Sultan, Salys, and Permanand Mohan. "Experiences from the MediNet Project: The programmer's perspective." *mHealth in Practice: Mobile technology for health promotion in the developing world*. Ed. Jonathan Donner and Patricia Mechael. London: Bloomsbury Academic, 2013. 119–134. *Bloomsbury Collections*. Web. 26 Apr. 2023. <<http://dx.doi.org/10.5040/9781780932798.ch-009>>.

Downloaded from Bloomsbury Collections, www.bloomsburycollections.com, 26 April 2023, 02:12 UTC.

Copyright © Jonathan Donner and Patricia Mechael 2013. You may share this work for non-commercial purposes only, provided you give attribution to the copyright holder and the publisher, and provide a link to the Creative Commons licence.

9 Experiences from the MediNet Project

The programmer's perspective

Salys Sultan and Permanand Mohan, University of West Indies, Trinidad and Tobago

Project summary

The MediNet Project (Mohan and Sultan, 2009) started back in 2007 as a response to a Microsoft External Research Request for Proposals (Microsoft, 2007). The theme was 'Cell phone as a Platform for Health Care'. The main objective of the project was to develop a Caribbean-wide healthcare management system that would pool the healthcare resources of the Caribbean Islands. The core technology proposed for the design of this integrated system was the mobile phone. In the Caribbean region, mobile ownership surpasses computer ownership and landline service (Galperin and Mariscal, 2007). This is primarily due to the lower cost associated with acquiring the devices and the fact that the introduction of wireless telecommunication has made it possible to reach areas that were previously disconnected.

The first phase of the project was the design and development of a *remote patient monitoring system* for Trinidad and Tobago. For this pilot study, the diseases initially targeted were diabetes and cardiovascular disease, two diseases with a high prevalence in the region, but the system was designed to scale to meet the needs of other chronic diseases such as asthma and cancer.

The MediNet architecture is broken down into three main components: the patient interface, a collection of healthcare web services, and the healthcare provider interface. The patient interface comprises a mobile phone and the patients' physiological meters (glucometer and blood pressure meter). The patients use their mobile phone to record their health data. Recordings include their blood sugar reading, their blood pressure reading, their food intake, and daily exercise. The readings from the physiological meters are automatically transferred to the phone using Bluetooth technology. The mobile phone has a software application called 'My Daily Record' that acts as an electronic diary for the recording of the patient's

health data. The application allows the patient to enter the readings, view past readings, and enter information regarding their caloric intake and the amount of time spent exercising. The application has a *view tip* feature that allows the patient to receive feedback on the most recent recordings made. This type of feedback is personalized, because it is tailored to the individual patient's current status as opposed to a *one-size-fits-all* approach.

The next component of the MediNet system is a collection of healthcare web services. This component is the mechanism that orchestrates the receipt of data (recordings) from the distributed mobile phone units, as well as delivery of data (feedback to patients, reminders to patients, and alerts to healthcare providers) to the devices. The data transfer takes place using GPRS over a GSM network. These web services are made available through a remote server. This server acts as a central repository for the patient healthcare data. A subset of this data is also stored on the mobile device so that the patients can access their data even without reception. Data on the phone and on the server are encrypted, and a protocol was designed to ensure the integrity of data when it is received at the destination point.

The healthcare provider's interface acts as a portal to the patients' healthcare data. The healthcare provider can monitor their patients' health status remotely and provide feedback when exceptional cases occur. In these cases, alerts are sent to the healthcare provider's mobile phone. The portal provides different views on the patients' data set. The current implementation of the portal takes the form of a website which a doctor or caregiver can access using a computer.

How we got started

The MediNet project (short for Medical Networks) came out of a request for proposals from Microsoft External Research. The theme for that year was the use of cellphones as a platform for healthcare. The call sought 'to incubate creative and novel healthcare solutions that are accessible, affordable, and relevant for "smart" mobile phones. An additional focus was the creation of appropriate services, systems, and infrastructures to provide solutions to the global healthcare community' (Microsoft, 2007). Kristin Tolle, the director of program management at Microsoft External Research, was our main point of contact and overseer for our project.

This was our first experience with a mobile health initiative. To kick-off the project, a group of researchers at the University of the West Indies, including myself, brainstormed on the different ways that the cellphone could be used to provide healthcare services. The main issue that arose was the challenges faced in the Caribbean region when it came to the management of chronic noncommunicable

diseases (CNCDs) – one of the main causes of deaths (Douglas 2007). From the beginning, we decided to keep the focus on two diseases – diabetes and cardiovascular disease, but always keeping in mind how the system would be able to scale to support other diseases.

In his book, *Development as Freedom*, Amartya Sen warns of the tendency to identify human capacities with human capital. Human capital considerations focus on the human capacity to augment production possibilities. In contrast, Sen advocates that human capacities should focus on the ability (or substantive freedom) of people ‘... to lead the lives they have reason to value and to enhance the real choices they have’ (Sen, 1999). A range of freedoms is then presented as the foundation of the Good Life; these freedoms are the means by which wealth is generated or the ends which become a more effective means to economic ends. It should be noted that diabetes and other CNCDs are lifestyle diseases and control can be achieved through behavior modification. Taking Sen’s line of reasoning, a substantive freedom of diabetics and persons suffering from CNCDs is to take better care of themselves causing them to lead the lives they have reason to value. This freedom will ultimately result in more productive lives and less impact on the economy. Clearly then, tackling diabetes and other CNCDs through behavior modification can play a significant role in developing countries (Sen, 1999).

Our vision took into account this notion of freedom. We saw the patient’s mobile phone as a tool to collect medical data within the patient’s home or work environment, and allow the patient to make more informed decisions regarding his health. Each patient’s medical history would then be stored electronically and compared to the data originating from the patient’s cellular phone. Based on the data collected, the system would recommend a certain course of action to be taken by the patient or may notify other agencies, depending on the severity of the case. This would result in better diagnosis, prevention, and routine health management. By implementing the system across the Caribbean region, a distributed system would be obtained where most of the knowledge concerning diseases can be shared among countries. It was noted that most of the healthcare services that may be available to a patient are likely to be in the same country, so it would be necessary to create countrywide networks (called MediNets) that would connect to the overall healthcare management system. The originally proposed architecture of each MediNet is shown in Figure 9.1. It focused primarily on cardiovascular disease and diabetes but can be extended to other medical diseases in later phases.

This vision came from the fact that there was a need to increase the availability of healthcare services in the Caribbean region and the mobile phone was seen as a platform with the potential for great impact. Mobile phones are widespread in the Caribbean with some people even owning two. We were proposing that the mobile

Figure 9.1 Architecture of proposed MediNet

phone act as an ‘electronic log’ to mirror the daily recording process that was required by diabetics. The connectivity offered by the device afforded the exchange of health data, so once the phone was connected to a telecommunications network, data captured and stored locally could be transmitted to remote areas such as the healthcare provider’s location. This was seen as 1) increasing the reach of the services offered and 2) allowing shifting the management of the disease from the healthcare provider to the patient.

The project team was mostly composed of students, researchers, and lecturers in the Department of Computing and Information Technology at the University of the West Indies, St Augustine campus, Trinidad and Tobago. Each member was assigned a role. Dr Permanand Mohan was the principal investigator, and Salys Sultan was the project manager and lead system developer. There were five software engineers, Dylan Marin, Adil Sheikh, Kris Manohar, Phaedra Mohammed and Akash Harriram. Since we were all computer scientists, we brought onboard Dr Ahad Deen, a medical doctor who worked with diabetic patients. The first task that we addressed was getting a better understanding of the current healthcare problem and challenges faced by both doctors and patients – two of the primary users of the system.

Our investigations

One of the main challenges faced by the Caribbean population was that of accessibility to healthcare services (Fraser, 2001). Presently, patients only see their healthcare provider, once or twice in a year and diabetes-related information is not as readily available. Patients also kept poor records of their health status, so consultations with their doctor were left to memory recollection. Another major challenge was cost, that is, costs associated with the care of diabetes and its related complications. We saw prevention as the key to minimizing these costs. Given our technical background, there was a need to investigate further the leading causal agents for these challenges.

We followed a user-centered design methodology (Norman, 1988). This methodology was selected given the fact that mHealth on a whole was new to the Caribbean region and the target user group would not be familiar with *what to expect* from it. We believed once we got the users of the system involved from the early stages and throughout the system design, there was a higher probability that the final system would meet the needs of various stakeholders. We met with professionals in the field, medical students, and, of course, patients. This project had a personal slant to it, as a member of the team had some family members who have been living with diabetes, some even bed-ridden due to complications resulting from the disease. These meetings allowed us to get a better and clearer picture on 'how things were currently done'. It was important to get all the key stakeholders involved from the start so as to design and develop a system that meets the needs of its users, as well as, to design a system that complemented/ augmented the current rituals of the target users.

From these interviews, we were able to understand the gaps present in the healthcare system and identify how information and telecommunications technology (ICT) can be harnessed to fill some of these gaps. It was also important for us to establish from the start that we did not see the use of ICT as a replacement of a doctor, nurse, or healthcare provider but more of a way of extending the reach of healthcare, as well as engaging the patient more in the self-care process. We recognized that a healthcare system of this nature had to be more patient-centric than provider-centric, since the treatment of chronic diseases requires a preventative care model.

As a technical person, it was also important for us to know more about the disease itself. As we mentioned before, some family members have been living with this disease, so we had some basic understanding but a deeper understanding was required, especially in the area of prevention. In order to design a system that was effective, there was a need to understand the nature of the disease. We turned to the existing literature in search of current standards and practices.

One of the first articles we came across was the *National Standards for Diabetes Self-Management Education* (Funnell, Brown, Childs, Haas, Hosey, Jensen, Marynink, Peyrot, Piette, Reader, Siminerio, Weinger, and Weiss, 2008). The article provided guidelines on how to approach a DSME initiative including a defined curriculum on what content areas a diabetic should concentrate. This became the foundation for the educational component of the system.

One of the main objectives of the system was to improve the self-management practices of patients. This required a change management model. Human beings are creatures of habit and routine. The problem with most efforts at change is that the conscious effort cannot be sustained over the long term. Therefore, for a new mobile health initiative to be sustained, it is important to build engagement (Sultan, Mohan and Sultan, 2009). Engagement is the skillful mobilization of the energy required to achieve extraordinary results in any mission that really matters. This occurs when people are 'physically energized, emotionally connected, mentally focused and spiritually aligned' (Loehr and Schwartz, 2003). The *LGE Keys* provides three steps involved in building engagement:

- 1 Facing the truth
- 2 Defining purpose
- 3 Taking action

In the first step, the patient must face the truth and acknowledge that healthcare is important and required; this is the key motivating factor. The next step involves determining what needs to be done to achieve the desired state. In this context, it will involve improved self-management and overall well-being. Lastly, the third step is the conversion of the plan into action or doing what is required to achieve the desired objectives. Here is where mobile technology can have the greatest impact.

We incorporated these three steps in the design of the patient interface. The main thrust is that in order for a new ritual to develop, a minimum of thirty to sixty days was required of conscious effort before the new ritual turns into a habit. A ritual in this context is defined as a consciously acquired habitual pattern of thinking and acting that leads to a desired state. The key was to install good practices in the patient's life through the creation of rituals. Examples could include introducing exercise into his life, changing eating habits, or breaking a smoking habit. It is in this process of ritual building that the mobile phone made a positive impact. Since the patients used their mobile devices on a daily basis, we expected them to now use the health application regularly so as to develop a new habit.

We also used some works out of the Center for Creative Leadership (CCL). The CCL has developed a framework for coaching that is supported by a well-tested model of leader development (Ting and Scisco, 2006). This model is built on five

areas: the context in which the coaching occurs, assessment, challenge, support, and results. The framework uses coaching as one, but not the only way, to facilitate learning. When coaching is incorporated into a person's day-to-day activities, it becomes a powerful tool which helps people to access and use their lessons of experience.

In the case of eHealth initiatives, the context will depend on ICT that is being employed. For example, in the case of a mobile telemedicine system, the context will be the mobile phone, the device through which the coaching occurs. Therefore, factors such as location, connectivity, the device's screen size, data entry method, and environmental elements that may distract the user's attention must be taken into consideration.

Assessment deals with the unfreezing of present perceptions, providing realistic benchmarks, and understanding developmental needs and the current state of the patient. ICT initiatives which take into account knowledge of the patient and which can tailor the healthcare delivery to meet the patient's individual needs have a greater chance of success.

The healthcare initiative must also challenge the patient by providing an improved pathway to the desired state. Learning is a crucial step in the actualization of the desired state. Therefore, a clear road map on how this can be accomplished is required. Support is also important, as it creates safety for taking risks, ensures that motivation is maintained, and provides the resources necessary for success. Support can come in many forms, for example, by means of a person in the patient's environment, by making available information relating to the patient's illness, and by providing feedback on the patient's current status. Lastly, the results refer to the direct and indirect outcomes – a desired state with lasting impact. In the context of patient-oriented e-health initiative, the desired result is often the patient being in an improved state of health.

Change is difficult. Human beings are creatures of habit and routine; what we did yesterday is what we are likely to do today. The problem with most efforts at change is that conscious effort cannot be sustained over the long term. Will and discipline are far more limited resources than most people recognize. When developing new rituals, it is necessary to be as precise as possible in both the timing and behavior to habituate, as well as focus on acquiring only a few major rituals at any one time. Moreover, it is important to create an environment that is supportive during the ritual acquisition period. In the healthcare context, it is expected that a doctor or caregiver will work with the patient on the development of the new ritual. This should result in an improvement plan consisting of new habits and routines, thereby reducing the dependence on conscious self-regulated behaviors.

In the first step, the patient must first face the truth and acknowledge that the self-care is important and required. The next step involves determining what needs to be done to achieve the desired state (i.e. improved self-management and overall well-being). The third step is the conversion of the plan into action or doing what is required to achieve the desired objectives. These three steps nurture the ritual building process and it is this area where ICT initiatives can make the biggest impact on the healthcare domain.

Applying computer science to health

Once we had a clear understanding of the existing problem and the challenges associated with current ways of doing things, the next step was to identify possible solutions to address these challenges. The mobile phone was seen as a suitable platform to address some of these challenges. In the Caribbean region, mobile phones usage is very high. Most people owned one or even two mobile phones and this is mainly because the cost of owning a mobile phone is low and the wireless communication has enabled communication to some previously disconnected areas. The mobile phone also allows for a one-on-one mapping with patient and phone. It is a personal device; therefore, services offered through the phone can be tailored to the patient. This was one of the objectives of the study – to deliver personalized healthcare services through the mobile phone.

The MediNet project brought together skills from different areas in computer science (CS): mobile applications development, database design, user interface design, and web programming to name a few. Given that the choice of platform was the mobile phone, new skills were required in application development on small devices which had some physical constraints. At the start of the project and as part of the Microsoft awarded grant, we were provided with some HTC smartphones running Mobile Windows 6.0 Professional. This was our programming platform which was new frontier for the project team. In the next subsections, we explore some of the notable aspects of designing, developing, and implementing a mobile health solution.

Communication protocols

One of the features of the proposed system was to allow the patient to capture/log their daily readings. We were interested in how this could be done automatically without too much intervention by the patient. To achieve this, we needed the appropriate communication libraries to enable the exchange of data between the phone and the respective physiological meter (Sultan and Mohan, 2009). Our research showed that there were three popular communication protocols with

existing healthcare systems: USB, RS-232, and Bluetooth. Some vendors of healthcare meters provide USB port on their healthcare meters. These USB ports offer slave connectivity. This made them only compatible with a PC USB port. Therefore, USB-enabled healthcare monitors were not suitable for healthcare monitoring systems that use a mobile phone as the data access point.

Hardware implementation of RS-232 was simple; therefore, some vendors provided RS-232 connectivity with their healthcare meters. However, mobile phones available in the market do not contain RS-232 ports. Therefore, this option was not suitable for healthcare monitoring systems based on mobile telephony. Being a short-range and low-power communication protocol, Bluetooth was being used by some vendors of healthcare meters for communication between the monitors and PC or mobile phone.

Since Bluetooth was also very popular in mobile phone communication, it became an ideal candidate for transferring readings from the healthcare monitor to the mobile phone. Moreover, Bluetooth has been proven to have high data transfer rates, surpassing serial and parallel ports. Therefore, in our research, we only examined healthcare systems that used the Bluetooth protocol for communication between the mobile phone and the measuring devices. We narrowed down our selection to three Bluetooth enabled glucometer devices, then we chose the one that had an open programmable interface. At the time of this project, there was only one Bluetooth-enabled blood pressure meter available on the market.

It is important to note that there was no established mobile-to-healthcare meter communication standard; therefore, customization was required for each type of physiological device used. For our study, we used a LifeScan One Touch glucometer and an A&D Blood Pressure meter, both using the Bluetooth protocol to transfer results. In the case of the glucometer, additional accessory created by the PolyMap company was also needed to enable the Bluetooth transmission. At the beginning of the project, it was our intention to minimize the amount of data the user had to enter manually, that is why we used meters with some form of communication protocol. The assumption was the less input required by the user will make the data entry task easier to perform. However, after user trials, the communication problems that prevailed due to the use of the Bluetooth technology outweighed this perceived benefit. These communication problems are discussed in the 'Lessons Learned' section and the user trials are discussed in the 'Testing and Evaluation' section.

Data storage

For data storage and sharing, we designed a database that was hosted on a remote server. At the time of this research, online electronic health records (EHR) systems

such as MS Health Vault and Google Health were not available, so we developed our own custom EHR referred to as the *patient record*. This record held demographic information on the patient as well as the daily readings that were logged by the user. A subset of the patient record was stored on the patient's mobile phone. This was to ensure that the user had access to information even if they were not connected to the telecommunications network. Therefore, protocols were developed to ensure that the data stored on the local store and on the remote data store were in sync.

One of the interesting and more cost-effective features of the mobile application was that it allowed multiple users from the same family to access the system in a seamless manner. This entailed having a logon feature and also keeping different data sets for each member of the family. This was successfully tested in the trial by granting a patient's husband access to the system; he used the same blood pressure meter and blood glucose meter to take his readings.

Data integrity

One notable programming task when it came to applications of this nature was the 'seriousness of purpose'. When dealing with healthcare applications, the data captured and the results being processed and transferred can mean the difference between life and death; therefore, the integrity of the data stored and transferred was of paramount importance. Furthermore, the personal nature of health information means that data privacy and data protection are required. We had to address the fact that we were relying on a mobile telecommunications network to transfer data, and this network may not be reliable (i.e. the network might be 'down' or data packets sent may be dropped/lost). To ensure the integrity of data, custom protocols and algorithms were used to ensure that the data transferred was in fact the data received. Encryption algorithms were used to secure the data, on the local store, during the transmission, and on the remote store.

Usability

Another CS skill required was the design of the user interface. The two main interfaces for this system were the Patient Interface and the Health Care Provider Portal as shown in Figure 9.2. The Patients Interface included the mobile phone, the application running on the mobile phone, and the patient's physiological meters. The Health Care Provider interface included a web portal that was accessed through a computer.

When designing the interfaces for the patient and doctor, we used paper prototyping. Some mock screens were drafted and focus groups were conducted to elicit feedback on the usability of the interfaces. Given the small screen size of the mobile phone and the fact that one of the complications relating to diabetes is

Figure 9.2 User interfaces: (a) patient interface and (b) healthcare providers interface

impaired vision, special considerations are needed to address these challenges. For example, the maximum font size allowable may still be too small, especially for a diabetic with eye problems. We plan to address these issues in the next version of the application by incorporating appropriate graphical symbols and audio.

For the selection of mobile phone for the patient, a focus group was conducted to obtain some preliminary feedback on the current mobile phone usage within the target user group and the impressions on different models of mobile phones. The patients were presented with two types of phones: a Windows-based smartphone that was controlled through stylus-input and a Java-based phone with keypad user entry. The users were asked to complete defined tasks on the different phones and the time taken to complete each task, along with the users' feedback, were recorded. Overall, the users preferred the use of the smartphone (including some users who were not expert phone users) because of the perceived ease of data entry and the graphical user interface capabilities provided. A study was also performed on the usability of the glucometer and blood pressure meter that were selected for use in the MediNet project. It was important that the users felt comfortable with each component of the system.

From our study, it was evident that the mobile phone presented many constraints in terms of user interaction and device processing capabilities. The limited screen size meant that data input was restricted to a small onscreen keypad. This was also another motivation behind the automatic data transfer. We also wanted to create

different data visualizations for the patient health data. The patients are able to see the history of their readings both in a tabular format and in a graph format. The healthcare provider interface was web-based, so a different type of visualization was provided where they were able to compare the results of different patients and their associative parameters.

Mobile programming

When we first started the programming task, we explored the use of C++ for the development of the patient application on the mobile phone. We experienced some difficulties in writing C++ code to communicate with the measuring devices. At the end, we found a C# library that communicated successfully with the medical devices. However, this led to the patient interface having two components, one in C# (handling the communications feature) and the other in C++. During the testing process, synchronization problems were detected which caused usability issues (for example, while waiting for a reading from a measuring device, the interface would sometimes behave erratically). This led us to rewrite the patient mobile application in C# so that there was no need to synchronize two independent programs on the mobile phone. We also decided to go with C# as the language for a full scale mobile application versus another language for a web-based application because a reliable internet access was not always available.

Limited memory on the phone is also a challenge when it came to mobile programming. We tried to store only frequently accessed data on the phone. For example, in the case of the patient's history of readings, we stored about 100 days of readings on the phone itself. This was acceptable for the first version but in a later version we are planning to generate reports spanning longer periods at the server which are downloaded on request by the mobile device to display to the patient.

When it came to the patient feedback mechanism as programmers we were inclined to code the system using a rules-based approach but that was a challenge given the very nature of healthcare – i.e. what might work for one patient may not be the same for another. For example, a 'good' blood sugar reading for one patient may be seen as a high reading for another. Each patient is different and therefore personalized and adaptive systems are needed to meet the individual needs of each patient.

Testing and evaluation

Fifteen Type 2 diabetic patients were recruited from the doctor's practice to participate in a six-month field trial (July 2009 to December 2009). The participation was on a voluntary basis. To prepare each phone for the trial, we installed the mobile application and tested each device to ensure it worked as expected. We created log in credentials for each patient and healthcare provider.

For the first meeting with the patients, we executed two questionnaires: a patient profile questionnaire, to capture demographic data as well as current healthcare practices and a mobile usage questionnaire to gage how the patient presently used their mobile devices. A demonstration of the system was then conducted. It is at this demonstration we experienced first hand the problems inherent with the wireless communication between the mobile phone and the physiological meters. It is worth noting that we gave the demonstration at a clinic which had many types of equipment communicating at differing frequencies. We came to the conclusion that the wireless transmission failed because of the interference by other devices.

The patients were allowed to use the system in their home or work environment. Each patient was given a glucometer, blood pressure meter, and a mobile phone running the patient interface software. Because of the C++ and C# synchronization problems, the patients complained of usability issues but after the fully C# application was installed in September 2009, there were no further issues of this nature.

The doctor was also trained on the use of the Health Care Providers portal, and he monitored his patients remotely for the six-month period. During this period, he provided feedback via SMS and phone calls to his patients. Table 9.1 summarizes the feedback obtained from the patients after the first two months of the field study, for more discussion this feedback, see Sultan and Mohan (in press).

Table 9.1 Field study results

Feature	Value
Type of diabetes	Type 2
Participation Count (end of trial)	7
Residence	Trinidad and Tobago
Most popular day of usage	Mondays
Time taken to get comfortable with system	10–15 days
Ranking of most used featured of app	Get Readings, View Log, View Tip
Groups overall compliance	70%
Preferred history of readings view	Tabular
Users satisfied with system	100%
Users who will recommend system to family or friend	100%

Lessons learned

The project team combined had over fifteen years of programming experience in both academia and the industry, but this was our first experience with a health system. There were many lessons learned from this mobile health initiative. A deeper awareness and understanding of the issues faced by regular citizens of the Caribbean region in obtaining quality (if at all, any) healthcare services and the important role that mobile technology can play in providing healthcare services at a cheaper cost. An understanding of how software components can be developed to tackle many of the problems that plague healthcare systems in the region and an understanding of how software technologies commonly used today (for example Facebook-like systems) can be used to support the healthcare system. This is actually a spin-off of the MediNet project, another project called Mobile DSMS concentrates on the formation of virtual peer support groups using mobile phones.

Before the MediNet project, our programming focus or scope was narrow within a particular organization, discipline, and/or programming task. The MediNet project has incorporated a wide cross section within the computer science field as well as an integration with medical and behavioral sciences. We have a greater appreciation of the many factors involved in the design, implementation, and introduction of a new mobile health initiative as well as the realities involved with field work. In the medical space, our knowledge of the disease itself has increased and particularly in different ways, technology can be used in the disease management process. As mentioned before, in terms of behavioral science scope, we involved an external consultant who specialized in coaching initiatives targeted toward behavior change. This was addressed early on in the design stage because the proposed system was intended to in fact effect change. Working in these different disciplines meant that we had to be open to the reality of how current systems and practices worked and be creative in the application of ICT to effect behavior change. The consultant played an important role in explaining how the behavior theory was applied to different change management contexts, as well as providing feedback throughout our design, development, and testing phases. At times in our conversations, we had to make sure that we all spoke the same language because on the one hand we were dealing with theoretical subject matter and at other times technical implementation details. We now see ourselves as interdisciplinary researchers, always exploring ways in which the intersection of various disciplines can be used to generate new possibilities in the area of disease management.

Given our background, our contributions to mobile health included the ability to transform user and system requirements into a fully tested working system.

An understanding of user-centered design and the prototyping process: the importance of considering the user during the design process (for example in designing the user interface), implementation, and evaluation stages. We also have a keen awareness and understanding of the problems faced by the target audience as well as the unmet needs because of first-hand experience with a person belonging to the target audience. Our skills in teamwork helped keep the project team focused. We met regularly and worked together to iron out issues that were new to the area of mobile health, for example, how to treat with the sensitivity of the data being stored and transferred using a third-party telecommunications network, and the protocols used to transfer data between the mobile phone and the physiological meters. We also ensured that each of the technical challenges faced (the availability and reliability of telecommunications network, the design of a user interface on a small screen size with limited keyboard features, communication interferences using a wireless communication protocol, and the limited processing capabilities of the mobile phone) were addressed in a seamless fashion so as to not disrupt the user's experience.

Conclusion

Words of advice to other programmers entering this domain: the health space provides enormous potential for the development of software technology which can enable the provision of many unique forms of healthcare services (this can be very rewarding when one looks at the lives that are saved/improved due to the use of a system). However, the intended users of the software must always be considered in the development process, and user interfaces should be designed as simply as possible. Systems should concentrate on the value that intended users will gain from using the system rather than having impressive hard-to-use features which are seldom used. It is also important to become familiar with healthcare standards/government regulations and understand the implications of these standards/regulations on software being developed. Many different software development skills are required depending on the available resources and target delivery platform, and programmers would need to develop expertise in many of them. Teamwork is also very important, given the many facets of software development associated with a healthcare system and the different stakeholders involved.

References

- Fraser, H. (2001), 'The Dilemma of Diabetes: Health Care Crisis in the Caribbean', *Revista Panamericana de Salud Publica* 9(2): 61–4.
- Funnell, M., Brown, T., Childs, B., Haas, L., Hosey, G., Jensen, B., Maryniuk, M., Peyrot, M., Piette, J., Reader, D., Siminerio, L., Weinger, K. and Weiss, M. (2008), 'National Standards for Diabetes Self-Management Education', *Diabetes Care* 31 (Supplement 1): S97–S104.

- Galperin, H. and Mariscal, J. (2007), 'Mobile Opportunities: Poverty and Mobile Telephony in Latin America and the Caribbean', DIRSI. http://www.dirsi.net/files/regional/REGIONAL_FINAL_english.pdf [Accessed 15 February 2012].
- Loehr, J. and Schwartz, T. (2003), *The Power of Full Engagement: Managing Energy, Not Time, Is the Key to High Performance and Personal Renewal*, New York: Free Press.
- Microsoft. (2007), 'RFP: Cell Phones as a Platform for Healthcare', <http://www.rfpdb.com/view/document/id/1978> [Accessed 21 February 2012].
- Mohan, P. and Sultan, S. (2009), *Medinet: A Mobile Healthcare Management System for the Caribbean Region*. 6th Annual International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services, Toronto, Ontario, Canada.
- Norman, D. (1988), *The Design of Everyday Things*, New York: Basic Books.
- Sen, A. (1999), *Development as Freedom*, Oxford: Oxford University Press.
- Sultan, S. and Mohan, P. (2009), *How to Interact: Evaluating the Interface between Mobile Healthcare Systems and the Monitoring of Blood Sugar and Blood Pressure*. Workshop on Ubiquitous Mobile Healthcare Applications, Toronto, Ontario, Canada.
- Sultan, S. and Mohan, P. (in press), 'Transforming Usage Data into a Sustainable Mobile Health Solution', *Electronic Markets - The International Journal on Networked Business*.
- Sultan, S., Mohan, P. and Sultan, N. (2009), *Managing Change: Experiences from a New E-Health Initiative for Patients with Diabetes and Cardiovascular Disease*. 1st IEEE International WoWMoM Workshop on Interdisciplinary Research on E-Health Services and Systems, Kos, Greece.
- Ting, S. and Scisco, P. (2006), *The Ccl Handbook of Coaching: A Guide for the Leader Coach*, San Francisco: Jossey-Bass.