THE ADVANTAGES OF MOBILE SOLUTIONS FOR CHRONIC DISEASE MANAGEMENT

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Abstract

In an environment of escalating healthcare costs, chronic disease management is particularly challenging, since, by definition such diseases have no foreseeable cure and if poorly managed typically lead to further, complicated secondary health issues, which ultimately only serve to exacerbate cost. Diabetes is one of the leading chronic diseases and its prevalence continues to rise exponentially. Thus it behooves all to focus on solutions that can result in superior management of this disease. Hence, the following presents findings from a longitudinal exploratory case study that examined the application of a pervasive technology solution; a mobile phone, to provide superior diabetes self-care. The conclusions highlight the benefits of a pervasive technology solution for supporting superior self-care in the context of chronic disease. Moreover, it is proffered that by employing the theories of Actor Network and Social Network Analysis the full benefits of this technology enabled solution can be identified.

Keywords: pervasive wireless solution, chronic disease, healthcare, actor network theory, social network analysis
1 INTRODUCTION

Healthcare delivery for all OECD countries is experiencing exponentially increasing costs (OECDabc). This is of great concern to all and many believe IS/IT offers the promise of cost effective healthcare delivery (Geisler and Wickramasinghe, 2009). One area that appears to be particular problematic in this regard is connected with chronic diseases, such as diabetes and hypertension, not only because they consume a disproportionate slice of healthcare services but also because there is no foreseeable cure and hence these cost pressures will continue for the life of the patient. Moreover, they are likely to increase, because if the chronic disease is poorly managed secondary complications will inevitably develop (Wickramasinghe and Goldberg, 2003).

Diabetes is one of the five major chronic diseases. It afflicts over twenty million people in the United States and accounts for almost $100 billion in medical costs (Geisler and Wickramasinghe, 2009). Diabetes is also one of the leading chronic diseases affecting Australians and its prevalence continues to rise. The total number of diabetes patients worldwide is estimated to rise to 366 million in 2030 from 171 million in 2000 (Wild et al., 2004). With increasingly growing prevalence which includes an estimated 275 Australians developing diabetes daily (DiabetesAustralia, 2008). Given these alarming trends not only in Australia and the United States but worldwide Diabetes has been termed as the silent epidemic by the WHO. Table 1 shows the increases for diabetes in various regions throughout the world.

<table>
<thead>
<tr>
<th>Region</th>
<th>2010 (millions)</th>
<th>2030 (millions)</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>33.9</td>
<td>53.2</td>
<td>42%</td>
</tr>
<tr>
<td>South America</td>
<td>18</td>
<td>29.6</td>
<td>65%</td>
</tr>
<tr>
<td>Africa</td>
<td>12.1</td>
<td>23.9</td>
<td>98%</td>
</tr>
<tr>
<td>Europe</td>
<td>55.2</td>
<td>66.2</td>
<td>20%</td>
</tr>
<tr>
<td>Middle East</td>
<td>26</td>
<td>51.5</td>
<td>94%</td>
</tr>
<tr>
<td>S.E Asia</td>
<td>58.7</td>
<td>101.0</td>
<td>72%</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td><strong>284.6</strong></td>
<td><strong>438.4</strong></td>
<td><strong>54%</strong></td>
</tr>
</tbody>
</table>


Table 1. Prevalence of Diabetes throughout the World

Given that technology may play a role in contributing to a more efficient and effective delivery of care that may also assist in controlling costs, the following examines the possible potential use of wireless technology in the monitoring of diabetic patients. Specifically, this paper provides insights from a longitudinal exploratory case study that investigated the major research question “how can technology support superior self-care for sufferers of chronic disease”? To understand the role for technology it is first necessary to understand critical issues regarding diabetes self-care.

2 DIABETES SELF-CARE

Diabetes is a chronic disease that occurs when there is too much glucose in the blood because the body is not producing insulin or not using insulin properly (DA, 2007).
Diabetes management involves a combination of both medical and non-medical approaches with the overall goal for the patient to enjoy a life which is as normal as possible (AIHW, 2008; AIHW, 2007). Critical to this management regimen is the systematic monitoring of blood sugar levels. However, as there is no cure for diabetes, achieving this goal can be challenging because it requires effective lifestyle management and careful and meticulous attention and monitoring by the patient and health professionals (Britt, 2007). In particular, to be totally successful, this requires patients to be both informed and actively participate in their treatment regimen.

2.1 The Role for Technology to Facilitate Superior Chronic Disease Management

Simply stated, the research goal was to design and develop a mobile Internet (wireless) environment to improve patient outcomes with immediate access to patient data and provide the best available clinical evidence at the point of care. To do this, INET International Inc’s research (Goldberg, 2002a–e; Wickramasinghe and Goldberg, 2003, 2004) started with a 30-day e-business acceleration assessment in collaboration with many key actors in hospitals (such as clinicians, medical units, administration, and I.T. departments). From this it was possible to design a robust and rigorous web-based business model, the INET web-based business model (figure 1). The business model brings together all the vital considerations and in turn provides the necessary components to enable the delivery framework to be positioned in the best possible manner so it can indeed facilitate and support superior chronic disease management. From this business model then the INET mobile solution was developed.

Figure 1. INET-web-based-business model
(adapted from Wickramasinghe and Goldberg, 2004)
Thus, the INET Solution represents a pervasive technology enabled solution, which, while not exorbitantly expensive, can facilitate the superior monitoring of diabetes. The proposed solution (Figure 2) 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 this approach are outlined below (and depicted in Figure 2).

![Image](image_url)

**Figure 2. The Wireless Enabled Solution for Diabetes Self-care**
(Reproduced with the permission of INET)

Each patient receives a blood glucose measurement unit.
1. Patient conducts the blood glucose test and enters the blood glucose information into a hand-held wireless device.
2. 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.
3. The patient’s blood glucose data is then stored/integrated with the clinic’s electronic medical record (EMR) system.
4. An alert is generated for the clinical staff with the patient’s blood glucose information.
5. The blood glucose information of the patient is reviewed by the clinical staff (physician/nurse).
6. 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.

At face value this solution appears simple and trivial; however to fully understand the full and far reaching benefits of employing wireless technology solutions in this context it is necessary to view the solution through a combined lens of Social Network analysis and Actor Network Theory as is presented in the following sections.

3 SOCIAL NETWORK ANALYSIS (SNA)

Social network analysis (SNA) has now emerged as a modern technique to facilitate the systematic study of behaviour and trends of groups of people or communities (Wasserman and Faust, 1994). More recently, the major focus tends to be around communities and their use of technologies (Niessen 2007). Succinctly, SNA is a technique that facilitates the mapping and measuring of relationships and flows between people, groups, organizations and systems as well as all information/knowledge processing organizations and thereby enhances metacognition with respect to the representation of organizational knowledge in networks (Wasserman and Faust, 1994; Niessen 2007). People and groups are represented as nodes while the relationships or flows are represented by links. Taken together, this analysis of nodes and links builds the network under consideration. The location of actors in such a network is critical to a deeper understanding of the network as a whole and the participation of individual actors. Location is measured by finding the centrality of the node.

In terms of centrality, three considerations become important in any SNA; degree of centrality – in other words how many people connect with you, betweenness – or whether or not you are located between 2 key actors in the network and thus may play a “broker” role, and closeness – or one’s position relative to others (especially key players) in the network. In addition, it is important to note if there exist boundary spanners - actors who bridge or overlap into different networks, or peripheral players. Such actors may be perceived as unimportant but in reality they play key roles.

To illustrate the value for SNA in the context of supporting diabetes self-care let us return to figure 1. What becomes of crucial importance in supporting diabetes self-care is the distance or centrality of key actors since the key actors are the important decision makers and in such a context rapid prudent decision-making can facilitate prudent care options. Clearly then, the understanding of who/where the boundary spanners are as well as the betweenness and closeness constructs are key in designing a superior network that will enable at all times appropriate and speedy decision-making to ensue. It is also useful to note that SNA can be used in post facto analysis to facilitate necessary lessons learnt that can be applied to the future state. Thus the incorporation of SNA into the continuous design and development of the diabetes self-care model is going to facilitate the
realization of a well structured network that will indeed support all the complex and
dynamic operations in healthcare.

4 ACTOR NETWORK THEORY

Actor Network Theory (ANT) provides a rich and dynamic lens of analysis. Essentially,
it embraces the idea of an organizational identity and assumes that organizations, much
like humans, possess and exhibit specific traits (Brown, 1997). Although labeled a
"theory", ANT is more of a framework based upon the principle of generalized
symmetry, which rules that human and non-human objects/subjects are treated with the
same vocabulary. Both the human and non-human counterparts are integrated into the
same conceptual framework.

ANT was developed by British sociologist, John Law and two French social sciences and
technology scholars Bruno Latour and Michel Callon (Latour, 1987, 2005; Law and
Hassard, 1999; Law, 1992, 1987; Callon, 1986). It is an interdisciplinary approach that
tries to facilitate an understanding of the role of technology in specific settings, including
how technology might facilitate, mediate or even negatively impact organizational
activities and tasks performed. Hence, ANT is a material-semiotic approach for
describing the ordering of scientific, technological, social, and organizational processes
or events.

4.1 Concepts of Actor Network Theory
Table 2 (on the next page below) presents the key concepts of ANT and their relevance to
the diabetes self-care model.

5 THE S’ANT APPROACH TO RESEARCHING THE
DIABETES SELF-CARE MODEL

Recognising the benefits of both social network analysis and actor network theory to
studies pertaining to technology especially in a healthcare setting, Wickramasinghe and
Bali (2009) coined the term S’ANT approach. The S’ANT approach (Wickramasinghe
and Bali, 2009) essentially is a hybrid approach that combines the respective strengths of
SNA and ANT in order to facilitate the realization of superior diabetes self-care. Such an
approach requires the identification and tracing of specific healthcare events and
networks to “follow the actors” (Latour, 1996) and investigate all the relevant leads each
new actor suggests. The first step is thus to identify these actors (or actants),
remembering that an actor is someone or something that can make its presence
individually felt and can make a difference to the situation under investigation. Thus, in
healthcare contexts the actors would include: medical practitioners, nurses, medical
instruments, healthcare organizations, regulators, patients, equipment suppliers, medical
administrators, administrative computer systems, medical researchers, and so on. In a
particular operation (or event) it is important to identify all relevant actors before
proceeding further.
<table>
<thead>
<tr>
<th>Concept</th>
<th>Relevance to Diabetes self-care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actor/Actant: Typically actors are the participants in the network which include both the human and non-human objects and/or subjects. However, in order to avoid the strong bias towards human interpretation of Actor, the neologism ACTANT is commonly used to refer to both human and non-human actors. Examples include humans, electronic instruments, technical artifacts, or graphical representations.</td>
<td>In the diabetes self-care model this includes the web of healthcare players such as providers, healthcare organizations, regulators, payers, suppliers and the patient as well as the clinical, wireless and administrative technologies that support and facilitate healthcare delivery.</td>
</tr>
<tr>
<td>Heterogeneous Network: is a network of aligned interests formed by the actors. This is a network of materially heterogeneous actors that is achieved by a great deal of work that both shapes those various social and non-social elements, and “disciplines” them so that they work together, instead of “making off on their own” (Latour, 2005).</td>
<td>The wireless technology combined with the specific application is clearly the technology network in this context. However it is important to conceptualize the heterogeneous network not as the technology alone but as the aligning of the actors through the various interactions with the technology so that it is possible to represent all interests and thereby provide the patient with superior healthcare delivery. The key is to carefully align goals so that healthcare delivery is truly patient centric at all times.</td>
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<tr>
<td>Tokens/Quasi Objects: are essentially the success outcomes or functioning of the Actors which are passed onto the other actors within the network. As the token is increasingly transmitted or passed through the network, it becomes increasingly punctualized and also increasingly reified. When the token is decreasingly transmitted, or when an actor fails to transmit the token (e.g., the broadband connection breaks), punctualization and reification are decreased as well.</td>
<td>In the diabetes self-care model this translates to successful healthcare delivery, such as treating a patient in a remote location by having the capability to access critical information to enable the correct decisions to be made. Conversely, and importantly, if incorrect information is passed throughout the network errors will multiply and propagate quickly hence it is a critical success factor that the integrity of the network is maintained at all times.</td>
</tr>
<tr>
<td>Punctualization: is similar to the concept of abstraction in Object Oriented Programming. A combination of actors can together be viewed as one single actor. These sub actors are hidden from the normal view. This concept is referred to as Punctualization. An incorrect or failure of passage of a token to an actor will result in the breakdown of a network. When the network breaks down, it results in breakdown of punctualization and the view will now be able to view the sub actors of the actor. This concept is often referred to as depunctualization.</td>
<td>For example, an automobile is often referred to as n unit. Only when it breaks down, is it seen as a combination of several machine parts. Or in the diabetes self-care model the uploading task of one key actor, be it a provider or a patient is in reality a consequence of the interaction and co-ordination of several sub-tasks. This only becomes visible when a breakdown at this point occurs and special attention is given to analyse why and how the problem resulted and hence all sub tasks must be examined carefully.</td>
</tr>
<tr>
<td>Obligatory Passage Point (OOP): broadly refers to a situation that has to occur in order for all the actors to satisfy the interests that have been attributed to them by the focal actor. The focal actor defines the OPP through which the other actors must pass through and by which the focal actor becomes indispensable (Callon, 1986).</td>
<td>In the diabetes self-care model we can illustrate this by examining the occurrence of the diabetes or secondary complications that have resulted because of the primary disease. Such incidents form the catalyst for developing shared goals and united focus of effort so necessary to effect superior healthcare delivery.</td>
</tr>
<tr>
<td>Irreversibility: Callon (1986) states that the degree of irreversibility depends on (i) the extent to which it is subsequently impossible to go back to a point where that translation was only amongst others and (ii) the extent to which it shapes and determines subsequent translations.</td>
<td>Given the very complex nature of healthcare operations (von Lubitz and Wickramasinghe, 2006b-e) irreversibility is generally not likely to occur. However it is vital that chains of events are continuously analyzed in order that future events can be addressed as effectively and efficiently as possible.</td>
</tr>
</tbody>
</table>

Table 2. Key Concepts of ANT

The next step is to „interview” the actors. With human actors this is, of course, quite straightforward, but with non-humans it is necessary to find someone (or something) to speak on their behalf. For an item of medical technology this might be its designer or
user, or it might just be the instruction manual. The aim of this step is to see how these actors relate to each other and the associations they create – to identify how they interact, how they negotiate, and how they form alliances and networks with each other. These „heterogeneous networks” consists of the aligned interests held by each of the actors.

Human actors, such as medical practitioners, can „negotiate“ with non-human actors such as X-Ray or dialysis machines by seeing what these machines can do for them, how easy they are to use, what they cost to use, and how flexible they are in performing the tasks required. If negotiations are successfully completed then an association between the medical practitioner and the machine is created and the machine is used to advantage – the network has become durable. If the negotiations are unsuccessful then the machine is either not used at all, or not used to full advantage.

Once this is developed it is then important to apply the techniques of SNA to map the flows of pertinent information and germane knowledge throughout this network and thereby not only enhancing the metacognition of the system but also the ability to rapidly extract and utilize the critical knowledge to support prudent decision making. In this way it will be possible to be at all times in a state of being prepared and ready (Wickramasinghe and von Lubitz, 2007; von Lubitz and Wickramasinghe, 2006 a;f)

The main advantage of the S’ANT approach in considering the diabetes self-care model is in being able to identify and explore the real complexity involved. Other approaches to technological innovation, Innovation Diffusion for example, put much stress on the properties of the technology or organization themselves, at the expense of looking at how these interact. Unfortunately in doing this they often tend to oversimplify very complex situations and so miss out on a real understanding. The ANT approach of investigating networks and associations provides a useful means to identify and explain these complexities as well as to track germane knowledge and pertinent information. This is paramount if the doctrine of network-centric healthcare is to be successfully realized.

Borrowing ideas from innovation translation in actor-network theory (LAtour, 1996; 1986; 1999; Law, 1991) we will argue that, rather than just the technology, people are very important, as they may either accept an innovation in its present form, modify it to a form where it becomes acceptable, or reject it completely. “If we know one thing about innovation and reform, it is that it cannot be done successfully to others” (Fullan, 1991 pp xiv). An innovation translation approach has been shown to be useful in considering ICT (information and communications technology) innovation in small business (Tatnall and Davey, 2002) and in education (Tatnall,2000; Tatnall and Davey, 2001; Bigum, 1998; Busch, 1997).

The innovation translation approach to innovation originates in actor-network theory (ANT) and draws on its sociology of translations. In ANT, translation (Law, 1992) can be defined as: “... the means by which one entity gives a role to others” (Singleton and Michael, 1993 pp. 229). Using an innovation translation approach to consider how the adoption of web-based mobile learning occurs, it is necessary to examine the interactions of all the actors involved (Tatnall and Davey, 2003b).
6  DISCUSSION

The longitudinal exploratory case study that we embarked upon started with an examination of the technology solution to facilitate communication of blood sugars between patient and provider, to an assessment of the delivery framework and business model developed by INET to an analysis of the data from trials and pilot studies conducted. Based on rigorous thematic analysis of interview data, gathered following the techniques prescribed by Yin (1994), Kavale (1996) and Boyatis (1998), triangulated with data from internal documents, reports and medical records as well as our own observations not only was proof of concept attained; ie using the pervasive technology solution did facilitate better self-care and resulted in a decrease in blood sugar, but all patients in the study reported only positive comments about the solution as the following quote highlights:

“I loved the solution. It was like an answer to a pray. I could control my sugars more easily and have confidence and peace of mind to enjoy my life.”

This serves to underscore the benefits of such an approach.

In the current context, healthcare delivery, especially in the US, is in need of fundamental re-design (Porter and Tiesberg, 2006). The focus on cost containment also necessitates a shift to prevention rather than cure. This is particularly important in the case of chronic diseases such as diabetes; thereby making any solution that has the potential to enable cost effective quality care a strategic necessity.

Diabetes is the fifth-deadliest disease in the United States. Since 1987, the death rate due to diabetes has increased by 45 percent, while the death rates due to heart disease, stroke, and cancer have declined. The total annual economic cost of diabetes in 2002 was estimated to be $132 billion. Direct medical expenditures totaled $92 billion and comprised $23.2 billion for diabetes care, $24.6 billion for chronic diabetes-related complications, and $44.1 billion for excess prevalence of general medical conditions. Indirect costs resulting from lost workdays, restricted activity days, mortality, and permanent disability due to diabetes totaled $40.8 billion. The per capita annual costs of health care for people with diabetes rose from $10,071 in 1997 to $13,243 in 2002, an increase of more than 30%. Further, in 2010 only the total cost of diabetes was $174 billion with approximately $116 billion direct medical costs and at least $58 billion in indirect costs (Wickramasinghe, 2010).

Without a doubt the costs in the United States are alarming, however it should also be noted that evidence also shows that diabetes and its complications incur significant costs for the health system in Australia. These costs include costs incurred by carers, government, and the entire health system (DiabCostAustralia, 2002). For instance, in 2004-05 direct healthcare expenditure on diabetes was A$907 million which constituted approximately 2% of the allocatable recurrent health expenditure in that year (AIHW, 2008). In addition, further costs include societal costs that represent productivity losses for both patients and their carers (DiabCostAustralia, 2002).
7 CONCLUSIONS
Technological developments in ubiquitous and mobile computing offer possibilities to many aspects of healthcare and, due to their non-reliance on traditional communications infrastructure, they offer emerging countries an opportunity to jump ahead. Exactly how these technologies should best be used in diabetes treatment, however, is not completely clear at this time (Morel et al., 2005).

There has been a considerable amount of research into the impact and use of technology in healthcare delivery, but not much into explaining the uptake of this technology. We have argued that for research of this type, it is useful to consider this technology in terms of technological innovation and to make use of an approach based on innovation theory. Actor-Network Theory provides a perspective that can resolve the dilemma of how to handle both the human and non-human contributions to technological innovation, and provides a useful explanatory system for doing so (Tatnall, 2009).

In the specific case of diabetes discussed in the proceeding, clearly stemming the cost pressure is important but of greater importance is providing sufferers of diabetes with a possibility to experience a better quality of life. When it is possible to provide both a low cost as well as a superior patient-centric solution this would appear to be a very compelling case for the large scale adoption of pervasive wireless solutions to facilitate superior care not only for diabetes but for all chronic diseases. Our analysis of this solution drawing upon both Actor Network Theory and Social Network Analysis demonstrate that there are very important aspects that are being addressed by adopting a pervasive wireless solution and these need further investigation. We close by not only calling for more research which particularly focuses on how to move from idea to realization as rapidly as possible but also for further exploration into the incorporation of pervasive technology solutions in general for supporting superior patient-centric healthcare delivery.

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