2011

Cost Models for mHealth Intervention in Aged Care Diabetes Management

Saradhi Motamarri
University of New South Wales, msaradhi@yahoo.com

Pradeep Ray
University of New South Wales

Christopher J. Poulos
University of New South Wales

Cost Models for mHealth Intervention in Aged Care Diabetes Management

Saradhi Motamarri[1]

Pradeep Ray[1]

Christopher J. Poulos[2]

[1]Asia Pacific ubiquitous Healthcare research Centre (APuHC)

School of Information Systems, Technology and Management,

[2] Hammond Chair of Positive Ageing and Care

University of New South Wales, Sydney, Australia

Email: s.motamarri@student.unsw.edu.au

Abstract

Governments across the globe are facing the challenges posed by ageing population. Diabetes is one of the leading causes of disease burden to the economies. A proactive management of diabetes for the elderly can offer benefits to all the stakeholders. Mobile Health (mHealth) can play a vital role to tackle the complexities associated with aged people who are living independently. While there have been several pilot studies of mHealth interventions in diabetes management, they have not made inroads into operational reality. The significant factors appear to be lack of comprehensive cost models and business case for mHealth interventions. The paper reviews some of the related research work and argues for the development of cost models for mHealth interventions in aged care diabetes management. It also presents the work-in-progress of creation of cost models and envisages that such a development will help the operational adoption of mHealth benefiting all the stakeholders.

Keywords

Aged Care, Diabetes, mHealth, Cost Model, Mobile Phone.

INTRODUCTION

An ageing population is a known global phenomenon. Estimates suggest that by 2050 the proportion of people over the age of 60 will be about 20%, nearly doubling from the current 10%. Furthermore the greatest rate of increase is amongst ‘oldest old,’ people aged 85 and over (Pollack 2005). In Australia, the number of people aged over 65 years will increase from the current 2.5 million to around 7.2 million; and people aged 85 years and over is projected to increase from 0.4 million to 1.8 million (5.1% of the population) by 2050 (PC 2011). It does not seem that the Australian aged care industry has the capacity to handle this multiplying demand, as it is inefficient in converting inputs (labour and capital) into outputs (days of care) (Hogan 2004). The Australian Government’s *2010 Intergenerational Report* estimates that the Australian Government’s expenditure on aged care will increase from the current 0.8 per cent of *Gross Domestic Product* (GDP) to 1.8 per cent by 2050 (AIHW 2010).

Economic Consequences of Ageing and Disease

This frail group of elderly among the population is prone to chronic diseases (like cardio-vascular, diabetes etc.) and the incidence of these diseases among this age demography is the highest (AIHW 2010). The advances in disease management are expected to improve the health and longevity of the population. However, the increase in obesity bucks this generic trend, and is likely to bring with it, a greater risk of diabetes (Begg 2007). It is anticipated that more and more people will require complex care for dementia, diabetes and other morbidities associated with longevity as well as palliative care (PC 2011). Diabetes is one of these chronic diseases among the elderly people. More than 3 million or *one in four* Australian adults have either diabetes or impaired glucose tolerance. As survival rates for people with diabetes increase, there will be an increased risk of them developing other non-fatal but disabling conditions including renal failure and vision loss (Begg 2007). In light of these research findings, it is projected that by 2023 diabetes to be the leading cause of disease burden. Costs from diabetes alone are projected to increase from the current $1.6B to $8.6B, an increase of a massive 436% (AIHW 2010).

Research Objective

In the world where economies are struggling to meet complex competing demands for allocation of limited resources (money, land, materials and people), it will be hard to assume that the aged care and the associated overall disease burden will be adequately funded if the status-quo is maintained. *Information and Communication Technologies* (ICT) can play a vital role in offering safer and secure diagnosis, treatment and remote monitoring services. The application of *Information Technology* (IT) within healthcare is broadly referred to *Health IT (HIT)* has made significant advances in not only improving efficiencies but also in promising cost savings (Agarwal, Gao et al. 2010). The ATSE report on *2010 Smart Technologies for Healthy Longevity,* suggests that smart technologies can offer substantial savings in residential aged care (Tegart 2010).

In consideration of the ageing population's growing affluence and the desire to live independently (PC 2011), *electronic health* (eHealth) or *mobile health* (mHealth) can offer a viable technological and economical option in achieving diabetes management for the aged care. This paper focuses on mHealth as a channel for alerting, collecting, moniotoring and trending of blood glucose data through mobile phones/ devcies. Mobile phones are becoming widely available, easy to use, and there is significant penetration of mobile phones among the elderly across the globe (Akter 2010), makes mobile phones a dependable and cost-effective platform for diabetes management. Though assistive technologies can potentially reduce societal costs towards healthcare, to date, the long term care sector has not been convinced of the benefits of ICT (Yu 2004). All these facets of aged care, disease burden and mHealth have motivated to conduct research to establish the economic sustenance of mobile phones in diabetes management for the aged care through the development of cost models.

Summary of Research Findings

Aged care is a complex process as the service delivery is spread across a continuum of environments, simply speaking: home, community, residential and hospitals. The challenge here is to develop cost-effective systems covering these varying service models and yet achieve patient satisfaction. Bodenheimer et al. (2002a) proposed *Chronic Care Model* (CCM) enumerating various aspects related to management of the chronic diseases like diabetes. The model consists of four components: self-management, decision support, delivery system design and clinical information system. They studied the effectiveness of the CCM in improving the primary care for patients with chronic illness. The CCM is applicable for all age groups. The research concluded that CCM when combined with multifaceted interventions can actually improve the process and outcome measures for diabetes (Bodenheimer, Wagner et al. 2002b). They concluded that congestive heart failure (CHF) and asthma had shown immediate benefits reflected through reduced hospital and emergency department use. For programs of diabetic glycaemic control the improvements occurred over a longer term. The model confirms self-management of diabetic control is feasible and benefits healthcare system.

Yu et al. (2011) shared an innovative business model they had setup in Taiwan to provide tele-health services to cater to patients with cardiovascular disease. They noticed that post-discharge heart failure patients were not well rehabilitated in terms of closely monitoring their medication schedule, blood sugar, blood pressure and lipid levels. Adopting CTM's VISOR Framework (CTM 2005) for their business model, they developed tele-health service to ensure that the patient's recovery is systematically monitored and reactive steps taken in case adverse conditions develop. They reported that the tele-health had resulted in reducing hospital re-admission rates, hospital stay and emergency department use.

Lyles et al. (2011) expanded the CCM to include mobile phone and game console as delivery channels to facilitate collaboration between patient and care givers. They conducted trials with a small sample of patients, age ranging from 18-75 years. Qualitative thematic analysis of the semi-structured interviews of the participants revealed that the participants preferred wireless communication and then communication through game console. They concluded that the data uploads through mobile phones was frustrating to some of the patients. Hanauer et al. (2009) developed a *Computerised Automated Reminder Diabetes System* (CARDS) to deliver reminders to young adolescents to encourage them with their blood glucose (BG) monitoring. Of the 40 participants 22 were randomly chosen to receive alerts through *short messaging service* (SMS) while the rest 18 to receive email alerts. The authors concluded that SMS is a viable and acceptable alternative to promote BG monitoring among young adolescents. However, they cautioned that retaining the participants' prolonged interest is a challenge.

Wojcicki (2005) provided a historical perspective on transfer of patient collected diabetic monitoring data to health care providers. She noted that the first ever application of telemedicine to diabetes treatment occurred in late1980s. Broadly there are 2 modes of transfer: (1) live transmission or (2) scheduled basis (day/ week/ month). Early systems depended on modem technology to transfer data. Since the introduction of GLUCOFACTS™ in 1991 as a step for tele-monitoring in diabetes treatment, better data transmission systems evolved, including the mobile phones, which were efficient and clinically verified. Despite of these facts, Wojcicki notes that these systems have not been applied for diabetes treatment. She observes that the obstacles seem to be: lack of standards for tele-medicine safety and efficiency, lack of incentive to healthcare professionals, privacy, security, and communication costs. The other obstacle is the lack of standards for interoperability between BG monitoring devices and their respective software programs. Wojcicki foresees that a standard data exchange protocol for glucometers could progress telemedicine from ‘trial’ status to ‘operational’ status.

Diabetes management involves a lifetime of self-care coupled with regular visits to the physician’s office is required for the patients. With the ageing population and increasing number of diabetic patients this ideal situation of regular monitoring will become both costly and infeasible. Realising these issues, Kim et al. (2010) tested an insulin dose adjustment system for diabetic control through SMS. They developed a knowledge matrix which infers the amount of insulin dose based on 3 consecutive days of BG data. They did a controlled experiment where the intervention group’s BG levels were monitored closely and the dosage was adjusted whereas the controlled group received conventional treatment. Based on their 12-week study with a total sample of 100 patients, Kim et al. concluded that their SMS based system was effective and safe in insulin dose adjustment for patients with Type-2 diabetes.

In Panama, Central America, researchers tested a holistic, interactive, and persuasive model to facilitate self-care of diabetes patients (hiPAPD) (Vargas-Lombardo, Jipsion et al. 2010). In this innovative initiative the patients were connected with their family, friends, doctors, healthcare professionals and society and facilitated the self-care of the diabetic patient. The model employed ambient intelligent technologies (like Bluetooth-enabled devices: pedometer, glucometer, and blood pressure monitor). The authors found that blood sugar levels dropped once the patients became part of the intervention group.

Darkins et al. (2008) provided a case study of a real implementation of *Care Coordination/ Home Telehealth* (CCHT) program of *Veterans Health Administration* (VHA). VHA’s program was intended to assist elderly patients with chronic conditions. The program reduced costs, hospital admission rates, bed-days-of-care and achieved high levels of patient satisfaction. VHA’s successful turnaround in performance shall be a great encouragement to institutions that are dedicated to provision of aged care services whether they are public funded or privately operated (Oliver 2007). The important lesson is that with simple but effective use of ICT, VHA has achieved far reaching results. The *Taiwan Telehealth Pilot Project* (TTPP) (Hsu, Chu et al. 2010) initiated by Taiwan’s Department of Health achieved a mixed level of success. The authors reported that their experiment reduced the non-adherence to medicine, and drug duplication rate. However, they could not establish cost-effectiveness of Telehealth. The possible reasons for this could be the lack of willingness of patients to pay for the tele-health services, in-person visits are still mandatory for majority of healthcare events and lack of substantial evidence for the government to accept the business case.

In a recent paper Whited (2010) noted that economic considerations are vital for the planning of telemedicine deployment. Quoting past research, he observed that telemedicine will provide comparable or even better clinical outcomes in comparison to traditional practices. However, Whited points out that telemedicine must demonstrate either it is highly effective over the conventional practice or it provides substantial cost-effectiveness with a comparable level of clinical outcome for it to be adopted in practice. He cautions that the evaluation perspective of the researcher may bias towards a particular stakeholder group. He suggests that a societal perspective ought to be considered for the assessment of telemedicine initiatives. Noting on the lack of such an analysis in the literature he provided a case for the teledermatology intervention.

Technologies adopted for aged care shall consider physical, cognitive and visual limitations associated with age (Soar 2006). Many authors argued the adoption and proliferation of HIT is hindered by privacy concerns (Anderson and Agarwal 2011). Contrary to this notion (van Hoof, Kort et al. 2011) found in their qualitative research on *ageing-in-place* that the aged people had not shown any excessive concern on privacy and expressed satisfaction with the pervasive ambient intelligence technologies as they enabled them to live independently. The intrusion of technology into the personal space is possibly the highest in this environment. This is a surprising result and giving rise to the notion that *privacy concerns* are only in the minds of the IS researchers. There are wide spread notions that older adults do not use technology or new devices. A recent study undertaken by Mitzner et al. dispelled these notions and provided very interesting facts about the technology usage and attitudes of older people. The recurring theme of the conclusion is similar to other ICT adoptions that the technologies must be easy to use and provide real benefit (Mitzner, Boron et al. 2010).

Artificial Intelligence (AI) techniques were also employed to devise intelligent assistive technologies for older people especially with cognitive decline. These are interesting outcomes as aged care providers can focus on devising usable, useful and effective solutions for the older people which enables them communicate, do their works with ease and help them live independently. This would benefit the individual as they reduce their reliance on carer or care providers which shall lessen the pressure on the community, the healthcare system and eventually the government’s overall funding.

RESEARCH AGENDA

The above review findings highlighted the global issue of ageing population and the related challenges being faced by both developed and developing nations. It identified the widespread prevalence and consequences of the chronic disease, diabetes. Researchers have attempted to address some of these challenges and bring efficiencies and effectiveness through the application of mHealth or telemedicine, an emerging branch of ICT (Bashshur, Reardon et al. 2000; Koch and Hägglund 2009; Agarwal, Gao et al. 2010). Mobile phones appeared to be a powerful delivery channel to act as a reliable and dependable platform to achieve proactive disease management due to the characteristics like: wide spread penetration across all age groups, affordability, easiness to adopt and ubiquitous in nature (Akter 2010). It is possible to find many successful pilot studies and experiments with mobile phones as a service delivery platform. However, there appears no single operational solution of telemedicine. Furthermore, there is a dearth of specific cost model and/or business justification in the literature to suggest the sustainability of a mHealth solution (Moullec and Ray 2009; Liu, Castle et al. 2010).

These facts pertaining to the broad domain of aged care are the motivations for this research in the areas of *cost models for mHealth intervention in diabetes management for aged care*. The research identified a set of research questions (RQs) and thus the motivation for this research project is to find an answer to this complex issue affecting several developed as well as developing economies. The next sections will present the rationale for the study, the RQs, framework for the research undertaking, methodology of the research, data collection and analysis methods, and contribution of this research to the body of knowledge.

The Rationale for the Study

Diabetes is one of the leading chronic diseases affecting Australians. With nearly 6.6% of the total disease burden, diabetes is the sixth leading causes of disease burden and injury in Australia in 2010. However, this estimate does not include the contribution of diabetes to coronary heart disease and stroke. When these effects are included, the burden attributable to diabetes increased from 5.5% to 8.3% in 2003 (Begg 2007). Type 2 diabetes is estimated to account for the great majority (94%) of the diabetes burden in 2010. The ranking of Type 2 diabetes as a cause of disease burden has increased over time: from sixth among the 20 leading causes of disease burden for both males and females in 1993 to second for males and third for females in 2010. Type 2 diabetes is projected to be the leading cause of disease burden by 2023 for males and second for females. Expenditure on diabetes and neurological conditions is expected to grow most rapidly in the 30 years from 2002–03 to 2032–33 (AIHW 2009), although diabetes is coming off a low base (1.9 per cent of total expenditure in 2002–03). Costs from diabetes alone are projected to increase 436 per cent, from the current $1.6 billion to $8.6 billion in 2023 (AIHW 2010).

Research Questions and Objective

The objective is to explore whether it is feasible to develop cost models for the mHealth intervention for the diabetes management for aged care. This broad research theme can be progressively addressed through the resolution of the allied research questions:

RQ-01:
What are the clinical needs for the diabetes management of independently living elderly?

RQ-02:
What are the cost elements to meet the above clinical monitoring needs?

RQ-03:
What are the benefits of mHealth intervention and are they quantifiable?

***RQ-04*:**
Is it possible to develop cost models combining these costs and benefits?

Addressing this broad research theme and the associated pursuit for an answer to each of the research questions will have a significant impact on the daily lives of the individuals who suffer from a chronic disease. It will also alter their life patterns for the better, gives them an opportunity to a play a role and take ownership of managing their own critical conditions. Though the benefits of mHealth have been generally debated, some pilot projects have been taken up to confirm the theory, no significant sustainable work was undertaken to operationalize mHealth solutions. A success to this research will give a great impetus to the advancement of the mHealth and possibly the realisation of *the hospital without walls* (Wilson, Gill et al. 2000). Finally an operational and effective solution will positively influence in reducing the forecasted disease burden of diabetes.

Conceptual Framework/ Theoretical Foundations

Aging populations, limited hospital facilities and rising healthcare costs are straining the welfare system in the provision of appropriate care for the elderly. The ongoing innovations in ICT have made possible many effective and operational solutions which were unthinkable in the past. One such promise of ICT is to facilitate remote monitoring of the patients or in a way provision of care to the elderly at their own home (Wilson, Gill et al. 2000). eHealth encompasses any form of health service rendered electronically. mHealth is a specific case of eHealth where the delivery of service depends on the wireless cellular technology. Wireless communication through mobile phones has seen a multi-scale explosion in the last decade. Across the globe currently there are 5 Billion devices, and Ericsson predicts in the ensuing decade there will be a 10 fold growth in connections giving rise to 50 Billion connected devices (Ericsson 2010). Ericsson estimates that in Australia mobile phone penetration has approached 125%. With the ongoing innovations in ICT and availability of a wide variety of devices at affordable prices to the individual users, the mHealth frontiers are ever expanding. What was viable technically but not operationally in the past is now becoming a possibility.

Mobile phones offer easy accessibility, personalised solutions and location based services (Akter 2010). Globally the mobile phone wireless networks expanded massively, they were able to provide wide spread coverage to the remotest corners and at times, to even geographically inaccessible locations. In some parts of the world where wired-phone was never heard of, today the populations have adopted mobile phones with ease. The ready availability of low cost mobile phones makes it a formidable platform for healthcare delivery. The mobile technology can scale well to handle the healthcare challenges with its low cost and simplicity to use (Akter 2010). These interesting developments make the researcher believe that mobile phone intervention can help in the self-management of the diabetes.

Research Methodology

Diabetes management for the elderly through the intervention of ICT and the exploration of the operational sustainability is a broad and multi-disciplinary research problem. The research consists of three phases: namely (a) qualitative analysis of secondary data; (b) gathering requirements for diabetic monitoring; and (c) building of economic models. Following the definition for positivist approach by Neuman (2011): the research ultimately aims at building models to evaluate the economic sustenance of mHealth intervention in aged care. Both quantitative and qualitative methods will be cooperatively applied across all the phases of work. Broadly the phase (a) forms a quantitative assessment of the available data and a qualitative analysis of the data required for the next phases. Phase (b) involves site visits and unstructured interviews so as to develop an interpretive perspective of the existing processes versus clinical needs (Weber 2004). The last phase (c) involves the development of economic evaluation model following quantitative and operational research techniques.

Research Methods

Given the diverse nature of these tasks, a mixed research methodology provides a natural basis to combine methods and paradigms of different disciplines in conceptualising the research problem. The research task necessitates at the minimum collection of knowledge from ICT, medical, economic evaluation and Operations Management domains. A mixed research methodology consists of using more than one research method (qualitative or quantitative) in formulating and testing of one's research questions at hand (DeMarco Jr, Newman et al. 2003). In essence the objective of science or scientific research is to achieve social betterment (Johnson and Onwuegbuzie 2004), focusing more on the holistic application of a wide range of bodies of knowledge in deciphering the problems of utmost importance to the society and generating plausible operational alternatives.

In the resource constrained world, every government, every corporation and even every individual is challenged to provide justification for each dollar of investment to be incurred. The agencies also need to consider why a particular investment has to be taken up over a competing range of alternatives. This gives rise to economic justification. The primary focus of this research is to evaluate economic sustainability of a mHealth solution for aged care. The research work shall rely on economic evaluation methods suitable for mHealth in the formulation, estimation and comparison of costs.

Economic Evaluation

The economic evaluation or 'comparative evaluation of alternative courses of action' calls for identification, quantification of both costs and consequences. This calls for the identification, measurement and valuing of costs of each of the alternatives and assessment of benefits in monetary terms so as to arrive at the comparative benefit of each alternative. It is generally accepted that the aim of any health care system is provisioning of health and welfare to its constituents. This objective works well with unbounded budgets. But as it is noted earlier there are limits to the resources and thus calls for prioritisation irrespective of whether it is a non-profit system or for-profit system. In such an environment, every player (individual, service providers or government) will look to minimise their burden and maximise their value (Wells 2003). Some of the most commonly used cost models in mHealth environment are:

- Cost Minimisation Analysis;
- Cost Benefit Analysis;

- Cost Effectiveness Analysis; and
- Cost Utility Analysis.

In mHealth literature, though there appears to be some cost related information, concrete information is missing from the perspective of stakeholders. Important information from research about costs needed for mHealth investment decisions is difficult to detect. Besides, there is a strong need to identify whose perspective is taken in mHealth economic analysis as the specific perspective taken (society, patient, provider, facility or system) is seldom made explicit in most studies (Moullec and Ray 2009).

Working for the European Union on the economic evaluation of mHealth, Dobrev, Jones et al. (2008) developed a framework to assess the costs and benefits of the mHealth solution. The proposed research will benefit from this framework in the identification of cost and benefit elements. The researchers' point of view of the analysis is an important influencing factor in the deduction of conclusions of a particular technological intervention. The *Panel on Cost Effectiveness in Health and Medicine* recommends that the societal perspective shall be considered always (Gold 1996). It implies that all costs incurred by the patient, service provider, healthcare system, government and any other affected agencies shall be taken into account. Apart from the costs the results of such an intervention shall also be considered in the analysis (Whited 2010).

Model Building

Given the brief discussion on the research questions and the economic evaluation methods, estimation of cost elements and linking them into a theoretical model will involve considerable challenges. In such unstructured situations, simulation comes in handy in synthesising the divergent sets of information. A simulation model will also facilitates scenario generation as well as sensitivity analysis which in turn, allows the researcher to quickly demonstrate the decision support it can offer without the lengthy process of collection of data which sometimes may not be available in a form ready for consumption. Future econometric studies will have to undergo a paradigm shift from statistical correlations to the establishment of causation in mHealth applications, for instance an economic simulation model based on the Markov chain approach (Moullec and Ray 2009).

The mHealth cost deals (Health Economics) at an abstract, strategic level operating on macro system parameters. The relationships among the stakeholders form to be aggregate dealing with global casual dependencies (Borshchev 2010). The emerging field of Agent Based Modelling (ABM) allows many advantages over the traditional Dynamic Event simulation or System Dynamic paradigms. ABM facilitates modelling of objects of very diverse in nature as well as scale. ABM is well suited to address global business optimisation tasks and provides deeper insights by allowing the researcher to represent complex interdependent processes (Borshchev 2010).

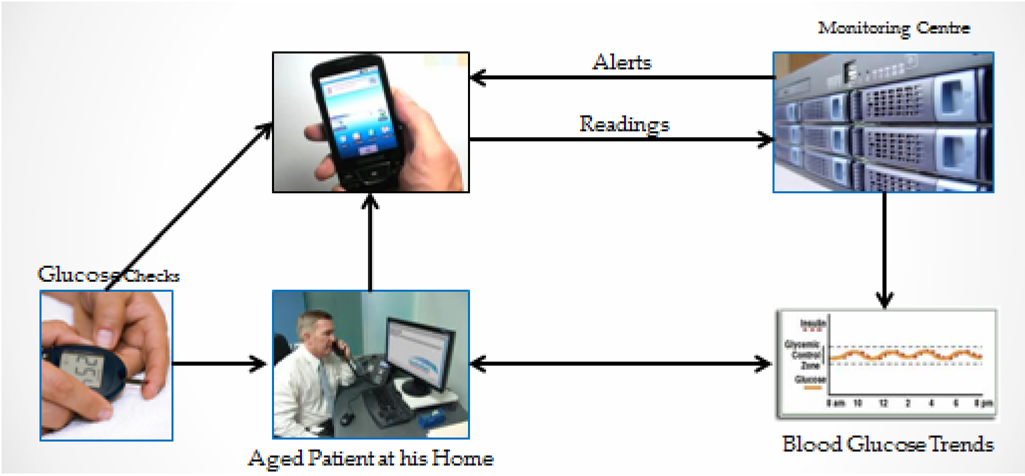
Diabetes Management through Mobile Phones (mHealth) for Aged Care

The UN Foundation and Vodafone Foundation report in 2009 has presented 6 categories of applications based on mobile technology for the healthcare sector, namely: education and awareness, helpline, diagnostic and treatment support, communication and training for healthcare workers, disease and epidemic outbreak tracking, remote monitoring and remote data collection (UNF 2009). Mobile phones are anticipated to serve as the universal patient terminal in telemedicine scenarios as well as data collection and monitoring device in the self-management of diabetic patients (Giménez-Pérez, Gallach et al. 2002).

The mHealth intervention for diabetes management can be implemented through simple infrastructure as shown in the Figure 1 schematic. A centralised monitoring centre can be setup with all the registered aged people who are suffering from diabetes. The database shall include important information about the patient such as: name, address, mobile phone number, disease details, monitoring schedule and historical data of vital signs (like blood glucose levels, HbA1C etc.) which will be monitored at regular intervals. The system shall be initiated and on the ongoing basis be maintained with the schedule of monitoring for each patient. The historical and ongoing data collection of the patients provide an insight to the patient's doctor or designated medical practitioner, into how each patient is performing in terms of their diabetes level based on the clinical outcomes. The medical practitioners may intervene and fine tune the patient schedule either like increase/ decrease in the prescribed medicines or increase/ decrease on the need for alerting and data collection.

The monitoring centre shall be equipped with an SMS Gateway capable of sending and receiving SMS through wireless mobile technology. Except the ongoing costs for the IT support for the server infrastructure and mobile subscription charges there are no specific costs involved for any network infrastructure to establish connectivity between the patient and the monitoring centre. The pre-existing wireless mobile infrastructure provides a global coverage as well as a dynamic connection between the patient's mobile phone and monitoring centre on a per use basis. The costs involved for the communication are the mere incremental charges based on usage. This is the substantial impetus as well as motivation to achieve proactive diabetic management for elderly at the lowest of costs possible. Studies have shown that the adoption of the CCM does improve clinical outcomes for the diabetic patients as well as reduce costs in the longer term (Bodenheimer, Wagner et al. 2002b).

Figure 1: Mobile Phone Intervention in Diabetes Management for Aged Care



ITIL and mHealth Change Management

mHealth solutions rollout is a complex task as it has to deal with patient safety and differing standards of cooperating systems. ITIL v3 provides a systematic framework to define service- strategy, design, transition, operation and continual improvement. mHealth solutions require changes to operational procedures across the value chain and every stakeholder is impacted in one way or the other. Systematic Change Management is a prerequisite for a successful deployment and operationalisation of a service. ITIL v3 Service Transition stage provides valuable guidance to manage change in an orderly fashion and the mHealth implementers and proponents shall give due considerations for operationalisation. Only then the stakeholders can enjoy the fruits of mHealth.

Directions for the Future Work

The next major task of this research is to collect information about the various cost elements and associated costs incurred in the process by different stakeholders of the eco-system. Actual costs incurred will either be derived from published quantitative reports, online data or where appropriate will be sourced from the eco-system agencies. In situations where information either is hard to obtain or not available proxy costs will be estimated using comparable data (Dobrev 2008). The construction of cost model can leverage on the systems modelling and description methodology which enables in creating a robust model incorporating *restraint disaggregation* (Motamarri 1992). The model construction will utilise Dobrev's framework of costs, and Operations Management methods. Finally *Agent Based Modelling and Simulation* will enable scenario generations and for arriving at an optimal mix of policy alternatives.

CONCLUSION

The research highlighted the challenges being faced by global economies in dealing with the ageing population. It also provided the increasing threat of diabetes and the associated burden on the economy in the years to come. The review pointed out that mHealth can provide promising solutions to alleviate the economic challenges. The technology is not an off-the-shelf solution, it has to be adapted, adopted, and accepted in order to visualise the anticipated benefits. There are substantial challenges for IS researchers to address these issues. The telehealth is impaired by the lack of standards to integrate disparate systems, an evaluation framework and guidelines.

The review also noted that while mHealth can produce comparable clinical outcomes in diabetes management for aged people in comparison to conventional care. The research establishes that the elderly people are willing to adopt novel technologies. It dispelled the notions that the aged people are concerned about privacy and security to adopt pervasive technologies. However, there is a wide gap in providing evidence for cost-effectiveness of mHealth for aged care in general and diabetes management in particular. The authors envisage that the research frameworks will shift sooner than later so that mHealth can have a definitive impact in achieving optimal aged care that balances the requirements as well as societal investments.

The research will contribute towards enhancing the body of knowledge of mHealth in providing a case for diabetes management of aged care. Importantly on the operational end, the research facilitates decision making with respect to mobile phone interventions for aged care in diabetes management. The successful deployment of these ICT shall not only advance the practical relevance of the advanced technologies but will also help governments in gaining economic benefits sustainably.

REFERENCES

Agarwal, R., G. G. Gao, et al. (2010). "The digital transformation of healthcare: Current status and the road ahead." Information Systems Research **21**(4): 796-809.

AIHW (2010). Australia's Healath 2010. Canberra, AIHW. **Australia's Health Series:** 579.

Akter, S., Ray, P. (2010). "mHealth - An Ultimate Platform to Serve the Unserved." IMIA Yearbook of Medical Informatics: 7.

Anderson, C. L. and R. Agarwal (2011). "The Digitization of Healthcare: Boundary Risks, Emotion, and Consumer Willingness to Disclose Personal Health Information." Information Systems Research: isre.1100.0335.

Bashshur, R. L., T. G. Reardon, et al. (2000). "Telemedicine: A New Health Care Delivery System." Annual Review of Public Health **21**(1): 613-637.

Begg, S., Vos, T., Barker, B., Stevenson, C., Stanley, L., Lopez, AD. (2007). The burden of disease and injury in Australia 2003. Canberra, AIHW. **Cat. no. PHE 82**.

Bodenheimer, T., E. H. Wagner, et al. (2002a). "Improving primary care for patients with chronic illness." JAMA : the journal of the American Medical Association **288**(14): 1775-1779.

Bodenheimer, T., E. H. Wagner, et al. (2002b). "Improving primary care for patients with chronic illness: the chronic care model, Part 2." JAMA : the journal of the American Medical Association **288**(15): 1909-1914.

Borshchev, A., Filippov, Alexei. (2010). "From System Dynamics and Discrete Event to Practical Agent Based Modeling: Reasons, Techniques, Tools."

CTM (2005). The VISOR Framework: Business Model Definition for New Marketspaces in the Networked Digitial Industry, Ver2. Los Angeles, CTM, University of Souther California Campus.

Darkins, A., P. Ryan, et al. (2008). "Care Coordination/Home Telehealth: The Systematic Implementation of Health Informatics, Home Telehealth, and Disease Management to Support the Care of Veteran Patients with Chronic Conditions." Telemedicine and e-Health **14**(10): 1118-1126.

DeMarco Jr, G., C. Newman, et al. (2003). A Typology of Research Purposes and Its Relationship to Mixed Methods. Handbook of Mixed Methods in Social & Behavioral Research. A. Tashakkori and C. Teddlie. Thousand Oaks, Sage Publications.

Dobrev, A., Jones, Tom., et al. (2008). Effective and efficient healthcare management support for eHealth investment. **European Society**.

Ericsson (2010). TOWARDS 50 billion connectED DEVICES**:** 16.

Giménez-Pérez, G., M. Gallach, et al. (2002). "Evaluation of accessibility and use of new communication technologies in patients with type 1 diabetes mellitus." J Med Internet Res. **4**(3).

Gold, M., Siegel, JE., Russelll, LB., Weinstein, MC., Ed. (1996). Cost-Effectiveness in Health and Medicine. New York, Oxford University Press.

Hanauer, D. A., K. Wentzell, et al. (2009). "Computerized Automated Reminder Diabetes System (CARDS): E-Mail and SMS Cell Phone Text Messaging Reminders to Support Diabetes Management." Diabetes Technology & Therapeutics **11**(2): 99-106.

Hogan, W. P. A. C. P. R., Taskforce (2004). Review of pricing arrangements in residential aged care : report / WP Hogan, reviewer. [Canberra :, Dept. of Health and Ageing].

Hsu, M.-H., T.-B. Chu, et al. (2010). "Development and implementation of a national telehealth project for long-term care: A preliminary study." Computer Methods and Programs in Biomedicine **97**(3): 286-292.

Johnson, R. B. and A. J. Onwuegbuzie (2004). "Mixed Methods Research: A Research Paradigm Whose Time Has Come." Educational Researcher **33**(7): 14-26.

Kim, C. S., S. Y. Park, et al. (2010). "Insulin Dose Titration System in Diabetes Patients Using a Short Messaging Service Automatically Produced by a Knowledge Matrix." Diabetes Technology & Therapeutics **12**(8): 663-669.

Koch, S. and M. Hägglund (2009). "Health informatics and the delivery of care to older people." Maturitas **63**(3): 195-199.

Liu, D., N. G. Castle, et al. (2010). "Does Use of Advanced Information Technology in Commercial Minimum Data Set Systems Improve Quality of Nursing Home Care?" American Journal of Medical Quality **25**(2): 116-127.

Lyles, C. R., L. T. Harris, et al. (2011). "Qualitative Evaluation of a Mobile Phone and Web-Based Collaborative Care Intervention for Patients with Type 2 Diabetes." Diabetes Technology & Therapeutics **13**(5): 563-569.

Mitzner, T. L., J. B. Boron, et al. (2010). "Older adults talk technology: Technology usage and attitudes." Computers in Human Behavior **26**(6): 1710-1721.

Motamarri, S. (1992). "Systems modelling and description." SIGSOFT Softw. Eng. Notes **17**(2): 57-63.

Moullec, B. and P. Ray (2009). Issues in E-Health Cost Impact Assessment. World Congress on Medical Physics and Biomedical Engineering, September 7 - 12, 2009, Munich, Germany. O. Dössel and W. C. Schlegel, Springer Berlin Heidelberg. **25/12:** 223-226.

Neuman, W. L. (2011). Social Research Methods: Qualitative and quantitative approaches, 7th Edition. Boston, Pearson.

Oliver, A. (2007). "The Veterans Health Administration: An American Success Story?" Milbank Quarterly, Vol. 85, No. 1, pp. 5-35, January 2007.

PC (2011). Caring for Older Australians, Draft Inquiry Report. Canberra, Productivity Commission.

Pollack, M. E. (2005). The Use of AI to Assist Elders with Cognitive Impairment. AI Magazine, AAAI. **26:** 16.

Soar, J. (2006). Aged-care – privacy and security of the Smart Home. e-PASS, National e-Health Privacy and Security Symposium. P. Croll. Brisbane, Australia, Queensland University of Technology.

Tegart, W. J. M. (2010). Smart Technlogy for Healthy Longevity, Melbourne: Australian Academy of Technological Sciences and Engineering (ATSE). Melbourne, Australia, Australian Academy of Technological Sciences and Engineering (ATSE).

UNF, V. (2009). mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World. Washington, United Nations**:** 70.

van Hoof, J., H. S. M. Kort, et al. (2011). "Ageing-in-place with the use of ambient intelligence technology: Perspectives of older users." International Journal of Medical Informatics **80**(5): 310-331.

Vargas-Lombardo, M., A. Jipsion, et al. (2010). "Scope of Information Communications Technology in the Health of Diabetes Patients in Poor Rural Zones of Panama Through Holistic, Interactive, and Persuasive Model to Facilitate Self-Care of Diabetes Patients." Diabetes Technology & Therapeutics **12**(9): 717-722.

Weber, R. (2004). "The rhetoric of positivism versus interpretivism: a personal view." MIS Quarterly **28**(1): 10.

Wells, P. N. T. (2003). "Can technology truly reduce healthcare costs?" Engineering in Medicine and Biology Magazine, IEEE **22**(1): 20-25.

Whited, J. D. (2010). "Economic Analysis of Telemedicine and the Teledermatology Paradigm." Telemedicine and e-Health **16**(2): 223-228.

Wilson, L. S., R. W. Gill, et al. (2000). "Building the Hospital Without Walls - a CSIRO Home Telecare Initiative." Telemedicine Journal **6**(2): 275-281.

Wojcicki, J. M. (2005). "Analysis: Transfer of the Data Collected by the Patient to the Health Care Providers: Problems and Solutions." Diabetes Technology & Therapeutics **7**(2): 248-252.

Yu, J.-Y., Ho, Yi-Lwun., Guo, Ruey-Shan. (2011). Innovative Tele-Health Business Model For Patients With Cardiovascular Disease. INFORMS Healthcare 2011.

Yu , P. C., Nicholas (2004). An Exploration of the Barriers to the Adoption of Information Technology in Australian Aged Care Industry. National Health Informatics Conference (12th : 2004 : Brisbane, Qld.). Brunswick East, Vic., Health Informatics Society of Australia**:** 127-131.

ACKNOWLEDGEMENTS

The authors would like to thank the two anonymous reviewers for their valuable review comments and encouragement. This work was done as part of the APuHC project on long term strategic IT plan for aged care in Australia, partly supported by the Aged Care Industry IT Council (ACIITC) of Australia, Australian Institute for Population and Ageing Research (AIPAR) and the IT industry.