The benefits of wireless enabled applications to facilitate superior healthcare delivery: the case of DiaMonD


DOI: 10.4018/jehmc.2012100102

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The Benefits of Wireless Enabled Applications to Facilitate Superior Healthcare Delivery: The Case of DiaMonD

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ABSTRACT

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. The authors focus on wireless healthcare solutions, specifically examining a single exemplar case study, the diamond solution that describes a pervasive technology solution of a diabetes monitoring device. They contend that a key barrier for preventing the full realization of the true potential of wireless solutions lies in the inability of information and necessary data to pass seamlessly from one platform to another. In addition, the authors 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: Diabetes, E-Health, Electronic Health Records (EHR), Knowledge Management, M-Health, Pervasive Technology

INTRODUCTION

The need for improvement in the delivery of healthcare is paramount. Today, much of the literature pertaining to healthcare continually discusses the many severe challenges such as exponentially increasing costs, pressures to provide appropriate quality and access as well as to incorporate best practice and recent new findings at the point of care. Specifically, healthcare expenditure as a percentage of Gross Domestic Product (GDP) by the 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, with the US having the worst figures (OECD, 2010a, 2010b).

Government agencies and the private sector are alarmed with rising costs, and the decline in quality, access and availability of care, in particular to the underinsured and underserved segments of the population (Geisler & Wickramasinghe, 2009). In addition, we are now witnessing the increased role of chronic diseases as a major contributor to cause of death and morbidity, replacing communicable diseases, and sapping the resources of an already strained health care delivery system (Wickramasinghe et al., 2012).

Without a question there is a clear need for short and long term solutions to this current crisis in the delivery of care. Such a search for a solution has led to the growing focus on technology, especially telemedicine and remote care, as a useful alternative to the prevailing models of inpatient care (Geisler & Wickramasinghe, 2009; Wickramasinghe et al., 2012). The utilization of information and communication technologies (ICT) seems particularly attractive given its allure in the support of- and enablement of a cost-effective model of care to the underserved population of patients with chronic diseases.

Given this in-flux of technology into health-care 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 a specific solution is assimilated and integrated into the context of care so that data and information can pass seamlessly from one platform to another. To illustrate, this paper describes a specific case study of DiaMonD (diabetes monitoring device) and how this ICT provides support for clinics and hospitals to achieve meaningful use with wireless technologies. This paper concludes with business models for revenue generation using wireless monitoring solutions as well as other ICTs in healthcare contexts.

**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.

Today, chronic diseases have replaced infectious diseases as the leading global causes of deaths and morbidity (Centers for Disease Control and Prevention, 2006; Zimmet, 2000; Zuvekas & Cohen, 2007); further non-communicable diseases—such as cardiovascular disorders and strokes, respiratory illnesses such as asthma, arthritis, and diabetes—now account for more deaths, and for a disproportionate burden on healthcare budgets of governments, than infectious diseases such as tuberculosis, HIV/AIDS, and malaria (ibid). This trend is magnified by the demographic realities of this century including the aging of the population and the increased longevity of major segments of the American population which are key contributors to the emerging picture of a crisis in the delivery of health services today; thereby leading to a situation where more patients afflicted by chronic diseases will continue to be a burden on an already drained healthcare delivery system (Windrum, 2008; Wickramasinghe & Geisler, 2008).

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 (Geisler & Wickramasinghe, 2009; Wickramasinghe et al., 2012). 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 manage-
ment 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 (Victorian Government, 2007; AIHW, 2008; Diabetes Australia, 2008; Wild et al., 2004; Australian Diabetes Society, 2002). 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 (Geisler & Wickramasinghe, 2008; Wickramasinghe et al., 2012) thereby making telemedicine and wireless technologies at least partial solutions for this healthcare crisis (Capuano et al., 1995; Tan, 2008). The issue is not whether agencies responsible for healthcare should implement such technologies, but how these agencies should best apply them (Blount et al., 2007; Saxena et al., 2003).

We note that to date technology initiatives in healthcare have had mixed results at best (Wickramasinghe & Goldberg, 2007, 2009; Geisler & Wickramasinghe, 2009). 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 case of DiaMonD (diabetes monitoring device) and the factors that have made this solution sustainable including its delivery framework and business model. As noted by Yin (1994), such an approach is appropriate when trying to identify in an exemplar context key benefits and success factors.

DiaMonD – A PERVASIVE WIRELESS SOLUTION

DiaMonD – diabetes monitoring device – is a pervasive technology solution designed to provide superior healthcare for sufferers of diabetes. The solution incorporates software that facilitates the ubiquitous monitoring of an individual’s blood glucose levels; 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, 2002b, 2002c, 2002d, 2002e) 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 (column 3 of Table 1).

Successful m-health projects require a consideration of many components. In an attempt to realize a value proposition of excellence the INET business model has been designed to provide an integrative model for all key factors that have been identified through research that are necessary in order to achieve m-health excellence (Wickramasinghe & Schaffer, 2010; Goldberg, 2002a, 2002b, 2002c, 2002d, 2002e; Wickramasinghe & Goldberg, 2004). Specifically, the inputs into any mobile e-health project fall into three main categories physical resources, intellectual resources and financial resources. As with all IT projects people, process and technology inputs are vital, however in healthcare the protection (i.e., security aspects), especially in light of HIPAA in the US (and other similar regulations in other countries), is also a key input. As our longitudinal research has revealed (Wickramasinghe & Schaffer, 2010; Goldberg, 2002a, 2002b, 2002c, 2002d, 2002e; Wickramasinghe & Goldberg, 2004) it

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**Table 1. Components of chronic care model (Rachlis, 2006)**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>How Addressed in INET Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization of Health System</td>
<td>• Leadership in chronic disease management (CDM)</td>
<td>• Key inputs from the specific healthcare system are incorporated primarily into the People, Process, Platform and Protection components.</td>
</tr>
<tr>
<td></td>
<td>• Goals for CDM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Improvement strategy for CDM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Incentives and regulations for CDM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Benefits</td>
<td></td>
</tr>
<tr>
<td>Self-management support (SMS)</td>
<td>• Assessment and documentation of needs and activities</td>
<td>• Key inputs from the specific healthcare system are incorporated primarily into the People and Process.</td>
</tr>
<tr>
<td></td>
<td>• Addressing concerns of patients</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Effective behavior change interventions</td>
<td></td>
</tr>
<tr>
<td>Decision Support System (DSS)</td>
<td>• Evidence-based guidelines</td>
<td>• Key inputs from the specific healthcare system are incorporated primarily into the People component.</td>
</tr>
<tr>
<td></td>
<td>• Involvement of specialists in improving primary care</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Providing education for CDM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Informing patients about guidelines</td>
<td></td>
</tr>
<tr>
<td>Delivery System Design (DSD)</td>
<td>• Practice team functioning</td>
<td>• Key inputs from the specific healthcare system are incorporated primarily into the People, Process and Platform components.</td>
</tr>
<tr>
<td></td>
<td>• Practice team leadership</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Appointment system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Follow-up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Planned visits for CDM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Continuity of Care</td>
<td></td>
</tr>
<tr>
<td>Clinical Information Systems (CIS)</td>
<td>• Registry</td>
<td>• Key inputs from the specific healthcare system are incorporated primarily into the People, Process and Platform components.</td>
</tr>
<tr>
<td></td>
<td>• Reminders to providers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Feedback</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Information about relevant subgroups of patients needing services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Patient treatment plans</td>
<td></td>
</tr>
<tr>
<td>Community</td>
<td>• Linkages for patients to resources</td>
<td>• Key inputs from the specific healthcare system are incorporated primarily into the People and Process components.</td>
</tr>
<tr>
<td></td>
<td>• Partnerships with community organizations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Policy and plan development</td>
<td></td>
</tr>
</tbody>
</table>
is best to address these considerations as inputs to the system than after the fact trying to assess compliance; hence people, process, platform and protection from the inputs in Figure 1. It is important to note that these 4 Ps were chosen after discussions with various healthcare professionals in focus studies as to the areas they believed were critical inputs for such a model. Further, these categories are mutually exclusive and collectively exhaustive based on the views of key experts consulted.

Moreover, given the dynamic nature of healthcare, new discoveries are being made continuously. Any mobile e-health project must try to capture these latest findings and apply them to the project, especially in the areas of medical informatics, e-health ICT and business management. It is for this reason that the Wi-INET business model has research findings drawn from medical informatics, e-health, business and information technology areas as inputs to the specific mobile e-health project.

Lastly, in order to sustain the solution the critical success factor is funding. Hence, funding is naturally a critical resource and can come from several sources depending on the specific healthcare system as noted in Figure 1.

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 a specific 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” are important aspects in the delivery framework. Thus, the delivery framework helps to make the solution applicable to any context of diabetic patients which is an essential consideration given that diabetes cuts across all areas of the community.
Therefore the output of this model (Figure 1) is the delivery framework made up of 4 key criteria scope (whether the focus is on type 1, type 2 and/or gestation diabetes), localize (which takes into account the nuances of the specific patient demographics (e.g., age, gender and ethnicity), filed (i.e., the healthcare team make up) and evaluate (i.e., the key evaluation criteria).

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.

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.

Together the components of the model will help in actualizing a 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 & 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; Wickramasinghe et al., 2009 Moghimi et al., 2012) 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 & Goldberg, 2007). Together, they represent a very powerful system for refining the raw data stored in data marts and/or data warehouses, thereby maximiz-
ing 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.

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, 2002b, 2002c, 2002d, 2002e).

To date, directional data has already shown the benefits of this solution in various pilot studies in Canada (Wickramasinghe & Goldberg, 2009). Table 2 presents a summary of results from the pilot study. 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

Figure 2. AMR methodology
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 summarized as follows:

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;

Table 2. Results from Canadian pilot study

<table>
<thead>
<tr>
<th>Patients</th>
<th>Pre-Med</th>
<th>Post-Med</th>
<th>Change in HA1C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.098</td>
<td>0.071</td>
<td>-0.027</td>
</tr>
<tr>
<td>2</td>
<td>0.129</td>
<td>0.108</td>
<td>-0.021</td>
</tr>
<tr>
<td>3</td>
<td>0.155</td>
<td>0.090</td>
<td>-0.065</td>
</tr>
<tr>
<td>4</td>
<td>0.122</td>
<td>0.086</td>
<td>-0.036</td>
</tr>
<tr>
<td>5</td>
<td>0.112</td>
<td>0.071</td>
<td>-0.041</td>
</tr>
<tr>
<td>6</td>
<td>0.263</td>
<td>0.206</td>
<td>-0.057</td>
</tr>
<tr>
<td>7</td>
<td>0.068</td>
<td>0.049</td>
<td>-0.019</td>
</tr>
<tr>
<td>8</td>
<td>0.132</td>
<td>0.052</td>
<td>-0.080</td>
</tr>
<tr>
<td>9</td>
<td>0.082</td>
<td>0.079</td>
<td>-0.003</td>
</tr>
<tr>
<td>10</td>
<td>0.117</td>
<td>0.075</td>
<td>-0.042</td>
</tr>
<tr>
<td>11</td>
<td>0.077</td>
<td>0.029</td>
<td>-0.048</td>
</tr>
<tr>
<td>12</td>
<td>0.073</td>
<td>0.071</td>
<td>-0.002</td>
</tr>
<tr>
<td>13</td>
<td>0.097</td>
<td>0.086</td>
<td>-0.011</td>
</tr>
<tr>
<td>14</td>
<td>0.078</td>
<td>0.077</td>
<td>-0.001</td>
</tr>
<tr>
<td>15</td>
<td>0.089</td>
<td>0.072</td>
<td>-0.017</td>
</tr>
<tr>
<td>16</td>
<td>0.188</td>
<td>0.174</td>
<td>-0.014</td>
</tr>
<tr>
<td>17</td>
<td>0.268</td>
<td>0.195</td>
<td>-0.073</td>
</tr>
<tr>
<td>18</td>
<td>0.281</td>
<td>0.297</td>
<td>+0.016</td>
</tr>
<tr>
<td>19</td>
<td>0.088</td>
<td>0.094</td>
<td>+0.006</td>
</tr>
</tbody>
</table>

This study shows that of the 20 patients; Patient 4 had a slight increase in blood sugar readings. Patient 14 had no change.

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the future course of patient management and self-care is built on the current readings and medical advice.

**INTEGRATION OF WIRELESS MONITORING WITH EXISTING ELECTRONIC HEALTH RECORDS (EHR)**

The 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 and Microsoft HealthVault are examples of 3rd party PHR systems that allow patients to upload their medical data from selected clinics into an online repository.

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).

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 (Wickramasinghe et al., 2012). 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 thou-

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*Figure 5. The logical design of the relationship between the proposed software modules and the PHR, EHR systems*
sands 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).

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 (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.

**Facilitators to Implementation**

Returning to the exponentially increase trends for chronic disease and more specifically diabetes, it is important to understand the key facilitators to implementation. We believe that as government leaders in the healthcare sector ponder the implementation of ICT for the care of patients with chronic diseases, the following factors may facilitate such implementations on a large scale such as DiaMonD.

The first factor that may facilitate implementation is positive previous experience with telemetrics and tele-monitoring in other industries. Telemetry has been successfully applied in the financial sector (e.g., electronic banking) and in transportation (e.g., GPS instruments for worldwide positioning). Technologies that entail wireless transmission of data are at the core of very useful systems in various economic sectors. This successful experience may serve to boost confidence in telemedicine, even when accounting for the legal, ethical, and human constraints of health information systems (Helal et al., 2008).

The second facilitating factor is the ever-ubiquitous use of cellular telephones by all socio-economic segments and age groups of society. This phenomenon clearly facilitates any application of medical care based on cellular technology. Health leaders need not be concerned with how patients will adopt or be exposed to such applications, because chances are high that they are already users of cellular telephones—regardless of their income, demographics, and/or social status.

Moreover, the ubiquitous use of cellular telephones by all segments of the population substantially reduces the need for specialized training in the use of smart phones. There is also the benefit of a low level of resistance (if any) to the use of smart phones in healthcare delivery to disadvantaged patients; in fact one need go no further than examine the penetration rates and adoption of iPhones globally as well as the numerous Apps that continually come to market for these devices.

The acceptance of cellular technology and smart phones also extends to providers. Caregivers will be much more likely to use medical applications of wireless technology when they are well cognizant of the fact that their patients are well acquainted with such technology and can readily adopt wireless applications of medical care.

A third facilitating factor is the relatively low cost of set up and maintenance of such wireless systems. For the purpose of remote home care of chronic diseases, presently the technology requires the installation of a base at the hospital or clinic. Cellular telephones would need to be equipped with the software needed for the processing of clinical data from the patient.

The fourth facilitator is the relatively low level of intrusion of care, at least in the early stages of evolution of the wireless technology. By using cellular telephones to monitor clinical indicators of chronic diseases, caregivers are
able to obtain critical data without resorting to visits to the hospital, multiple and perhaps unnecessary encounters, as well as sessions in which patients are questioned about their medical conditions. Much of the clinical information of interest to caregivers is already on file electronically in the base station at the hospital. Blevins (2008), for example, has written in The Christian Science Monitor that HIPAA permits healthcare providers to widely share clinical information about a patient without prior consent. By strengthening privacy laws, the use of cellular telephones will be enhanced. As clinical data flows from smart phones to the base station at the hospital, there is no further need to share such data with other entities that are not directly connected with the treatment and management of the chronic disease.

Furthermore, the current technology allows the base station at the hospital to translate individual patient data into an aggregate form of data about a given chronic disease and a category of patients—rather than sharing raw data of individual patients. This advantage of the system also allows another adherence to strict HIPAA regulations. The cellular telephones can be equipped with an electronic mechanism that codifies patient identity when transmitting data to the base unit at the hospital. Even when produced at the factory, the necessary software will allow the base unit to decipher the codified identification of individual patients. In this case, HIPAA regulations are a facilitator to cellular technology rather than a barrier.

The fifth facilitator is the support already in place, and the support we advocate and recommend in this report from government agencies in the healthcare sector: regulators, legislators, and payers. Government health leaders in agencies within the Department of Health and Human Services (Centers for Medicare & Medicaid Services, the National Institutes of Health, the Department of Health and Human Services, the Food and Drug Administration, and the Centers for Disease Control and Prevention) and the Department of Veterans Affairs will be particularly interested in wireless technology for the care of chronic diseases among the over 40 million Americans who are uninsured or underinsured. The more the leaders know about the benefits from this technology, the more they will support its wide implementation throughout the healthcare delivery system.

Thus, as the benefits to patients and the greater social good from wireless technology become more visible, legislators can help by codifying those variables that can further support widespread applications of telemedicine. There may not be a need for targeted legislation, but there may be a need to tailor state and federal regulations to a more viable environment for the implementation of telemedicine and wireless technology for the underserved.

**DISCUSSION AND CONCLUSION**

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. 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;

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. The model used by Google Health PHR allows

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**Figure 6. Impact of 1% sustained decrease in HAIC on co-morbidities**

![UKPDS: decreased risk of diabetes-related complications associated with a 1% decrease in AIC](image)

**Observational analysis from UKPDS study data**

- **UKPDS:** decreased risk of diabetes-related complications associated with a 1% decrease in AIC

- **Peripheral vascular disease:** 43%
- **Microvascular disease:** 37%
- **Cataract extraction:** 19%

*Lower extremity amputation or fatal peripheral vascular disease, *P* < 0.001*
patients free access, with the online advertising provides 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 key aspects of wireless monitoring for chronic diseases. It also discussed how data from wireless monitoring can be integrated into the existing EHR/PHR infrastructure. Figure 6 shows the findings from a study conducted in the UK which serves to highlight the benefit of just a 1% sustained decrease in blood glucose levels and the consequent decrease to key, unpleasant and costly co-morbidities of diabetes. These findings provide compelling support indeed for the adoption of pervasive technology solutions such as DiaMonD.

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 health 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. We are convinced that wireless holds the key to superior healthcare delivery of the future and close by calling for more research in this vital area.

ACKNOWLEDGMENT

An earlier version of this paper was presented at the 2011 AMCIS (Americas Conference on Information Systems) in Detroit, Michigan Aug 4th –7th 2011.

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