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Business and IT Aspects of Wireless Enabled Healthcare Solutions

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ABSTRACT

Use of technology for achieving superior healthcare delivery has been advocated for decades. Globally, both wired and wireless technologies have been used for healthcare delivery. However, in the frenzy to secure the best solutions and applications, few have delved deeper into the key issues of how to successfully assimilate these new technologies into the whole healthcare delivery process as well as the ramifications and implications to other systems already in place. In this paper, we consider wireless healthcare solutions to monitor chronic diseases and suggest that a key barrier for preventing the full realization of the true potential of wireless solutions lies in the enabling of information and necessary data to pass seamlessly form one platform to another. We suggest ways to integrate data from wireless healthcare solutions with the existing electronic health records (EHR) systems, and discuss the impact of wireless enabled solutions on the meaningful use of EHRs.

Keywords (Required)

Pervasive technology, m-health, diabetes, knowledge management, e-health, electronic health records

INTRODUCTION

Globally, healthcare expenditure as a percentage of Gross Domestic Product (GDP) by 29 members of the Organization for Economic Cooperation and Development (OECD) rose from 5.0% to 8.1%, between 1970 and 1997 (Huber 1999). Moreover, since 2000, total spending on healthcare in these countries has been rising even faster than economic growth (OECD 2010a & OECD 2010b). To address this significant problem and thereby provide value driven superior healthcare, most, if not all, countries within the OECD are investigating possibilities for a variety of e-health implementations. Such e-health solutions include various wired and wireless solutions including electronic medical records, e-prescription systems, PACS and other lab/radiology systems as well as various billing and practice management type systems. Given this in-flux of technology into healthcare delivery, the most recent Obama healthcare reform identifies that a key consideration of the use of technology in healthcare delivery should be concerned with meaningful use. It is the contention of this paper that meaningful use of the technology as well as its full potential can only be realized when the specific solution is assimilated and integrated into the context so that data and information can pass seamlessly from one platform to another. Thus this paper describes a specific case study of DiaMonD (diabetes monitoring device) and then discusses how it is easier for clinics and hospitals to achieve meaningful use with wireless technologies. This paper concludes with business models for revenue generation using wireless monitoring solutions.

CHRONIC DISEASE MANAGEMENT

Many have noted that the US has an unparalleled capacity to treat, especially in the context of trauma and infectious diseases (Gibbons et al. 2010; Porter 2006). However, and sadly, the US healthcare system too often fails to provide appropriate and adequate healthcare delivery for patients with chronic diseases such as diabetes and hypertension. Chronic diseases such as diabetes, asthma or hypertension if detected early can be contained and the sufferers from these diseases can continue to lead high quality lives. Conversely, if these diseases are not well managed, they can develop into more complicated healthcare problems and life for such patients becomes less than satisfactory. Critical to effective chronic disease management is regular monitoring and an informed patient who takes responsibility for managing his/her wellness. As identified by Rachlis (2006) a chronic care model requires the interaction and co-ordination of numerous areas. In particular, it requires the interaction of four key components of the healthcare system including self-management support, delivery support, decision support and clinical information systems and support from the community at large. These support mechanisms provide a conducive environment for productive interactions between an informed and activated patient and a prepared and proactive healthcare team.

Diabetes, one important chronic disease is increasing in its prevalence throughout not only North America but also the world. The world diabetes population is expected to increase by 76% from 159 million in 2000 to 236 million in 2025, and thus diabetes has been called a silent epidemic by the World Health Organization. The cost of treatment of an increasing number of diabetics is indeed alarming to any healthcare system.

Regular monitoring of diabetes is a necessary part to controlling this particular chronic disease and keeping it from evolving into more complicated healthcare problems. To do this efficiently and effectively we believe ICT (information communication technologies) can play a critical role by providing a means to enable superior monitoring anywhere anytime and thereby also allowing the patient to enjoy a high quality lifestyle. However, technology initiatives in healthcare to date have had mixed results at best (Wickramasinghe and Goldberg, 2009; Wickramasinghe and Goldberg, 2007). We believe this is connected with the failure of current IS (information systems) methodologies to correctly capture the richness and complexities of a modern healthcare environment. To address this issue and in so doing provide an environment enabled by ICT that facilitates superior chronic disease management we describe the idea behind wireless monitoring of diabetes.

DiaMonD – A PERVASIVE WIRELESS SOLUTION

DiaMonD – diabetes monitoring device – is a pervasive technology solution to provide superior healthcare for sufferers of diabetes. The solution incorporates software that facilitates the ubiquitous monitoring of an individual's diabetes, thereby, contributing to diabetes self-management. The solution is grounded in trying to support key components of a chronic disease care model (Table 1). INET International Inc.'s research (Goldberg 2002a-e) starts with a 30-day e-business acceleration project in collaboration with many key players in hospitals, such as clinicians, medical units, administration, and IT departments. Together, they follow a rigorous procedure that refocuses the traditional 1-5-year SDLC into concurrent 30-day projects to accelerate healthcare delivery improvements. At completion, an e-business acceleration project delivers a scope document to develop a handheld technology application (HTA) proof-of-concept specific to the unique needs of a particular environment. The proof-of-concept is a virtual lab case scenario which operates within a mobile Internet (wireless) environment by working with hospitals and technology vendors. The final step is the collection of additional data with clinical HTA trials consisting of two-week hospital evaluations.

The INET web-based model (Figure 1) provides the necessary components to enable the delivery framework to be positioned in the best possible manner so it can indeed facilitate enacting the key components of the chronic disease model successfully (Table 1). The model is positioned to suit the complex nature of healthcare environments by iteratively, systematically, and rigorously incorporating lessons learnt data to healthcare processes for ensuring superior healthcare delivery. This manner not only maximizes the value of past data and organizational learning, but it also makes processes amendable as complex needs and requirements evolve.

It is important to note that in the INET web-based model the three key areas of risk, namely, people, processes and technology, are minimized through the use of pervasive technology, which we believe is a unique benefit of the INET solution. Specifically, since the proposed solution is an application that is compatible with any mobile phone or wireless device (e.g. a PDA), data transfers occur between patients and providers on a well-vetted model. Therefore, the learning curve for patients is minimal as they are likely to be in possession of mobile devices.

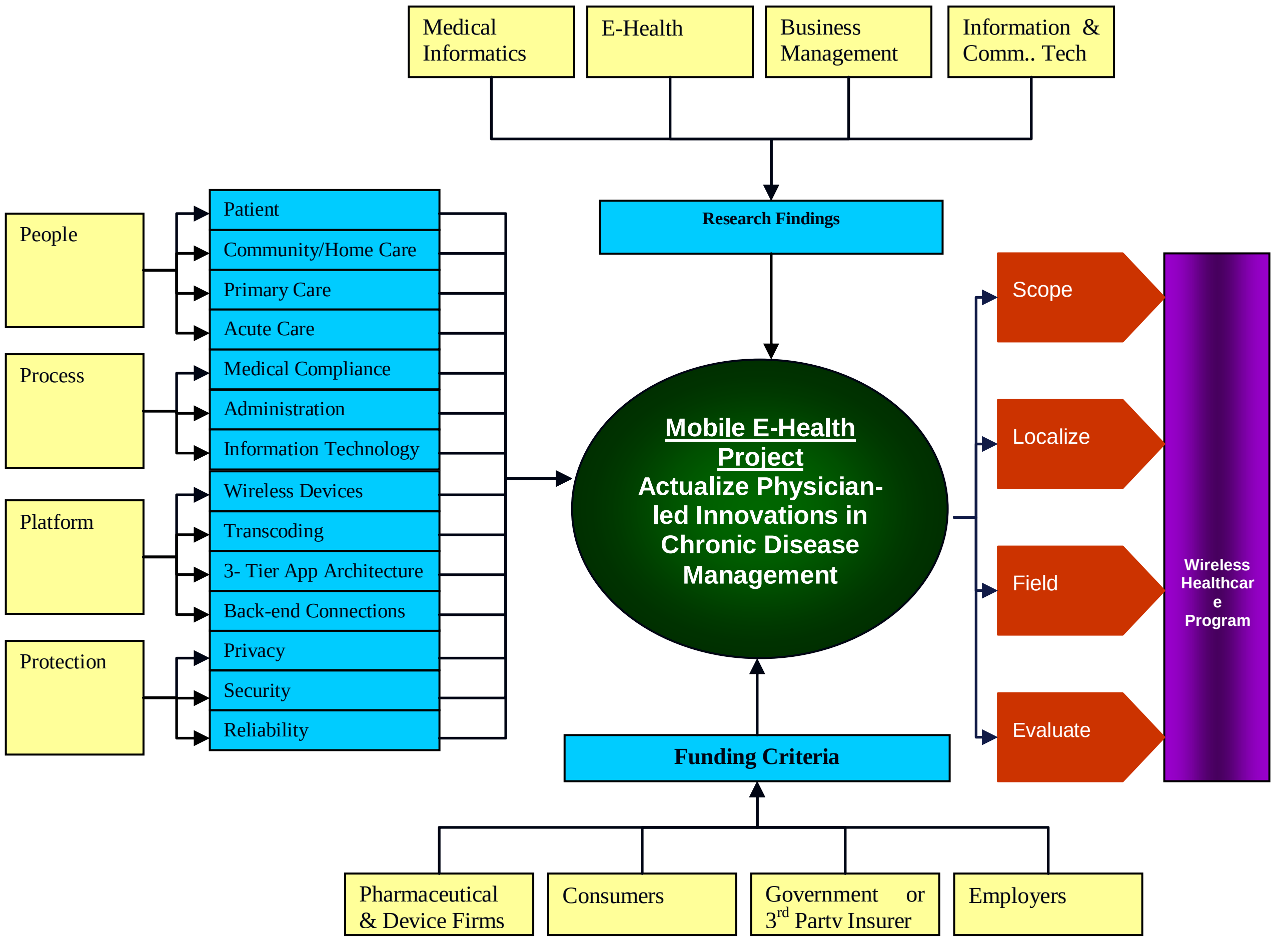

Figure 1: INET Model.

Table 1: Components of Chronic Care Model (Rachlis, 2006).

Component	**Description**
Organization of Health System	• Leadership in chronic disease management (CDM) • Goals for CDM • Improvement strategy for CDM • Incentives and regulations for CDM • Benefits
Self-management support (SMS)	• Assessment and documentation of needs and activities • Addressing concerns of patients • Effective behavior change interventions
Decision Support System (DSS)	• Evidence-based guidelines • Involvement of specialists in improving primary care • Providing education for CDM • Informing patients about guidelines
Delivery System Design (DSD)	• Practice team functioning • Practice team leadership

	• Appointment system • Follow-up • Planned visits for CDM • Continuity of Care
Clinical Information Systems (CIS)	• Registry • Reminders to providers • Feedback • Information about relevant subgroups of patients needing services • Patient treatment plans
Community	• Linkages for patients to resources • Partnerships with community organizations • Policy and plan development

What makes this model unique and most beneficial is its focus on enabling and supporting all areas necessary for the actualization of ICT initiatives in healthcare. By design, the model identifies the inputs necessary to bring an innovative chronic disease management solution to market. These solutions are developed and implemented through a physician-led mobile e-health project. This project is the heart of the model that bridges the needs and requirements of many different players into a final (output) deliverable, a "Wireless Healthcare Program". To accomplish this, the model is continually updated to identify, select and prioritize the ICT project inputs that will:

- Accelerate healthcare system enhancements and achieve rapid healthcare benefits.
- Close the timing gaps between information research studies and their application in healthcare operational settings.
- Shorten the time cycle to fund an ICT project and receive an adequate return on the investment.

The model identifies key healthcare system inputs with the four Ps, namely, 1) People that deliver healthcare, 2) Process to define the current healthcare delivery tasks, 3) Platform used in the healthcare technology infrastructure, and 4) Protection of patient data. These 4 Ps were chosen after discussions with various healthcare professionals as to the areas they believed were critical inputs for any model. These categories are mutually exclusive and collectively exhaustive based on the views of experts consulted. In applying the DiaMonD solution to any particular context of diabetes sufferers it is necessary to consider the scope or extent of the diabetes problems in this context, the specific contextual features such as demographics as well as current processes in place to treat patients so that the application will be tailored to this population hence "localize" is an important aspect in the delivery framework. Thus, the delivery framework helps to make the solution applicable to any context of diabetes patients which is an essential consideration given that diabetes cuts across all areas of the community. Together the components of the model will help in actualizing physician-led solution for the management of chronic diseases in general and of diabetes in particular. To successfully implement the INET web-based model described above, it was necessary to have an appropriate methodology. Based on this need, the adaptive mapping to realization methodology (AMR) was developed (Figure 2) (Wickramasinghe and Goldberg, 2007). The idea of the methodology was to apply a systematic rigorous set of predetermined protocols to each business case and then to map the post-prior results back to the model. In this way, it was possible to compare and contrast both a priori and post priori findings. From such a comparison, first a diagnosis of the current state was made, and then prescriptions were derived for the next business case. Hence, each pilot study incorporated the lessons learnt from the previous one and the model was adapted in real time.

By applying the tools and techniques of today's knowledge economy as presented in the intelligence continuum (IC), it is possible to make the AMR methodology into a very powerful knowledge-based systems development model. The IC was developed by Wickramasinghe and Schaffer (2006) to enable the application of tools and technologies of the knowledge economy to be applied to healthcare processes in a systematic and rigorous fashion, thereby ensuring superior healthcare delivery. The collection of key tools, techniques and processes that make up the IC include, but are not limited to, data mining, business intelligence/analytics and knowledge management (Wickramasinghe and Goldberg, 2007). Together, they represent a very powerful system for refining the raw data stored in data marts and/or data warehouses, thereby maximizing the value and utility of these data assets for any organization. To maximize the value of the data generated through specific healthcare processes and then to use this to improve processes, IC techniques and tools must be applied in a systematic manner. Once applied, the results become part of the data set that are subsequently reintroduced into the system and combined with other inputs of people, processes, and technology to develop an improvement continuum.

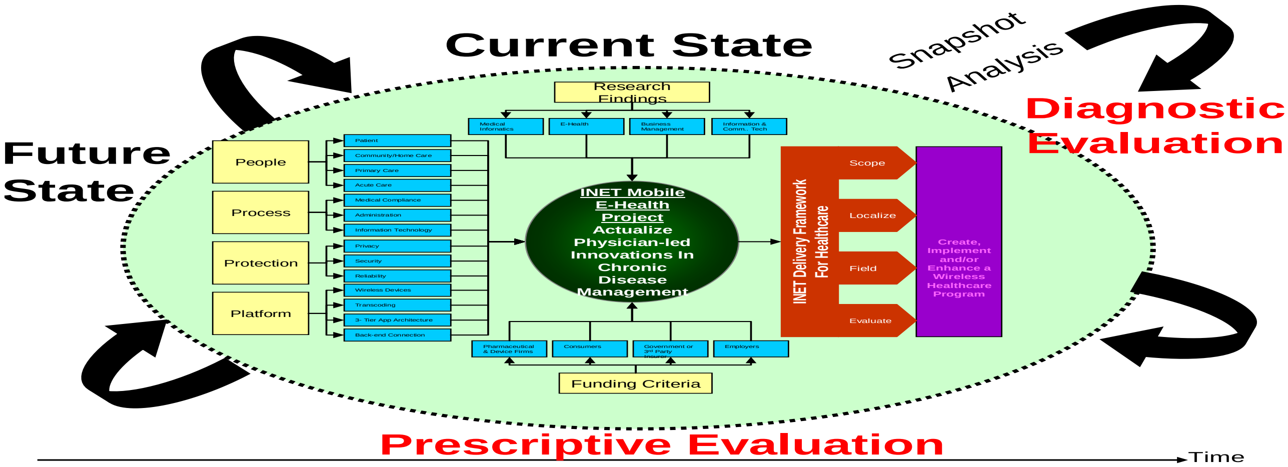

Figure 2: AMR Methodology.

Thus, the IC includes the generation of data, the analysis of these data to provide a “diagnosis”, and their reintroduction into the cycle as a “prescriptive” solution. In this way, the IC is well suited to the dynamic and complex nature of healthcare environments and ensures that the future state is always built upon the extant knowledge-base of the preceding state. Through the incorporation of the IC with the AMR methodology we then have a knowledge-based systems development model that can be applied to any setting, not necessarily to chronic disease management. The power of this model is that it brings best practices and the best available germane knowledge to each iteration, and is both flexible and robust.

Given the uniqueness of this approach it was necessary to develop this model from the beginning rather than look at other existing models. This was done by trying to understand key criteria from various stakeholders such as patients, healthcare professionals and hospital personnel and sort this information into a coherent whole. This was an iterative process which involved many and multiple discussions with the various stakeholders until all parties were agreed the model captured the essential elements as discussed in details in Goldberg (2002a-e).

To date, directional data has already shown the benefits of this solution in various pilot studies in Canada (Wickramasinghe and Goldberg, 2009). We believe that DiaMonD is a most beneficial solution given the huge and growing impact of diabetes. In particular, it is very cost effective for both patients and healthcare providers. We believe that as more pilot studies are conducted in different settings this will add data that will show the full and far reaching benefits of the proposed solution. What is certain is that current methods for treating patients with diabetes are unwieldy, generating significant costs, not especially patient-centric and doing little to stem the development of secondary complications thus a better solution is required.

Thus, DiaMonD represents a pervasive technology enabled solution, which, while not exorbitantly expensive, can facilitate the superior monitoring of diabetes. The proposed solution enables patient empowerment by way of enhancing self-management. This is a desirable objective because it allows patients to become more like partners with their clinicians in the management of their own healthcare (Radin, 2006; Mirza et al. 2008) by enhancing the traditional clinical-patient interactions (Opie 1998). The process steps in monitoring diabetes using the DiaMonD approach are outlined below.

1. Each patient receives a blood glucose measurement unit.
2. Patient conducts the blood glucose test and enters the blood glucose information into a hand-held wireless device.
3. The blood glucose information is transmitted to specialized database servers that store patient data. Patient’s hand-held device uniquely identifies the patient for recording the blood glucose data. Thus no patient information such as the name, ethnicity or date of birth is transmitted to the clinic.
4. The patient’s blood glucose data is then stored/integrated with the clinic’s electronic medical record (EMR) system.

5. An alert is generated for the clinical staff with the patient's blood glucose information.
6. The blood glucose information of the patient is reviewed by the clinical staff (physician/nurse).
7. Feedback on glucose levels is transmitted back to the patient's hand-held device. Feedback examples include complimenting the patient when glucose levels are normal or asking the patient to come for a follow-up appointment when the levels are out of norm.
8. Monitor trends in diabetes management for patients over a period of time.

This process is illustrated in Figures 3 and 4. The iterative nature of the DiaMonD approach is consistent with the AMR methodology, and hence the solution continuously diagnoses, evaluates and prescribes so that the future course of patient management and self-care is built on the current readings and medical advice.

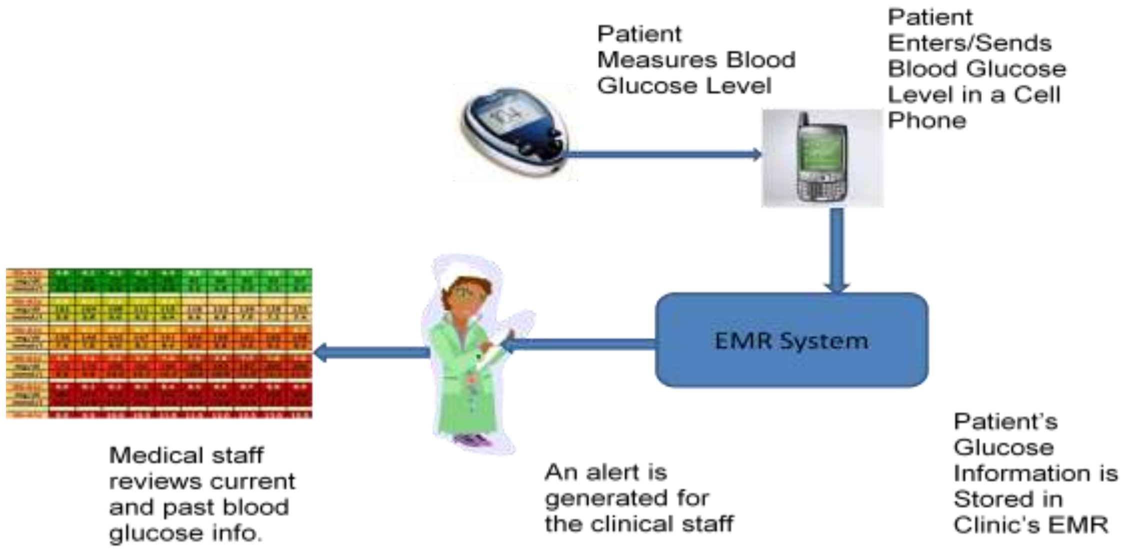

Figure 3: Flow of blood glucose information from the patient to clinical staff via EHR.

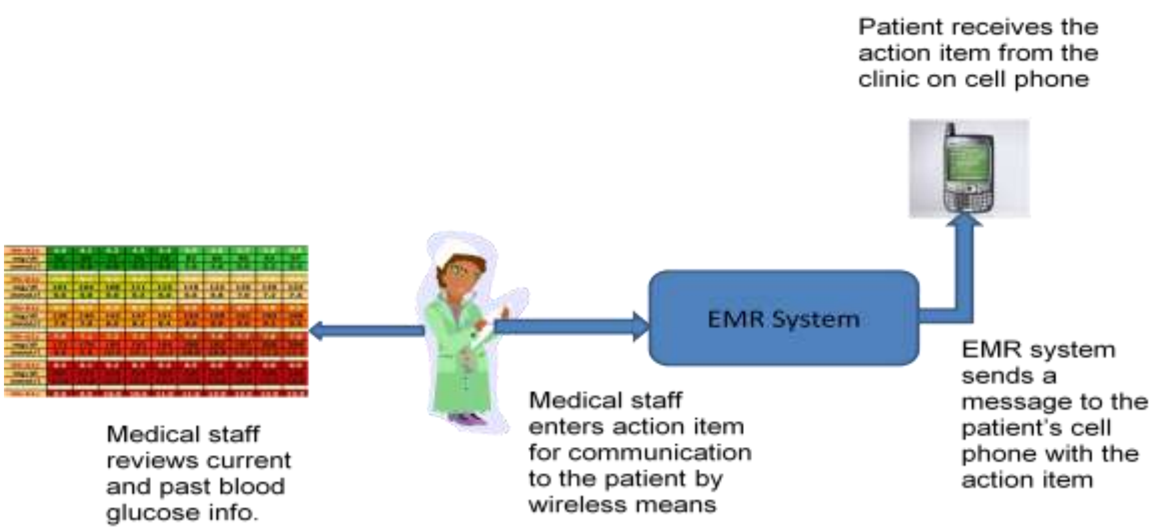

Figure 4: Flow of messages from the clinical staff to the patient via EHR.

INTEGRATION OF WIRELESS MONOTORING WITH EXISTING ELECTRONCI HEALTH RECORDS (EHR)

Electronic health record (EHR) is the most commonly used term for storing accessing patient medical information electronically. EHR systems provide significant functionality that enable entering and accessing patient demographic data, patient charts, medical history, progress notes, medications, immunizations, past medical history, vital signs, laboratory data, transcription, and e-prescriptions. Computerized physician order entry (CPOE) systems can capture the physicians' orders with respect to patient care. CPOE is often a component of the EHRs and enables physicians to enter orders and disseminate those orders to the labs, radiology department, pharmacy, and other healthcare providers such as specialists. Personal health record (PHR) systems enable patients to access their personal medical information via the Internet. PHR systems allow patient access to their medical records, prescriptions, laboratory data, appointments and other pertinent medical information. Google Health is a PHR system that allows patients to upload their medical data from selected clinics into Google Health.

To integrate data from wireless monitoring devices into existing EHR/PHR infrastructure, the software modules outlined below play a key role.

- Software Module 1 – Wireless Devices to EHR Interface: Accepts patient blood glucose readings from wireless devices and stores the data into electronic medical records systems.

- Software Module 2 – Health Data Analyzer: Analyzes patient blood glucose data over time and provides summary data and suggested next steps. Automatically generates alert messages for patients and clinical staff to follow-up.

- Software Module 3 – PHR Data Extractor: Exports blood glucose data for patients and enables patients to store their data into their personal health records systems (PHRs).

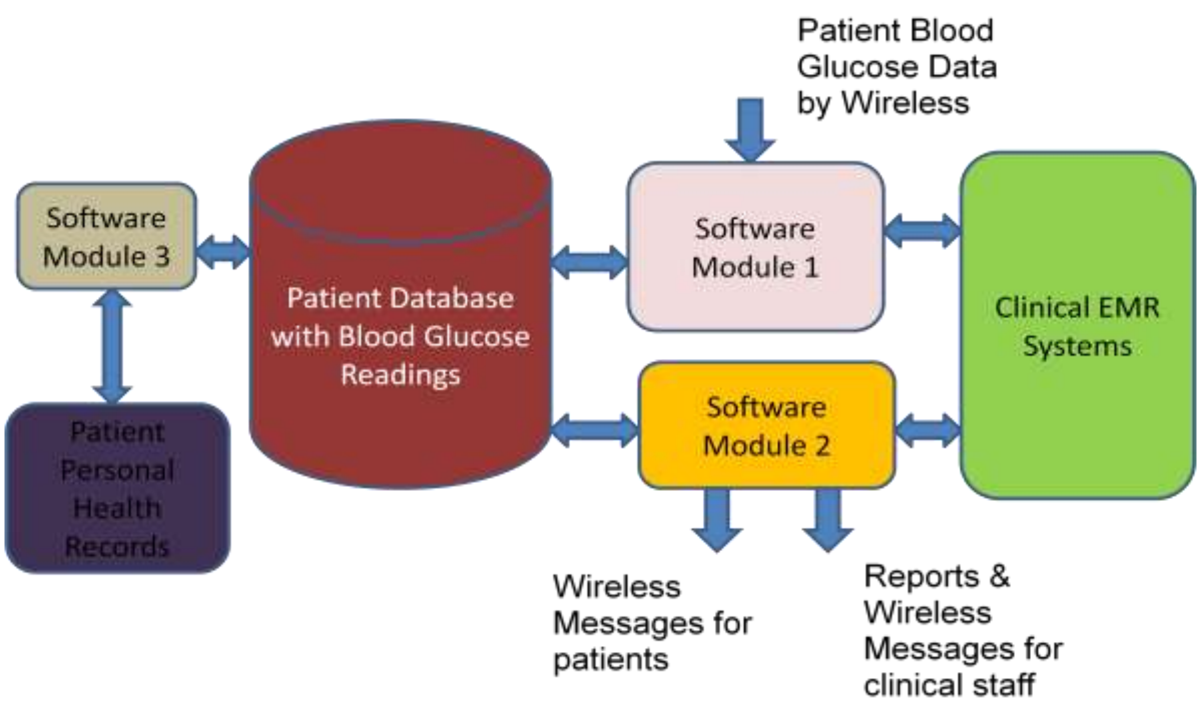

Figure 5: The relationship between the proposed software modules and the PHR, EHR systems.

The three software modules will utilize a back-end database that stores the patient data and blood glucose readings. The interaction of these three software modules and the other software components with the external environment is depicted in Figure 5.

The current processes for monitoring chronic diseases are based on manual intervention. Patients often record their blood glucose and blood pressure information using hand-written notes or in spreadsheets and the clinical staff look for such data in the patient charts and/or EHR systems that they may have. The software technologies discussed in this section have the ability to automatically integrate data from wireless monitoring with the EHR/PHR infrastructure.

IMPACT OF WIRELESS TECHNOLOGIES ON MEANINGFUL USAGE OF EHRS

In 2010, federal government defined 25 objectives that healthcare providers need to meet to demonstrate the meaningful use of EHRs. If the providers are able to demonstrate meaningful use of EHRs, they stand to gain tens of thousands of dollars in incentives for the adoption of EHRs. Out of the 25 objectives, 15 objectives are deemed core objectives and are outlined below (Federal Register, 2010).

- Use computerized physician order entry (CPOE) for medication orders directly entered by any licensed health care professional who can enter orders into the medical record per state, local and professional guidelines.
- Implement drug/drug and drug/allergy interaction checks.
- Maintain an up-to-date problem list of current and active diagnoses.
- Maintain active medication list.
- Maintain active medication allergy list.
- Record and chart changes in vital signs, including: Height, Weight, Blood pressure, Calculate and display BMI, Plot and display growth charts for children 2-20 years, including BMI.
- Record smoking status for patients 13 years-old or older.
- Provide patients with an electronic copy of their health information (including diagnostic test results, problem list, medication lists, medication allergies) upon request.
- Capability to exchange key clinical information (for example, problem list, medication list, medication allergies, and diagnostic test results), among providers of care and patient authorized entities electronically.
- Protect electronic health information created or maintained by the certified EHR technology through the implementation of appropriate technical capabilities.
- Generate and transmit permissible prescriptions electronically (eRx).
- Record demographics, including: preferred language, gender, race, ethnicity, date of birth.
- Implement one clinical decision support rule relevant to specialty or high clinical priority, along with the ability to track compliance that rule.
- Report ambulatory clinical quality measures to CMS or states.
- Provide clinical summaries for patients for each office visit.

With wireless monitoring for chronic diseases, demonstrating meaningful use becomes much easier for healthcare providers. For example, the objective of implementing clinical decision support and ability to track compliance for diseases like diabetes is easier since the blood glucose readings are automatically obtained and integrated with the EHR systems. The modules that enable export of patient data to PHR systems (see Figure 5) help achieve the objective "Provide patients with an electronic copy of their health information." Recording changes in vital signs such as blood pressure can be achieved by wireless monitoring of blood pressure for hypertensive patients. Thus, acceptance of wireless technologies by patients and healthcare teams accelerate and help healthcare providers to demonstrate the meaningful use of EHRs.

CONCLUDING REMARKS

Two distinct business models can be used for companies to become commercially viable with wireless monitoring of patients with chronic diseases. Companies can provide one or both of the following services: (A) chronic disease data service to patients and (B) chronic disease data service to the clinics. The business models for these two services are briefly described below. The description below assumes a fictitious company by name "ChronicCare" and is limited to patients with diabetes.

(A) *ChronicCare data service to patients:* Patients subscribe to ChronicCare by paying an annual subscription fee. The subscription fee varies depending on the services that the patient chooses (see below). In return, ChronicCare provides the following services to each patient:

- Collect and store patient blood glucose data
- Send blood glucose data for storage in the patient's primary care physician (PCP) clinical EHR system
- Analyze blood glucose data and send messages to patient's (PCP) and other clinical staff
- Enable patients to view and export blood glucose information (over years or months or for any selected period of time) to a preferred format including the patient's personal health records
- Provide services that automatically send all patient blood glucose data to a new clinic when the patient changes PCP

(B) *ChronicCare data service to clinics:* Clinics subscribe to ChronicCare by paying an annual subscription fee that varies based on the patient volume and the services they need. In return, ChronicCare provides the following services to the clinic:

- Integrate the blood glucose data from the clinic's patients with the EHR system
- Enable PCPs and other clinical staff to view the patient blood glucose data and generate myriad reports
- Enable PCPs and clinical staff to send messages seamlessly to patients by wireless means (e.g. clinical staff may enter a plan of action for the patient in the EHR system, which could be automatically sent to the patient's wireless device using ChronicCare services)
- Provide research services to clinics on the effectiveness of drug 1 (e.g. metformin) versus drug 2 (e.g. onglyza) by age group, ethnicity, etc.
- Synchronize the EHR systems with blood glucose readings of new patients

There is an estimated number of 23.6 million diabetes patients in the US (2007 data) and an estimated 57 million patients in the US who are deemed pre-diabetic. A large majority of these patients may be willing to pay a small fee per year to have their blood glucose readings stored with time that they can access anytime and anywhere. An alternative business model is to provide free access to patients to store their blood glucose data, while the main revenue generation occurs via online advertising. Google Health PHR allows patients free access, with the online advertising providing the main source of revenue.

While wireless technologies for monitoring chronic diseases have not been very prevalent, they are expected to increase significantly in the coming years. This paper outlined the technical aspects of wireless monitoring for chronic diseases. It also discussed how data from wireless monitoring can be integrated into the existing EHR/PHR infrastructure. This paper indicated the impact of wireless technologies on the meaningful use of EHRs. In future, discussing the meaningful use criteria in the context of wireless technologies and expanding on the business models for wireless monitoring of chronic diseases are good directions for further research. The rate of adoption of electronic health records is low, especially in the clinics. The wireless healthcare solutions can be used independently of the adoption of electronic health records; however, this would necessitate that the data from wireless monitoring of chronic diseases be stored independently and retrieved on demand by patients.

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