ITESM Campus Monterrey, Mexico, lavariega@itesm.mx

Roberto Garza
roberto.garza7@gmail.com

Lorena G. Gomez Dr.
Tecnologico de Monterrey, lgomez@itesm.mx

Manuel J. Silva-Cavazos
Monterrey Institute of Technology and Higher Education, vj.laradiaz@gmail.com

Víctor J. Lara-Díaz
Monterrey Institute of Technology and Higher Education, manuel@silvacavazos.com

EEMI - An Electronic Health Record for Pediatricians: Adoption Barriers, Services and Use in MEXICO

Juan C. Lavariega, Roberto Garza, Lorena G. Gómez, Víctor J. Lara-Díaz, Manuel J. Silva-Cavazos
Tecnológico de Monterrey
Av. E. Garza Sada 2501, Monterrey NL, México
Telephone Number: +52 (81) 83581400 ext. 5250
lavariega@itesm.mx, roberto.garza7@gmail.com, lgomez@itesm.mx, vj.laradiaz@gmail.com, manuel@silvacavazos.com

Abstract: The use of paper health records and handwritten prescriptions are prone to preset errors of misunderstanding instructions or interpretations that derive in affecting patients' health. Electronic Health Records (EHR) systems are useful tools that among other functions can assists physicians' tasks such as finding recommended medicines (and their contraindications) and dosage for a given diagnosis, filling prescriptions and support data sharing with other systems. By using an EHR many errors can be avoided. This paper presents EEMI (Expediente Electrónico Médico Infantil), a Children EHR focused on assisting pediatricians in their daily office practice. EEMI functionality keeps the relationships among diagnosis, treatment, and medications. EEMI also calculates dosages and automatically creates prescriptions which can be personalized by the physician. The system also validates patient allergies to avoid prescription of any pharmaceutical with alerts. EEMI was developed based on the experience of pediatricians in the Monterrey metropolitan area. This paper also presents the current use of EHRs in Mexico, the Mexican Norm (NOM-024-SSA3-2010), standards for the development of electronic medical records and its relationships with other standards for data exchange and data representation in the health area. This system is currently in production. It uses novel technologies such as cloud computing and software services.

INTRODUCTION

Mexico, like other developing countries, holds a social debt for its citizens with respect to the provision of health services. In particular one of the most vulnerable groups is the infant population. Even though the global child mortality rate (considering children under five years old) has been declining from 90 to 48 deaths per 1000 live births between 1990 to 2012 (World Health Organization, 2013), there is still work to be done. In urban parts of Mexico, the infant mortality rate is 16.2 deaths per 1000 live births, but the number in rural areas is even higher, where children present symptoms of malnutrition, untracked growth and untracked immunizations. However, more than a half of child deaths in general (rural and urban areas) are due to diseases that are preventable and treatable through simple and affordable interventions. Some of the most deadly childhood diseases like measles, polio, diphtheria, tetanus, pertussis and pneumonia have immunizations available that can protect children from illness and eventually, death (World Health Organization, 2013).

Electronic Health Records (EHRs) systems with key functionality for pediatricians can help reduce these problems (malnutrition, untracked growth and untracked immunizations) by recording a child's information, generating immunization schedules and comparing child growth with recommended world charts (Bulletin of the World Health Organization, 2007). EHRs assist pediatricians, who, as many other medical professionals, have a heavy work load and a priority for up to date knowledge. Pediatricians manage the physical, behavioral and mental health of children from birth up to age 21. They are trained to diagnose and treat a broad range of childhood illness, ranging from minor health problems to serious diseases. Unfortunately, pediatricians just like any human being, are susceptible to make mistakes, can feel tired and/or be distracted, and then write incorrect dosages, misspell a medication name or simply write an illegible prescription.

The National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) defined a medication error as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer (NCCMERP). According to the American Society of Health-System, Pharmacists prescription errors are any incorrect drug selection, dose, dosage form, quantity, concentration, rate of administration, instructions of use, and any illegible prescriptions that

lead to errors (ASHP Guidelines, 1993). The dose selection errors represent more than 50% of all prescribing faults, but other possible errors could be due to inaccuracy in writing, poor legibility of handwriting, use of abbreviations or incomplete writing of a prescription because all of these errors can lead to misinterpretation by pharmacists and patients (Velo & Minuz, 2009).

In a study conducted at a Mexican university (Zavaleta-Bustos, et al, 2008), a sample of 370 prescriptions were randomly selected for analysis. The results indicated that 214 prescriptions (58%) of the sample had at least one error. The most common errors were incorrect indication, patient allergy to a medication, incorrect dosification, unjustified medications and duplicity of medications. Many of these errors were produced during the act of writing out a prescription.

Pediatricians, when confronted with an adult-oriented EHR, complain about not having specific functions for child medical care. The pediatricians' software requirements for EHRs are: immunization management, growth tracking, and medication dosing. Without these functions in an EHR, pediatricians are not capable to provide with quality care (Spooner, et al., 2007).

An EHR system that fully supports pediatric practice must allow the recording of multiple immunizations and be able to analyze immunization data to determine the age when each vaccine should be administered. In addition, the system must provide graphic information of a child's body measurements (weight, height, head circumference, body mass index) over time, as pediatricians make judgments based on these measurements. Another requirement is the method for calculating drug dosages; the system must be able to calculate doses based on weight or age depending of the medication (Spooner, et al., 2007). Based on these needs, EHR should be adopted as a helpful tool for physicians. However, in developed countries existing EHRs are expensive, difficult to use, developed from the hospital administration point of view, or do not meet physician's needs. As a consequence, unless there is a clear benefit (economical or better job status) for using EHR, physicians do not use EHRs and usually see these systems as a waste of time.

This papers presents EEMI (abbreviated by its name in Spanish, Expediente Electrónico Médico Infantil or Child Electronic Health Record) a system for the administration of medical records planned for pediatric medical practice. EEMI was designed and tested with the active participation of experienced pediatricians working at one of the top hospitals in the metropolitan area of Monterrey, Mexico. The objective of EEMI is to help pediatricians to minimize the possibility of errors, optimize consultation time (spend more time with patient, rather than filling forms) and keep track of patients' information.

The rest of this paper is organized as follows. Section 2 presents the use of EHR in context, including the barriers that this type of systems face during its adoption or rejection by medical professionals; a brief discussion of standards and international norms for EHRs; and a comparison of current EHRs including EEMI. Section 3, formally presents EEMI through the description of its functionality. Section 4 describes the technology used inEEMI. Finally, Section 5 discusses current status and future work.

BACKGROUND AND RELATED WORK

This section includes a description of the adoption barriers that EHRs face with the physician community; describes the standards and regulations currently available for EHR's; and concludes with a brief description of the main EHRs used in the US and in Mexico.

Adoption Barriers

According to some studies (Humpage, 2010; NCCMERP; Spooner, et al., 2007; Velo & Minuz, 2009), and our own experience (Ruiz, 2011) the use of EHRs, increases productivity by 20%, reduces waiting time up to 60% and saves 80% of paper work cost. Additionally, EHRs have other benefits such as: increasing security on patient sensitive data; providing easy and fast access to patient information; decreasing negative medical events (overmedication, incorrect treatment, etc.); and decreasing cost by unnecessary or repetitive treatments or laboratory tests. Despite their benefits, EHRs have not been fully adopted due to factors such as change resistance, cost, lack of incentives and complex customization (Humpage, 2010; Spooner, et al., 2007; Ruiz, 2011).

Diverse technology and adoption speed. There is no clear measure of how successful is the use of EHR, because doctors, patients and hospitals are using diverse technologies, and some of them are not using any at all. Some EHR systems run on standalone machines, others use mobile devices and internet services.

Resistance to change is the main barrier for adoption, particularly by physicians. Arguments given by physicians include system cost, job overload and concerns about information security and privacy. Physicians which use EHR, do because they have been instructed by their superiors or see a benefit, for example an economic bonus or a job promotion.

Cost is another barrier for adoption of EHRs. Most of electronic health record systems are implemented in large medical centers with complex functionality; from administrative activities management (insurance processing, billing, patient's registration, etc.) to health information management (patient medical history, lab analysis, surgery schedules, etc.). Therefore the cost of EHR increases and only large medical centers can afford to have electronic health records. It is difficult to quantify the benefits that physicians find in their practice when using EHR. It is hard to evaluate the increase in productivity, cost reduction, and the return of investment (ROI).

Incentives wrongly aligned. Cost savings by using an EHR may not have a direct impact in the physician income, but in the patient cost or in the health insurance company earnings. For example, an EHR can alert when a medicine is prescribed to an allergic person, then the patient or his/her insurance company can save money with the avoidance of the need for further anti-allergy-related treatment.

Personalization and work flow. Successful systems are customizable to different types of users (physicians in this case) but such a customization may be complex and time consuming. Additionally, physicians have a personal style to do their job and they see EHR as an unwelcome change in the way they work, affecting their productivity.

During the design and development of EEMI, pediatricians worked directly with the development team in order to correctly map their needs into EEMI functionality, minimize resistance to change and technology adoption. Deployment of EEMI was done in increments; physicians had a functional version of the system, on every release. Also workflow templates were generated for a less complex customization and a successful implementation.

Health Standards and the Mexican Norm

EHRs are nowadays subject to regulations with respect to how they represent, store and share information with other systems. A brief description of the Mexican norm for electronic health systems and international health information standards follows.

The Mexican Norms (**Norma Official Mexicana** NOM-024-SSA3-2010 and NOM-024-SSA3-2012) (Secretaría de Salud, 2011) are the standards that sets the objectives and functional requirements that an electronic health record must have in order to guarantee the interoperability, confidentiality, security, and information catalogs. Among its specification the Mexican Norm states that electronic health records have to demonstrate that a minimal set of data is generated. The Mexican Norm requires the use of international standards for disease classification (ICD), interoperability (HL7) and medical images format (DICOM). Systems that are regulated by the norm include those used in outpatient consultation, inpatient care, emergency care, pharmacy, laboratories, surgery, and imagining.

The **International Classification of Diseases (ICD)** [37] is the standard diagnostic tool for epidemiology, health management and clinical purposes. This includes the analysis of the general health situation of population groups. It is used to monitor the incidence and prevalence of diseases and other health problems, proving a picture of the general health situation of countries and populations. The ICD is published by the World Health Organization. The Mexican Norm requires that EHR use a disease catalog such as the ICD.

Logical Observation Identifiers Names and Codes (LOINC) [29] is the standard for identifying medical laboratory observations. LOINC includes categories for chemistry, hematology, and microbiology, among others in

its laboratory section. The clinical observations section includes vital signs, electrocardiograms and echocardiograms among other categories.

Digital Imaging and Communications in Medicine (DICOM) [17] is the standard for medical images. DCOM defines how to handle, store, print and transmit information in medical imaging. It includes a file format definition and a network communications protocol. This standard is implemented in almost all devices used in radiology, cardiology, and ultrasound. The standard is also being applied to ophthalmology and odontology. The Mexican norm, mentions DICOM as the standard to be used for medical images by EHRs.

Health Level Seven (HL7) [24] is a set of standards for the transference of clinical and administrative data between different health software applications including EHRs. HL7 refers to the focus of the standards in the application layer (or layer 7) in the Open System Interconnection (OSI) model. There are two versions: HL7 Version 2 and HL7 Version 3 from which Version 2 is the most widely used in health related systems. Communication between applications as defined in HL7 is through well-formed text documents. Mexican Norm requires data exchange between health systems to follow the HL7 standard.

EHR systems comparison

In the US, the adoption of EHR has increased in the last years, in part due to government incentives, maturity of the EHRs, and better acceptance by medical professionals. EHR enterprises have perceived the market growth and therefore they have developed a great variety of products, as shown in Table 1 (EPIC; Cerner; Allscripts; drchrono Inc.; Entrada; Smart EMR; eClinicalWorks; PracticeFusion Inc.; Athenahealth Inc.; iCare).

In Mexico, after the release of the Mexican Norm for Electronic Health Records in 2010(Secretaria de Salud 2011; NOM 2010), new EHR's have been developed. The majority of these EHR implementations are in public health system hospitals and some in private medical centers. Public institutions such as IMSS (Social Security Institute for Mexico), ISSSTE (Social Security Institute for State Workers), PEMEX Hospitals (Mexican National Oil Company), Secretaría de Marina (Mexican Navy) and the private ABC Hospital have their in-site developed EHR. There are few commercial systems such as eMedix, Med2k, and, Alert. None of the reviewed systems for Mexico has a patient version or portal. Table 2 shows the characteristics of EHR in Mexico (ISSSTE, 2010; Estado de Colima; Secretaría de Marina; Yacamán, 2010; Ortega V, 2014; eMedix; Med2k; .*Alert Online*).

Table 1. EHRs in the USA

EHR	Deployment	Focus on	e-prescribing	Standards	Comments
EPIC	On Premise	Hospital	Prescription creation	HL7	Leader in the Gartner 2013 Magic quadrant for Enterprise EHR systems.
Cerner	Web, Mobile	Patient	NA	NA	Leader in the Gartner 2013 Magic quadrant forEnterprise EHRsystems. Personal Health Record. Shows metrics in a graph.
AllScripts	Web	Hospital	Pharmacy link	NA	Visionary in the Gartner 2013 Magic quadrant for Enterprise EHRsystems.
DrChrono	Web, Mobile	Physician	Prescription creation, Pharmacy link	ICD-9	Patients can access their demographic information, manage appointments, query lab results, send and receive messages to physicians, pre-fill forms in advance. Shows metrics in a graph.
SmartEMR	Web	Physician	Prescription creation, link to Surescripts (largest e-prescribing network)	NA	Patient can review their medical history, receive appointment reminders, fill information in advance, request appointments, review lab results, request medicine refills and communicate with physicians. Shows metrics in a graph.
eClinicalWorks	Web, Mobile	Hospital	Prescription creation, Pharmacy link	ICD-9	Patients can manage appointments, query their medical record, access lab results, request medicine refills and access educational information.
Practice Fusion	Web, Mobile	Physician	Prescription creation, Pharmacy link	ICD-9	Patients can manage appointments, query lab results, consult prescriptions, consult immunization schedule and send messages to physician. Shows metrics in a graph.
Athena Health	Web, Mobile	Physician	NA	ICD-9	Patients can manage appointments, receive appointment reminders, and consult lab results. Shows metrics in a graph.

Table 2. EHRs in Mexico

EHR	Deployment	Focus on	e-prescribing	Standards	Comments
IMSS	On Premise	Hospital	Prescription creation	NA	This system is only used for patients who are affiliated with IMSS.
ISSSTEMed	On Premise	Hospital	Prescription creation	NA	Interaction with pharmacy system and lab test, this system is only used for patients who are affiliated with ISSSTE.
SAECCOL	On Premise	Hospital	NA	ICD-9, ICD-10	This system is used by public hospitals in the state of Colima.
SICOHOSP	On Premise	Hospital	Prescription creation	ICD-10	System used by Mexican Navy. Interaction with lab test system
Hospital ABC	On Premise	Hospital	NA	NA	System only used for patients in hospital.
PEMEX	On Premise	Hospital	ICD-10	ICD-10	This system is only used to keep health records of PEMEX workers.
eMedix	Web	Physician	NA	ICD-9, ICD-10	Available for any physician. Monthly fee. Image storage
Alert	On Premise, Web	Hospital	Prescription creation	HL7	Software as a Service. Installed in 13 countries including Mexico.
Med2K	On Premise	Physician	Physician writes prescription	ICD-10	Available to any physician. Installation Maintenance and license costs. Image storage, video and voice.
EEMI	Web	Physician	Prescription creation	ICD-10	Available to any physician. Software as a service. Monthly fee. Automatic creation of immunization schedule.

The information summarized in Table 1 and Table 2 helped us to define and design the functionality on EEMI. One of the key factors we found in the analysis was the need to keep a record of immunizations, create prescriptions automatically but in an editable by physicians format and of course the imperative to follow the Mexican Norms (Secretaría de Salud, 2010, 2011) as well as international standards. In the following sections, a detailed discussion on EEMI is presented.

EEMI SYSTEM DESCRIPTION

EEMI is an electronic health record system based on the practice experience of pediatricians in Monterrey, Mexico. The system follows the Mexican norms in its functionality and data exchange. Figure 1 represents a contextual

overview of the services provided by EEMI. Users of the Child Electronic Health Record, presented in this paper, are physicians and their office assistants. The following paragraphs describe EEMI services.

Figure 1. EEMI Contextual Overview

Appointment Administration.
This module allows to creates and manage appointments. This service resolves date conflicts with national holidays and personal physician calendar. The physician can manage his/her own calendar to mark his/her vacations or define days out of the office.

Visits management.
This module includes access to previous diagnosis, known treatments and related medications to facilitate and speed up the physician diagnostic. The system is able to automatically generate a prescription based on the diagnostic and calculate the medication dosage. The automatically generated prescription can be edited by the physician according to his/her consideration.

Medical record management.
This module allows the management of information such as measurements, medical history, family, documents, laboratory results, immunizations, appointments, and visits history. New information can be added or current information can be updated.

Diagnosis.
This module allows the specification of visit diagnosis based on the International Classification of Diseases (World Health Organization). The system has a section for the diagnosis, treatments, medications formulary and brand names. This information is presented in form of lists that are related with each other and whenever a physician selects a diagnosis the system will display the possible treatments for that diagnosis, when a physician selects a treatment the system will display the possible medications for that treatment and the same goes for the medications and brand names.

Every time a physician selects a diagnosis the system will learn the relationships between diagnosis, treatment, medication and brand names and also the information for each one of them. This eliminates the need for the physician to type the same information every time for the same diagnosis. However, the possibility of modifying the selected treatment is kept always open, since there are no fixed combinations of diagnostic-treatment-medication-brand name.

Each physician can create, modify and save his/her own catalogs of diagnosis, treatments, medications and brand names and the information could be used by another physician but could also be modified in case of an error, or a different treatment preference, choice of medication or a different brand name. The creation of this medical collaboration will reduce the errors in diagnosis.

Additionally, the system identifies frequent diagnosis in the last "n" days and every time a physician selects one of them, the system will suggest a full diagnosis, set of diagnosis-treatment-medication and brand name based on the most recently used. This suggestion makes faster the process of consulting a patient and is also helpful because many diseases have different prevalence depending on the season of the year and have a tendency to appear as clusters.

Every time a medication is added to the prescription, the system validates that the medication doesn't have an incompatibility with other medications in the same prescription. EEMI also validates medication against patient's known allergies.

Prescriptions and dose calculation
Once the diagnosis is selected, the system creates the prescription based on the information of every treatment and medication; it calculates the dose and generates a text for each medication that contains the presentation, dose, administration route, dispensing time and duration of treatment. The physician can print the prescription and give the patient a legible prescription that will not cause any misinterpretation. The dose calculation for every medication can be calculated by bodyweight or patient's age.

Immunization schedule
The immunization schedule is automatically programmed based on the recommendations by the Mexican Ministry of Health (SSA). The doctor can personalize this schedule adding new immunizations not considered by the SSA. The system records the immunization and the age range of application. The recommended immunization date will be used for calculating the estimated date of application for a child and will create an appointment for that date. When a child is born and visits the pediatrician for the first time, the physician's assistant uses the system to schedule a full calendar of immunizations and appointments. This automation helps to keep track of the child's immunizations and allows the assistant and the physician to remind the family for future visits. EEMI sends automatic e-mail remainders to parents or tutors of child's immunizations appointments.

Growth graphs
The system displays the child's anthropometric measurements (weight, height, head circumference, body mass index) in a percentile chart, so the physician can assess the growth over time, but is also able to compare with population statistical data, because the system also displays the percentile distribution of all population values.

With EEMI, the pediatrician can view, print or save in various graphic formats data of weight for age, height for age, weight for height, head circumference for age, and body mass index for age.

In a weight for age graph the pediatrician can easily identify when a child presents overweight or malnutrition by just comparing the child weight and check if the value is outside the normal values. Figure 2 shows an example of a low weight for age graph, where the blue dots are the child's weight and the color lines are the normal values.

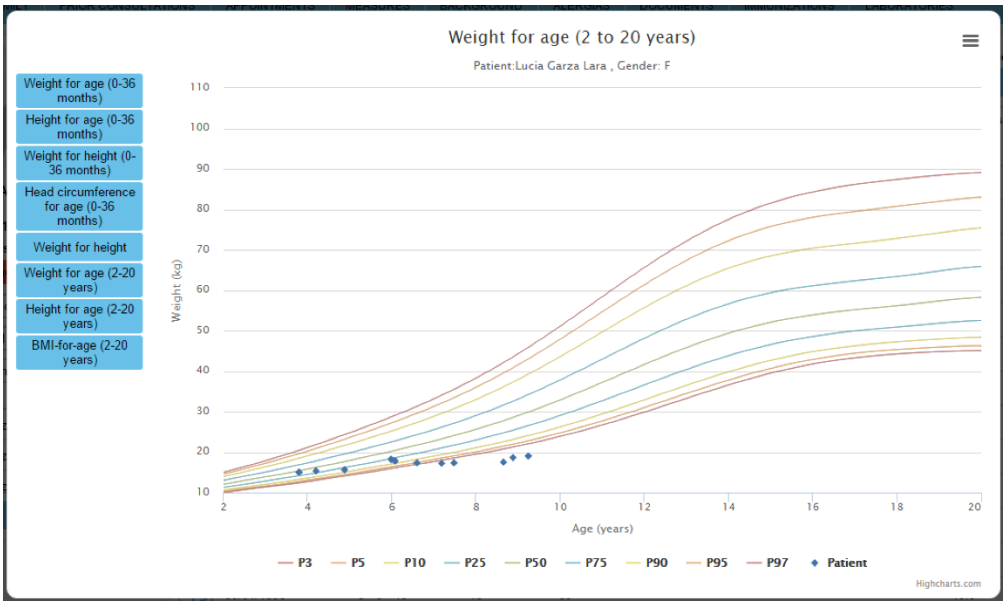

Figure 2 Growth Graph (weight vs age)

EEMI Benefits

The following are the benefits of EEMI adoption according to observations by the initial testing group. Most of the benefits are not directly quantifiable in monetary terms, but qualitative in terms of a better interaction between physicians and patients.

Tax Deductible Cost. In its current implementation as a software a service (SaaS), EEMI is tax deductible by the Mexican fiscal legislation. Therefore, there is no a direct economic cost to the physicians that are using EEMI. Other EHR that were developed as standalone desktop applications are not considered services by the fiscal law, and the investment and other monetary cost are covered by the adopters.

Optimization of Visit Time. During the visit, physicians spend more time talking with patients and understanding his/hers needs that looking for past visits records or writing down prescriptions and indications.

Elimination of prescription errors. One key functionality of EEMI is the automatic (and editable) creation of prescriptions. This feature reduces common errors that physicians may do while handwriting or even typing prescription. It also allows to reduce or even eliminate medication incompatibility errors by looking for contra-indications for medicines in the prescription.

Patient data consistency and privacy. Other key benefit mentioned by adopters of EEMI is the consistency in the information that is included in the prescriptions, such as medicines, dosage and particular indications. By having all this information at hand from visit to visit allows physicians a better understanding of the patients' progress.

Elimination of paper storage. The use of EEMI has permitted to reduce or eliminate the physical space required for storage of paper records.

EEMI Adoption and Barriers

EEMI has been evaluated by a group of physicians during its testing period. Even though, the acceptance of EEMI has been generally good, there are still some adoption barriers among the medical community. The most prevalent are:

Change resistance. As in any professional group, there is a group of physicians that is not willing to accept an EHR of any kind, and keeps attached to the traditional way to do a consult.

Use customization. One aspect for a good acceptance of an EHR according to the evaluation group has been the customization of the systems to the physician practice. EEMI has been successfully adapted to the way pediatricians work, however it is possible that other physicians find EEMI workflow inadequate to their practice.

Information transfer. Another key element for delay in the adoption of EEMI has been the burden of the initial transfer of patient information from one legacy systems to EEMI. Without this feature, physicians face the dilemma of capturing (typing) again all their patients records or to keep the legacy systems for old time patients and record the new patients in EEMI,

EEMI TECHNOLOGY DESCRIPTION.

EEMI is built based on the N-Tier Architecture, specifically 3-Tier Architecture. It's a client-server architecture where the logic, view and data are in different tiers. The data tier can contain one or more databases, the business tier contains all the logic of the project and the presentation tier contains the user interface. Currently EEMI is being implemented on a Service Oriented Architecture (SOA) that provides a loosely coupled approach that allows interoperability, maintenance and updates (Schuldt, 2009). The use of Web Services allows data sharing between applications. A study showed that physicians have an urgent requirement to access the electronic health record systems with personal devices such as tablets or smartphones; therefore, a Service Oriented Architecture is suggested in the study ((6). 624-628, 2009). With this architecture we can develop native applications for diverse operating systems (iOS and Android) that cover the mobile devices alternatives in the market. This is possible by only developing the presentation tier and using the Web services.

The Figure 3 shows the architecture of the system, which is composed of three tiers. The presentation tier contains all the interfaces that presents data to the end users and allows the data manipulation. The business logic tier contains all the web services that will obtain and modify the database. The data tier is responsible for the database management. This separation of tiers improves scalability, reusability, flexibility, and maintainability, because we have loosely coupled and highly cohesive methods in each tier that are easy to change or reuse. Is important that the system has these attributes because we want to extend this system to other medical areas like gynecology.

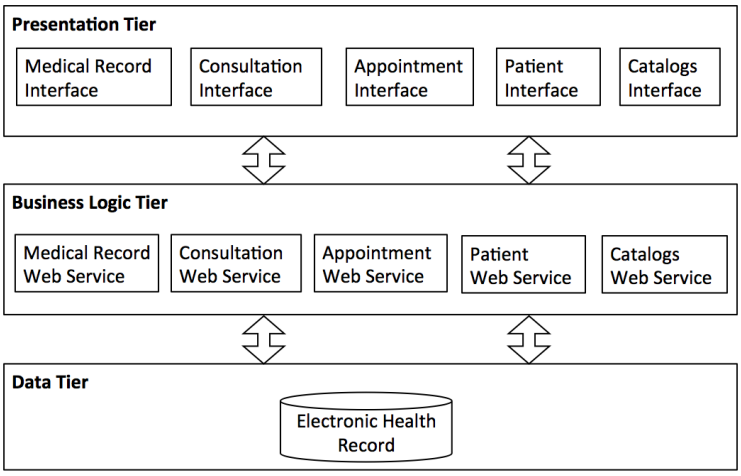

Figure 3. SOA for EEMI

EEMI is implemented in.NET Framework 4.5. The presentation tier was developed in ASP.NET, the business logic tier in Windows Communication Foundation (WCF) and for the data tier we use SQL Server 2012. The system is running in a cloud computing platform, Microsoft Azure.

CURRENT STATUS AND FUTURE WORK

At the time of writing this paper, EEMI has been in the acceptance testing phase with a pilot in a group of pediatricians in Monterrey, Mexico. We will review the results and observations of this phase for include improvements in the production version. The production version was completed by the end of August 2015.

As future work, EEMI will be integrated with the project for Monitoring and Assisting Maternity-Infant Care in rural areas (MAMICare) (Lavariega, Córdova, Gomez-Martinez, & Ávila, 2013). The MAMICare project monitors pregnant women to detect anomalies and prevent maternity and infant deaths. The EEMI system will continue with the monitoring of the child by keeping track of the growth and immunizations of the child.

New electronic devices are being reviewed. These devices send information via Bluetooth to automatically register the measurements in the system. One key idea is to incorporate these devices in the process of taking measurements to eliminate the possibility of human errors in typing data manually.

As a web application, EEMI can be accessed from any tablet or smartphone, however, the user interface may not look exactly the same in all devices. One objective in the short terms is to develop native iOS and Android applications of this electronic medical record, a decision has to be made upon including only the most important requirements for these new applications or include everything that is available in the current system.

CONCLUSION

In general, EEMI enhances the process of a pediatric medical consultation due to the automation of several common activities. It also reduces the possibility of error that could be incurred at any time the physician types repetitive diagnosis. Due to the automated functions, the physician can focus on giving a better medical care. As a consequence of fewer typing errors, patient information is more accurate and a sense of security can be established between physician and patients.

EEMI is a useful tool for keeping track of the child's growth and creating an immunization schedule for each child. The graphs will help the pediatrician to make decisions based on the weight, height, head circumference, and body mass index of a child.

With the use of a Service Oriented Architecture the system is scalable, reusable, flexible, and maintainable. This architecture makes it easier to make changes in the system, and reuse code because of the highly cohesive and loosely coupled methods. We can create native applications for iOS and Android by just developing the presentation tier and use the Web Services that are already developed in the business logic tier.

REFERENCES

Alert.*Alert Online*. Retrieved from: https://www.alert-online.com

Allscripts. *Professional EHR*. Retrieved from www.allscripts.com

ASHP guidelines on preventing medication errors in hospitals. American Journal of Hospital Pharmacy, 50(2), 305-314.1993

Athenahealth, Inc. *athenaClinicals*. Retrieved from www.athenahealth.com

Atlassian. *Jira*. Retrieved from https://www.atlassian.com/software/jira

Bates, D. W., Cohen, M., Leape, L. L., Overhage, J. M., Shabot, M. M., & Sheridan, T. (2001). Reducing the frequency of errors in medicine using information technology. *Journal of the American Medical Informatics Association*, 8(4), 299-308.

Benson, T. *Principles of Health Interoperability HL7 and SNOMED*. Health Informatics Series.2010

Bush, J. & Baker, S. *Where Does It Hurt? An Entrepreneur's Guide to Fixing Health Care* (1st ed.), 2014

Camacho Ortega V.*El Expediente Clínico Electrónico en PEMEX: un caso de éxito. 4a Reunión Nacional de Información en Salud*. 2014. Retrieved from http://www.dgis.salud.gob.mx

Cerner. *Cerner PHR*. Retrieved fromhttps://cernerhealth.com/

Development of a WHO growth reference for school-aged children and adolescents, Bulletin of the World Health Organization, 2007: 85:660-7

DICOM. *About DICOM*. Retrieved from http://medical.nema.org,

drchrono Inc.. *Dr Chrono*. Retrieved fromwww.drchrono.com

eClinicalWorks. *eClinicalWorks v10 (EHR Suite).*. Retrieved fromwww.eclinicalworks.com

eMedix. *eMedix Expediente Clínico Electrónico*. Retrieved fromwww.emedix.com.mx

Entrada. *Entrada EHR*. Retrieved from www.entradahealth.com

EPIC. *EpicCare Ambulatory Electronic Medical Record (EMR).*.Retrievedfromwww.epic.com

Estado de Colima. *SAECCOL SISTEMA PARA LA ADMINISTRACIÓN DEL EXPEDIENTE CLÍNICO ELECTRÓNICO COLIMA.* Retrieved fromwww.salud.gob.mx

Health Level Seven International. *About HL7*. Retrieved fromwww.hl7.org

Hsiao C-.J., &Hing E. *Use and characteristics of electronic health record systems among office- based physician practices: United States*, 2001–2013. NCHS data brief, no 143.

Humpage, S. *Benefits and Costs of Electronic Medical Records: The Experience of Mexico's Social Security Institute*. InterAmerican Development Bank 2010. Retrieved from http://www.iadb.org

iCare. *The Enterprise Cloud EHR*. Retrieved from www.icare.com

ISSSTE. (2010). *ISSSTEMed. Avances en la Implementación del Expediente ClinicoElectronico.*Retrieved fromwww.salud.gob.mx

Lavariega, J., Córdova, G., Gomez-Martinez, G, Ávila, A. (2013). "Monitoring and Assisting Maternity-Infant Care in Rural Areas (MAMIcare)", *Transactions of the International Conference on Health Information Technology Advancement*, 2(1), 175-184, Western Michigan University, Kalamazoo, MI., ISSN 2168-6335

LOINC. *History, Purpose, and Scope*. Retrieved fromwww.loinc.org

Med2k.M*ed2k ExpedienteElectrónico*. Retrieved from: http://www.complise.mx/software.asp?producto=med2k

National Coordinating Council for Medication Error Reporting and Prevention. NCCMERP About Medication Error. Retrieved from http://www.nccmerp.org/aboutmederrors.htm

PracticeFusion Inc. *PracticeFusion EHR*. Retrieved fromwww.practicefusion.com

Quintas Ruiz I, "Analisis de FactoresCríticos de Éxito para implantación de ExpedienteClínicoElectronicoen el ÁreaMetropolitana de Monterrey" (Analysis of Critical Success Factors in Implementation of E-Health Records in the Monterrey Metropolitan Area), Master of Administration on IT Thesis, ITESM-Monterrey Campus April 2011

Schuldt, H. (2009). *Multi-Tier Architecture*. Encyclopedia of Database Systems.

Secretaría de Marina Armada de México. *SISTEMA DE CONTROL HOSPITALARIO (SICOHOSP)*. Retrieved from http://www.salud.gob.mx

Secretaría de Salud. (2011). *Manual del Expediente ClinicoEletronico*. Retrieved from http://www.who.int/goe/policies/countries/mex_ehealth.pdf

Secretaría de Salud. *Norma Oficial Mexicana NOM-024-SSA3-2010*. Diario Oficial de la Federación. México- DF: Secretaría de Salud..Retrieved fromwww.dgis.salud.gob.mx

Smart EMR. *smart EMR*.. Retrieved fromwww.smartemr.com

Spooner, S. A., et al. (2007). Special requirements of electronic health record systems in pediatrics. *Pediatrics*, 119(3), 631-637.

Velo, G.P., &Minuz, P.. Medication errors: Prescribing faults and prescription errors. British Journal of Clinical Pharmacology, 67(6), 624-628, 2009

World Health Organization (WHO). Children: reducing mortality. 2013

World Health Organization (WHO*). International Classification of Diseases (ICD).*Retrieved from http://www.who.int/classifications/icd/en/

Wu, Y., & Yang, H. An electronic medical records review system for mobile healthcare based on web services. Paper presented at the *2012 5th International Conference on Biomedical Engineering and Informatics, BMEI 2012*, 1040-1044.

Yacamán, R. (2010). *Expediente Médico Electrónico en el Centro Médico ABC*. 3era Reunión Nacional de Información en Salud. Retrieved fromwww.dgis.salud.gob.mx

Zavaleta-Bustos, M., et al. Prescription errors in a primary care university unit: Urgency of pharmaceutical care in Mexico. Brazilian Journal of Pharmaceutical Sciences, 44(1), 115-125., 2008