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Abstract:

Better managing diabetes has become a global priority, especially given the exponential increase in the number of diabetes patients and the financial implications of treating this silent epidemic. In this paper, we focus on how it might be possible to use a mobile technology solution to support and enable superior diabetes monitoring and management. To test this solution, we examined the context of gestational diabetes and adopted a non-blinded randomized control trial with two-arm cross over applied to a private hospital in Victoria, Australia. Further, we use an accountable care system as the theoretical lens and, from this, develop a conceptual framework to bridge evidence-based management with technologies. Theoretically, we unpack McCleallan, McKethan, Lewis, Roski, and Fisher's (2010) study with our conceptual framework that comprises providers for information (evidence-based management) and technology (smartphone). We enhance Muhlestein, Croshaw, Merrill, Pena, and James' (2013) accountable care paradigm with three concepts: 1) quality of life, 2) evidence-based management, and 3) affordable care. From the perspective of practice, far-reaching implications have arisen particularly for hospital management pertaining to the cost and quality of care issues. In particular, it appears that adapting mobile technology solutions such as smartphones to support various aspects of care and patient-clinician interactions is a prudent choice to minimize costs and yet provide high-quality care.

Keywords: Evidence-based Decision Making, Accountable Care, Management of Gestational Diabetes Mellitus (GDM), Quasi-experimental Approach.

1 Introduction

Globally, diabetes is one of the leading chronic diseases: it is increases at such an alarming rate that the WHO has labeled it a silent epidemic (World Health Organization, n.d.; AIHW, 2007). Australia reflects this global trend with approximately 1 million Australians currently diagnosed with diabetes (Baker IDI, 2012). This alarming phenomenon serves to motivate the present research. Specifically, we focus on using a mobile technology solution to provide superior management and monitoring in the context of gestational diabetes and model this scenario in terms of accountable care and evidence-based decision making.

Traditionally, healthcare delivery has been designed to treat patients at the point of care with less focus on being proactive in supporting preventative measures that keep people healthy and away from the hospital (LeRouge & Wickramasinghe, 2013) due primarily to the fact that, historically, most key diseases have been infectious in composition (U.S. Department of State, 2015). However, we are now witnessing a significant rise in chronic diseases (Geisler & Wickramasinghe, 2009). Contemporaneous with this are two other key trends; namely, the rapid growth of technology solutions for healthcare (Wickramasinghe & Schaffer, 2010) and an increasing focus on the accountability of care (Morse, 2010).

Accountable care aims to improve quality and lower healthcare costs by proactively keeping people healthy and away from the hospital (Morse, 2010). This view of healthcare is one of the most significant drivers of the present U.S. health reform. Further, it has supported the launch of pilot projects to test the concept, examine its sustainability, and explore how the model might look and be assessed for its potential (McClellan et al., 2010). Australia shares this goal and, currently, Australian healthcare has a vision to provide a new paradigm of healthcare based on integrated, person-allied, distributed, and coordinated care delivery (Blatt, Dishman, & Wilson, n.d.). However, this concept is challenging, especially when applied into solo and small-group practices, given the set up cost required such as IT (information technology) investment and quality improvement training for staff (Shields, Patel, Manning, & Sacks, 2011). In view of this critical challenge, low-cost technology solutions that require little infrastructure are preferable. Hence, we examine the possibility of using a mobile Web-based reporting system that leverages existing available resources (e.g., smartphones and cloud systems) and, thus, requires minimal IT cost and/or user training. Thus, we use a pervasive mobile technology solution to address a current dilemma; namely, the support of gestational diabetes through improved accountable patient care.

Primarily, we examine the role a pervasive mobile solution might play in supporting the accountable care paradigm. To do so we specifically focus on the use of a pervasive mobile technology solution to support superior management and monitoring in the context of the chronic disease diabetes. Specifically, we investigate:

> **RQ:** How can mobile devices such as smartphones assist in preventing and/or reducing the impact of gestational diabetes (GDM)?

GDM is a type of diabetes that occurs during pregnancy and is defined as glucose intolerance that is first detected during pregnancy and affects about 5-8 percent of pregnant women (Siri & Thomas, 1999). Key considerations with gestational diabetes include the health of both the mother and the unborn child since, without proper care, there is a known increased risk for type 2 diabetes for the mother in the future and the child may also be at risk of developing type 1 or 2 diabetes later in life (Diabetes Australia, 2008, 2012). Our study focuses on GDM in adult women. Given that this age group is not only technology savvy but also in general represents a group in the population that frequently uses smartphones, we believe this is a prudent domain to focus our investigations to successfully address the study objective.

This study then serves to investigate the possibility for an innovative, easy-to-use, and cost effective solution to address a growing and serious health concern. It is one of the first studies to investigate the application of a pervasive mobile technologies to a major health problem in Australia. The proposed solution has the potential to have far-reaching implications to potentially all types of chronic diseases generally and specifically benefits the respective healthcare organizations that we involve in this study and more especially their patients by enabling them to have exclusive access to what has been described as a leading-edge technology solution for supporting superior care in managing chronic diseases.

2   Literature Review

Managing diabetes using information technologies is a relatively recent priority in the healthcare domain and the focus on diabetes has increased as this chronic disease has become one of the most prevalent and exponentially increasing diseases around the world (LeRouge & Wickramasinghe, 2013). Further, the cost of managing patients with diabetes is also considerable, largely due to the fact that, as a chronic disease, there is no foreseeable cure and that diabetes can lead to many complex co-morbidities that also require treatment (Troshani, Goldberg, & Wickramasinghe, 2012). Diabetes Australia (2012) has estimated that treating patients with diabetes costs the country over AUD$14.6 billion each year and that complications can increase this cost even further by at least AUD$9,645 per year per individual. Because diabetes is a chronic disease, there is by definition no cure; patients look forward to a reduced life quality for the rest of their life and to the real possibility of developing many of the unpleasant complications that can arise with long-term diabetes (Diabetes Australia, 2012). At the same time, from a healthcare management perspective, this scenario translates into significant costs for the respective health systems in Australia to bear and indirect societal costs that represent productivity losses for both patients and their careers (DiabCost Australia, 2002; Diabetes Australia, 2013). For this reason, an effective management system that enables early detection and supports pro-active management of diabetes is essential (Geisler & Wickramasinghe, 2009; AIHW, 2008).

2.1   Management of Diabetes

Generally, managing diabetes is based on a mixture of self-management protocols linked with the support of a dedicated medical care team (Victorian Government, 2007). An essential element of self-management relies on regular testing of blood glucose by using a glucometer or blood glucose monitor to enable better assessment and control of blood glucose and, thus, prevent further complications. Blood glucose tests are usually completed before meals, but, depending on how the diabetes is managed (diet only, insulin injections, insulin pumps), numerous blood tests may be conducted each day. Current blood glucose monitors can store individual glucose readings as a record over a period of time. More recently, we have seen monitors incorporate analysis tools for tracking trends based on these readings (e.g., Aviva Expert: https://www.accu-chek.co.uk/gb/products/metersystems/avivaexpert.html). Mobile apps are also used as diaries or records of these daily glucose readings (e.g., Glucose Buddy: https://itunes.apple.com/us/app/glucose-buddy-diabetes-helper/id294754639?mt=8). Continuous glucose monitoring systems continue to develop and provide the diabetic with trend information on their daily glucose patterns. Each of these approaches provides information that the diabetic needs to assess and interpret as part of their regular managing their diabetes. This information is complemented by other clinical tests such as the HbA1c, which measures longer-term glucose management (d'Emden et al., 2012). Such tests are managed by the clinical care team, and, generally, the daily self-recorded glucose information and the longer term clinical information is compared only during patient-clinician appointments. Glucose monitors provide increasingly more information and analysis tools to support individuals in self-managing their diabetes. However, feedback on this information by members of the clinical team tends to be limited because most of the self-managed information is "offline" to the clinical team or made available only in batch uploading. We suggest that using mobile communication to make self-managed readings accessible in real time to a clinical team may assist in managing and controlling diabetes

2.1.1   Gestational Diabetes Mellitus

Gestational Diabetes Mellitus (GDM) requires tight control of blood sugar levels, with a preferred range of readings between 4-6 mmol/L (Hoffman, Nolan, Wilson, Oats, & Simmons, 1998; Siri & Thomas, 1999). GDM is managed over a short period of time (typically only the last eight weeks of the pregnancy). Thus, a tighter control of sugar levels is required in the GDM context because of the impact of high blood sugar to not only the mother but also the developing foetus; poor control of sugars can lead to serious and far-reaching unpleasant consequences for the newborn baby. The need for such control draws into question the information that a diabetic may need when self-managing their condition.

Despite all the existing methods and technologies in the market, we need to maximize the benefits of digital convergence by providing a cost-effective solution that is convenient to both patients and clinicians, supports patient self-empowerment, and is minimally disruptive to patients' lifestyle. Hence, INET International developed a pervasive technology solution to facilitate patient empowerment with their diabetic care. Succinctly, the solution uses pervasive mobile technology to transfer critical information

between patient and providers so that superior monitoring may ensue. This solution has proved successful in Canada and the US (Wickramasinghe & Goldberg, 2004, 2007). We contend that a pervasive technology solution can not only enable ubiquitous (anytime, anywhere, anyplace) monitoring GDM patients but also provide them with accountable care service.

2.2   Accountable Care System

An accountable care system (ACS) refers to an entity that implements organized processes to improve and control the quality of care and cost and that, more importantly, holds the providers accountable for the results (Shortell & Casalino, 2008). Specifically, the term "system" refers to the care that must be established and delivered by healthcare providers (e.g., physicians, clinicians, nurses) and settings (e.g., hospital and nursing homes) over time with accountability to ensure quality care with reduced costs (Shortell & Casalino, 2008; McClellan et al., 2010; Shields et al., 2011).

An examination of the literature suggests that many studies look into the importance (Shortell & Casalino, 2008), application (Shields et al., 2011), and execution of the accountable care system (McClellan et al., 2010; Lewis, McClurg, Smith, Fisher, & Bynum, 2013), ethical challenges for ACOs (DeCamp et al., 2014), and its quality performance standard (Berwick, 2011). However, issues such as how quality of care is being defined and measured remain vast and unclear (Dentzer, 2013). More importantly, doctors' decisions are not always based on evidence and, in fact, only 55 percent adhere to evidence-based care (Asch, Kerr, & Keesey, 2006).

The pressure to provide evidence-based care has significantly impacted the medical sector over the past decade (Wickramasinghe & Schaffer, 2010). Much research is being conducted to understand what it is, how it will impact medical practices, what its challenges are, and how it could benefit people, organizations and society (Pfeffer & Sutton, 2006; Shortell & Casalino, 2008; Wickramasinghe & Schaffer, 2010). Traditionally, evidence-based management is complimented with online services and technology (Jadad, Haynes, Hunt, & Browman, 2000). In this context, quality of care and cost was often being compromised (Jadad et al., 2000). In this study, to overcome such an issue in achieving affordable care, we need a bridge between evidence-based care and technology that can then support the paradigm of accountable care. In view of this idea, we propose a conceptual model (Figure 1) to explore our research question. Accountable care "may involve a variety of provider configurations, ranging from integrated delivery systems and primary care medical groups to hospital-based systems and virtual networks of physicians such as independent practice associations" (McClellan et al., 2010, p. 983). Managing GDM calls on a range of such provider configurations including formal patient/health provider meetings and self-testing and the management of glucose readings. In this research, we examine the use of virtual network and communication through mobile and Web-based technology as a means to support and enhance patient care. In the framework of an accountable care system, such technology may allow increased patient support and care through continuous monitoring and professional feedback but in a paradigm that has minimal impact on delivery's financial needs.

Figure 1. Concept Model

2.3 Conceptual Model

McClellan suggests that "clinical transformation is the linchpin of ACOs' [accountable care organizations'] success" (McClellan, et al., 2013 p. 988) and that such a transformation "requires effective investment in infrastructure, process and organizational redesign, and other clinical activities to achieve delivery reforms that can actually produce needed improvements in care (for example, enhanced preventive care, better care transitions, and chronic disease management)" (McClellan et al., 2013, p. 989). McClellan sees that organizations that adopt an accountable care framework need to extend their IT healthcare systems so that they can manage more detailed clinical data as a means to improve healthcare. Researchers have developed several frameworks to support accountable care systems, including models for assigning patients to ACO using prospective and performance year methods (Lewis et al., 2013) and an accountable care paradigm to support implementation (Muhlestein et al., 2013).

The accountable care paradigm that Muhlestein et al. (2013) propose defines the movement in terms of structural requirements, core processes, and expected outcomes and presents these items as three tiers or levels: (1) "outcome measurements", (2) "process-level care management", and (3) "aligned financial structures". It is a reasonable framework on which we build our paper because we suggest that, to further develop this accountable care paradigm, quality of care should also be a focus and should include (1) quality of life, (2) evidence-based management, and (3) affordable care.

The first level of the accountable care paradigm is about **accountable care outcome measurements** (Muhlestein et al., 2013). It comprises three criteria: (1) improving the individual experience of care, (2) improving the population health, and (3) reducing the cost of healthcare for populations (Muhlestein et al., 2013). With these criteria, we believe that healthcare delivery can further improve individuals' quality of life. Usually, patients have little or no control over the cost of their care and almost no information available to them regarding the cost or quality of care delivered by their provider(s) or care giver(s) (Bozic, 2013). For this reason, we believe that, for some health issues, the ability to measure accountable care outcomes requires the care providers and givers avail patients with several treatment options that are based on the service the patients receive and costs involved. This provides patients with options as to how they can live a better-quality life.

Process level care management is the second level of the accountable care paradigm (Muhlestein et al., 2013). This level comprises three criteria: (1) overseeing the provision of clinical care, (2) adopting an administrative infrastructure to coordinate the provision of care across the continuum of health services, and (3) investing in and learning to use appropriate information technology to manage the population's health. To enhance the quality process level of care management, we suggest including the concept of evidence-based management. Especially with the empowerment from technologies, many physicians today are able to capitalize on rich online information to build expert communities for knowledge and best-quality evidence and to share information with care givers and patience directly. To better amalgamate evidence-based management into process level care management, we incorporated Rousseau's (2013) suggestion of "managing user expectation" through providing models of evidence-based practice that promote the active use of evidence and build collaboration among all users. In this study, users include physicians, nurses, and pregnant mothers.

The last level of accountable care paradigm is about **aligning financial structures** (Muhlestein et al., 2013). Specifically, it entails: (1) bearing financial risk for the measured health of a population, and (2) aligning financial and professional incentives to encourage the production of high-quality health outcomes. Since these two criteria concern a wider research scope that includes revising government policy and partnership between health plans and providers, we leave this section for future research. However, what is more relevant here is to incorporate affordable care by providing choices in finding plans that are cost-effective and appropriate to consumer needs. For example, using a smartphone approach may be a cheap option for patients who require regular health monitoring to record and communicate with health practitioners, which may become evident if compared to other more dedicated or sophisticated technology that usually comes at a higher cost.

As we suggest above, Muhlestein et al.'s (2013) model can act as a framework for examining how technology can support evidence-based care and reinforce McClellan et al.'s (2002) call for "clinical transformation". In this paper, the change agent we investigate is the addition of real-time glucose feedback for GDM patients. The technology intervention bridges current diabetic practice of self-glucose monitoring and "batched" clinical feedback from patient/clinician visits by providing real-time communication between patients and their clinical team. The need for GDM patients to maintain tight

control of glucose levels can be supported by clinical feedback and intervention on an ongoing basis. In a similar way that continuous glucose monitoring can provide regular information to help some diabetic patients to monitor glucose trends, the mobile solution we pose in this paper provides a communication channel for a clinical team to monitor the glucose control needs of a GDM patient. While it is not a continuous glucose reading, it is a framework for ongoing communication with the clinical team. This communication has the potential to improve patient care via using existing technology (smartphone and current glucose monitors) and a cloud-based information management platform and, thus, meet Muhlestein et al.'s (2013) framework levels.

3   Methodology

As part of our ongoing effort to understand changes occurring in the Australian healthcare system, we have been identifying and tracking healthcare organizations that appear to practice at least some aspects of accountable care from the Australian perspective. As such, we identified AusHospital (name anonymized) because we believe that it showed unique characteristics with regard to accountable care. In fact, the hospital's medical staff initiated and appreciated many of its aspects.

On selecting the specific hospital to evaluate, we adopted a user-centered design approach to develop a unique mobile solution to support GDM patients to self-manage their condition. Specifically, we adapted the Web-based mobile solution developed over several years by INET International (Goldberg, 2002; Wickramasinghe & Goldberg, 2008; Wickramasinghe, Troshani, & Goldberg, 2010). In particular, the solution works as follows (Figure 2): after the patient has taken their blood sugar reading using a glucometer, they enter the reading into a Web-based form designed for smartphones. The submitted reading is then accessible to the designated clinician who can then review the readings in conjunction with all other relevant medical data to provide immediate feedback and recommendations to the patient. Such recommendations pertain to food intake, exercise, and/or insulin titration. Figure 2 illustrates the charted record of patient readings that the clinician can access. The chart displays the four readings normally taken for GDM patients (i.e., before breakfast, two hours after breakfast, two hours after lunch, and two hours after dinner). The mobile interface also allows patients to write messages about their food and exercise consumption, and the clinician can review this information and provide additional feedback to the patient. All of this communication is managed through the mobile solution and provides a health model that can immediately support patients remotely located from the hospital setting.
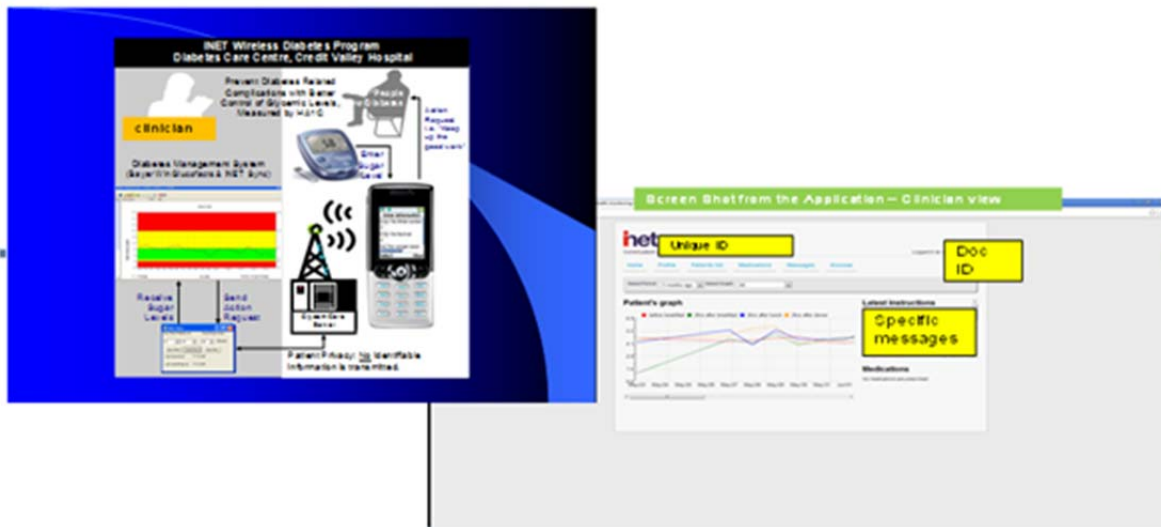

Figure 2. The Solution in a Nutshell

We adopted this specific mobile solution because it is independent of a specific mobile platform (i.e., it is pervasive in nature); instead, it uses the phone's (and, if needed, computer's) Web browser for data input. The solution is also independent of the device used for glucose testing. While future developments could adopt mobile app-based or glucose device-driven interfaces for inputting data, the current platform helps patients more easily adopt the solution because it is not tied to a single glucose of mobile technology. This pervasive quality makes the solution particularly consistent to an accountable care paradigm.

Once we correctly calibrated the solution to the local environment at AusHospital, we then trialed it using a two-arm, two-period cross-over clinical trial strategy after we obtained all necessary ethics clearances (Rigby, 2003; Senn, 2002) over 10-week duration. Research studies have shown (Rugby, 2003; Senn, 2002) that, when testing the usability and fidelity of a technology solution for a healthcare context, a two-period cross-over study research design is prudent because it enables all participants to have experience with and without the technology solution. The two arms (standard care and technology with standard care) are required so that it is possible to have one group start with the standard care and then progress to the technology with standard care solution and the other group start with the standard care with technology solution and then change to the standard care solution. Such an approach enables an internal validity check (Rugby, 2002; Senn, 2002). We chose the 10-week timeframe since most patients are diagnosed with GDM when they are around 26 weeks' pregnant; as such, the 10-week timeframe then enabled us to get a five-week timeframe for each cross over before the due date. Finally, the ethics committees at both the hospital and our university and the obstetricians involved cleared our study design.

In Australia, pregnancy studies require the highest level of ethics clearance by law. The ethics clearance approved 10 GDM patients to be recruited into the study on the approval of their consulting obstetrician. We deemed 10 to be sufficient to establish proof of concept while noting it would not provide statistical significant results at this point. However, we thought that, once proof of concept had been established, it would be possible to embark on a large-scale trial. Once the patients were identified as appropriate and "medically safe" to participate in the study, we then randomly allocated them to one of two trial groups—the study's technology arm or standard care arm. Patients in the standard care arm followed recognized current practices for treating patients with GDM at AusHospital, which primarily focused on patients reporting a batch of glucose reading at the physical time of their meeting with medical practitioners. Patients in the technology arm of the study, in addition to following the recognized practices in the standard care arm, also used the smartphone solution. In this way, we could capture the benefits of the technology solution over the existing standard care protocols. We briefed both groups of patients on critical factors for GDM care and management and gave them a questionnaire to complete before they began monitoring and managing their GDM. After five weeks, cross over took place, at which time we introduced the standard care arm to the technology and the initial technology arm to the standard care protocols. At this time, we provided participants with a cross-over point questionnaire. At the end of the 10-week period, we debriefed all patients and asked them to complete a final questionnaire. In addition, we asked all clinicians including obstetricians, diabetic nurses, and endocrinologists to complete a pre- and post-study questionnaire based on their observations and interactions. Some of the patients required insulin, and we programmed the mobile solution to support insulin titration and advise patients regarding their specific prescribed insulin. This trial took two years to complete given that we recruited patients as they presented to the clinic and we screened/approved them to be suitable for the study (i.e., it was not possible to at the same time have all 10 pregnant patients with GDM to commence the trial at the same time).

4 Results and Discussion

All patients preferred the technology solution irrespective of whether they started in the study's technology arm or standard care arm. Further, using the smartphone solution, clinicians and patients could more quickly and easily recognize out-of-range blood sugar readings. Patients who started with the mobile solution found it difficult to go to the standard care solution. Although the sample size (10 patients) was too small for statistical significance, we not only established proof of concept but also demonstrated the benefits of a real-time smartphone solution to help GDM patients self-manage and monitor their condition. The clinical care team (obstetricians, diabetic educators and endocrinologists) preferred the technology solution over the standard care approach: they noted that it enabled them to better keep track of patients and quickly recognize if there were problems developing and/or be able to reassure patients that all was okay. Both patient and clinical users had further suggestions at the study's conclusion for further additions to the technology solution's features and capabilities. Clearly, the small sample size is a limitation; however, given the very stringent ethics requirements concerning pregnancy-type studies, we could only run a small pilot initially to establish proof of concept. Armed with our positive results, we plan to embark on a larger study.

Based on the research method we used, we mapped the collected results with the affordable care paradigm. We found that the smartphone solution supports the affordable care paradigm at multiple levels.

The first level of the accountable care outcome measurements is based on **improved individual experience of care** and **improved population health** (all sufferers of GDM in this context) on maximizing outcomes and control costs. For example, one of the patients noted that "having the mobile phone to monitor my sugar helps me to plan my day and eating and stick to this plan" . In addition, we noted that **reductions in healthcare delivery cost** include less face-to-face consultation required with a similar-quality (and, according to some of the patients, better) outcome. Thus, with pervasive technology, patients can reduce their associated costs such as their time and traveling costs for their weekly consultation, increase their accessibility to their doctors and caregivers' advice at no extra cost 24 hours, seven days a week, and have a better level of peace of mind, which is especially significant in pregnancy-related health issues. These results address the issues of patients having no control over the cost of care and almost no information available to them as in Bozic's (2013) study. Thus, in our study, we show how, the Australian GDM patients can benefit by having a better quality of care and enjoying better health for themselves and their babies. Note, however, that, in this context, there was no additional risk to mother or baby in terms of the pregnancy or quality of care because no reduction of visits to consult with the patient's obstetrician occurs and so the patients at all times felt very comfortable with the quality of care they received. What was reduced were the additional medical visits. During pregnancy, these additional medical visits are time consuming and a hassle for patients, while, for healthcare, they represent an extra cost burden. It appears the pervasive technology solution offers the possibility for a best-of-both-worlds solution; namely, access to the best care (which does not compromise the mother and her baby's health) and convenience and cost effectiveness.

Process level care management is the second level of the accountable care paradigm (Muhlestein et al., 2013). At this level of care management, we see that using the digital convergence concept with smartphones and a cloud system is not only cost effective but also user friendly for both patients and clinicians. Based on our study, smartphone technology has demonstrated its ability to (1) provide quality clinical care, (2) facilitate the adoption of an administrative infrastructure to better co-ordinate care, and (3) low or essentially no learning curve because there is minimal need for the patient to invest in and learn how to use the mobile solution to manage their health issue. Succinctly, the solution uses pervasive mobile technology to transfer critical information between patient and providers so that they can better monitor the patients' health. Through this study, we contend that a pervasive technology solution that can not only enable GDM patients (and their clinicians) to ubiquitously (anytime, anywhere, anyplace) themselves but also provide them with process-level care management. To enhance the quality process level of care management, we include the concept of evidence-based management in this study. Our results show that the physicians were able to capitalize on the rich online information with Internet connections to consult and diagnose patients with best-quality evidence. They were able to manage patients' expectation, provide models of evidence-based practice, and actively use evidence, which subsequently built strong collaboration among all users (Rousseau, 2013).

Aligning financial structures (Muhlestein et al., 2013) is the third and last level of the accountable care paradigm. In this study, we incorporated affordable care by using a smartphone app that offers a cheaper and simpler option for patients who require regular health monitoring to record and communicate with their health practitioners. This affordability of care becomes evident if compared to other more dedicated or sophisticated technology that usually not only comes at a higher cost but also requires additional learning curve to use it.

From the perspective of measured outcomes of accountable care, it appears that using smartphones as a health monitoring and communication channel not only improved the patient experience but potentially provided them with a better quality of life. That is, patients with pertinent information were able to receive timely evidence-based medical feedback, understand the result, and take appropriate actions in controlling their blood sugar level. On a large scale, such results will serve to improve the population's health in a way that helps prevent GDM and reduces the impact of the mother passing high levels of glucose to her baby in utero. Further, with such control, there is evidence of smartphones' direct potential to reduce healthcare costs for key stakeholders such as patients, their careers, and healthcare professionals.

5 Conclusion

Our research contributes to theory and practice in several ways. From the perspective of practice, this study strongly suggests that using smartphones to support GDM self-management not only helps GDM patients to better monitor and manage their condition in an affordable way with evidence-based

management but also supports the accountable care paradigm. Moreover, patients suffering from GDM can benefit by having a better quality of care and enjoying better health for themselves and their babies.

From a theoretical stand point, we unpack McCleallan et al.'s (2010) study with our conceptual framework that includes providers for information (evidence-based management) and technology (smartphone), which are jointly held accountable for a defined population in achieving measurable healthcare quality improvements with reductions in healthcare spending. Further, we enhance Muhlestein et al.'s (2013) accountable care paradigm with the three concepts of (1) quality of life, (2) evidence-based management, and (3) affordable care, and we address the issue of control over the cost of care and information accessibility, which Bozic's (2013) does not address.

Finally, in terms of managerial contributions, the study uncovers far-reaching implications for hospital management as they currently wrestle with the orthogonal dilemmas of controlling costs and providing high-quality care and value to patients. In particular, it would appear that they should investigate the possibility of adopting smartphones to support many aspects of care and patient-clinician interactions.

In closing, we note that this was a small pilot study and one of the first of its kind to be run in Australia to investigate the potential of smartphones to support the affordable care paradigm in managing and monitoring GDM. Clearly, we need more confirmatory research to generate statistically significant results and investigate the wider issues including revising governmental policy and investigating the implications for contractual arrangements between health plans, healthcare organizations, and providers. We plan to investigate such things in future research.

Acknowledgments

www.manaraa.com

References

AIHW. (2007). *National indicators for monitoring diabetes: Report of the diabetes indicators review subcommittee of the national diabetes data working group.* Canberra: AIHW.

AIHW. (2008). *Diabetes: Australian facts (2008).* Canberra: Australian Institute of Health and Welfare.

Asch, S. M., Kerr E. A., & Keesey J. (2006). Who is at greatest risk for receiving poor-quality health care? *New England Journal of Medicine*, *354*(11), 1147-1156.

Baker IDI. (2012). Diabetes: *The silent pandemic and its impact on Australia*. Retrieved from http://www.diabetesaustralia.com.au/Documents/DA/What's%20New/12.03.14%20Diabetes%20management%20booklet%20FINAL.pdf

Berwick, D. M. (2011). Launching accountable care organisations—the proposed rule for the medicare shared savings program. *The New England Journal of Medicine*, (364)16, e32.

Blatt, M. N., Dishman, E., & Wilson, B. (n.d.). Accountable care organisations and beyond: IT Strategies for 21th century healthcare. *Intel.* Retrieved from http://www.intel.com/Assets/PDF/whitepaper/325069

Bozic K. J. (2013). Orthopaedic healthcare worldwide improving value in healthcare. *Clinical Orthopaedics and Related Research*, *471*, 368-370.

d'Emden, M.C, Shaw, J.E, Colman, P.G, Colagiuri, S., Twigg, M., Graham R. D. J., Goodall, I., Schneider, H. G., & Cheung, N. W. (2012). The role of HbA1c in the diagnosis of diabetes mellitus in Australia. *The Medical Journal of Australia*, *197*(4), 220-221.

DeCamp, M. Farber, N. J., Torke, A. M., George, M., Berger, Z., Keirns, C. C., & Kaldjian, L. C. (2014). Ethical challenges for accountable care organisations: A structured review. *Journal General Internal Medicine*, *29*(10), 1392-1399.

Dentzer, S. (2013). America's health deficit: Dying from policy neglect. *Health Affairs*, *32*(3), 446.

Diabetes Australia. (2012). *Managing gestational diabetes.* Retrieved from http://www.diabetesaustralia.com.au/living-with-diabetes/gestational-diabetes/

Diabetes Australia. (2008). *Diabetes in Australia*. Retrieved from http://www.diabetesaustralia.com.au/Understanding Diabetes/Diabetes-in-Australia/

Diabetes Australia. (2013). *A national diabetes strategy and action plan*. National Expert Advisory Group. Retrieved from https://static.diabetesaustralia.com.au/s/fileassets/diabetes-australia/e549bdb8-0f80-46f8-b827-35cb4f1b6cd2.pdf

DiabCost Australia. (2002). *Assessing the burden of type 2 diabetes in Australia*. Australia, Adelaide.

Geisler, E., & Wickramasinghe, N. (2009). *The role and use of wireless technology in the management and monitoring of chronic diseases.* Washington, DC: IBM Center for the Business of Government.

Goldberg, S. (2002). *Building the evidence for a standardized mobile Internet (wireless) environment in Ontario, Canada*. Ontario, Canada: INET.

Hoffman, L., Nolan, C., Wilson, J. Oats, J., & Simmons, D. (1998). Gestational diabetes mellitus—management guidelines. *Medical Journal of Australia*, *169*(2), 93-97

Jadad, A. R., Haynes, R. B., Hunt, D., & Browman, G. P. (2000). The Internet and evidence-based decision-making: A needed synergy for efficient knowledge management in health care. *Canadian Medical Association Journal*, *162*, 362-365.

LeRouge, C., & Wickramasinghe, N. (2013). A review of user-centered design for diabetes-related consumer health informatics technologies. *Journal of Diabetes science and Technology*, *7*(4), 1-18.

Lewis, V. A, McClurg, A. B., Smith, J., Fisher, E. A., & Bynum, J. P. W. (2013). Attributing patients to accountable care organisations: Performance year approach aligns stakeholders' interest. *Health Affairs*, *32*(3), 587-595.

McClellan, M. McKethan, A. N, Lewis, J. L., Roski, J., & Fisher, E. S. (2010). A national strategy to put accountable care into practice. *Health Affairs*, *29*(5), 982-990.

Morse, G. (2010). Ten innovations that will transform medicine. *Harvard Business Review*. Retrieved from http://blogs.hbr.org/cs/2010/03/health_care_of_the_future.html

Muhlestein, D. Croshaw, A. Merrill, T., Pena, C., & James, B. (2013). *The accountable care paradigm: More than just managed care 2.0. Leavitt Partners*. Retrieved from http://leavittpartners.com/wp-content/uploads/2013/03/Accountable-Care-Paradigm.pdf

Pfeffer, J., & Sutton, R. I. (2006). Evidence-based management. *Harvard Business Review*, *84*(1), 62-74.

Rigby, A. (2003). Cross-over trials in clinical research. *Journal of the Royal Statistical Society, 52*(3), 417-418.

Rousseau, D. M. (2013). Is there such a thing as "evidence-based management"? *Academic of Management Review*, *31*(2), 256-269.

Senn, S. (2002). *Cross-over trials in clinical research* (2nd ed.). New York: John Wiley and Sons.

Shortell, S. M., & Casalino, L. P. (2008). Health care reform requires accountable care systems. *Journal of the Americal Medical Association*, *300*(1), 95-101.

Shields, M. C., Patel, P. H., Manning, M., & Sacks, L. (2011). A model for integrating independent physicians into accountable care organizations. *Health Affairs*, *30*(1), 161-172.

Siri, L., & Thomas, A. (1999). Gestational diabetes mellitus. *New England Journal of Medicine*, 341(23), 1749-1756.

Troshani, I., Goldberg, S., & Wickramasinghe, N. (2012). A regulatory framework for pervasive e-health: A case study. *Health Policy and Technology*, *1*, 199-206

Victorian Government. (2007). *Diabetes prevention and Management: A strategic framework for Victoria 1007-2010*. Melbourne.

U.S. Department of State. (2015). Infectious and chronic disease. Retrieved from http://www.state.gov/e/oes/intlhealthbiodefense/id/

Wickramasinghe, N., & Goldberg, S. (2004). How M=EC2 in healthcare. *International Journal of Mobile Communications*, *2*(2), 140-156.

Wickramasinghe, N., & Goldberg, S. (2007). Adaptive mapping to realisation methodology (AMR) to facilitate mobile initiatives in healthcare. *International Journal of Mobile Communications*, *5*(3), 300-318

Wickramasinghe, N., & Goldberg, S. (2008). Facilitating superior chronic disease management through a knowledge-based systems development model. *International Journal of Electronic Healthcare*, *4*(3/4), 299- 311.

Wickramasinghe, N., Troshani, I., & Goldberg, S. (2010). An investigation into the use of pervasive wireless technologies to support diabetes healthcare. In A. Coronato & G. De Pietro (Eds.), *Pervasive and smart technologies for healthcare: Ubiquitous methodologies and tools* (pp. 114-129). New York: IGI Global.

Wickramasinghe, N., & Schaffer, J. (2010). *Realizing value driven e-health solutions.* Washington, DC: IBM Center for the Business of Government

World Health Organization. (n.d.). *World diabetes day 2013.* Retrieved from http://www.who.int/diabetes/en/

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