Closing the Knowledge Gap:
Internet-based Diabetes Self-Management Support System
led by Community Pharmacist

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Abstract

Better, sooner and more convenient healthcare services for people with diabetes is one of the New Zealand Government’s top health targets. The main clinical problem in diabetes management is the existence of a knowledge gap between what is being expected and what is actually being done. A literature search was carried out to identify relevant literature to support the proposed development of an Internet-based Diabetes Management Support System (DMSS) to better manage knowledge in diabetes self-care.

Based on the concepts of knowledge management DMSS, led by a diabetes trained health professional, could help bridge the knowledge gap by improving the way that knowledge is disseminated and translated. Through effective empowerment strategies patients could make better decisions on self-care practice that result in better health outcomes for the long term.

The community pharmacist is a potential primary care provider to lead DMSS, and having the prerequisite knowledge in diabetes care is essential for successful outcome. As not all pharmacists are trained in diabetes care, it is difficult to conclude that DMSS led by community pharmacists can close the knowledge gap. Evaluation using a longitudinal study is warranted to investigate the long-term effects of such a development led by pharmacists specialised in diabetes.

1. Introduction

Diabetes mellitus is a medical condition of long duration and slow progression. It is estimated that more than 200,000 people in the population of New Zealand (NZ) are diagnosed with diabetes [1]. Over time, diabetes-related complications such as retinopathy, neuropathy, nephropathy and vascular diseases may arise due to uncontrolled diabetes. This long-term condition causes a significant economical impact on the health system and better diabetes service is one of the top national health targets [1].

The primary goal of diabetes management is effective glycaemic control and management of risk factors associated with diabetes-related complications. This requires a combination of dietary and lifestyle modifications, and ongoing monitoring of drug therapy to achieve long-term optimised health outcomes [2].

In diabetes management, general practitioners (GPs) and nurses are responsible for providing ongoing monitoring of drug therapies and screening for diabetes complications; however, more than 95% of diabetes care is carried out by the patient at home [3]. Self-care of diabetes is crucial to keep the disease under control and prevent unnecessary diabetes-related complications. There are four aspects of self-care which include: self-monitoring of blood glucose, dietary variation, insulin dose adjustment, and regular exercise [4]. This indicates a vast amount of complex knowledge is involved in the process of knowledge conversion. Studies have shown that patients with diabetes generally have poor knowledge of care and that there is inconsistency in the way information is delivered to patients [5].

The main clinical problem in diabetes management is the existence of a knowledge gap between what is being perceived as best practice by health professionals and what is actually being done at patient level [6]. Therefore, development of a diabetes management support system (DMSS) is proposed to help bridge the gap by improving the way that knowledge is disseminated and translated. Effective translation could have a positive influence on a patient’s decision making about self-care practice, and through effective empowerment strategies patient could achieve better diabetes management in the long term. An exploration of knowledge management concepts is carried out in this literature review to further understand how the proposed DMSS may lead to better diabetes self-management.
The Ministry of Health has recently called for better, sooner, more convenient healthcare services for patients in the community [7]. The new direction was targeted at the primary healthcare workforce (GP’s, nurses, pharmacists, physiotherapists and other health professionals in the community) to effect care collaboration through better access to health information and advanced information and communication technologies. The community pharmacist, one of the most trusted and accessible primary healthcare professionals in the community [8], with the assistance of a DMSS pharmacist, could act as the first point of contact for better, sooner and more convenient diabetes service.

2. Method
The literature search was conducted primarily through the MEDLINE, PUBMED, NHS Evidence databases using the following keywords: diabetes, self-care, blood glucose, Internet, patient empowerment, knowledge management and pharmacist. Keywords were combined by AND to fine-tune the search results. Secondly, more articles were identified through the reference lists of included articles and links to related citations. Citations were limited to English, between year 1990 to 2012 but not limited to the type of diabetes. Clinical trials were limited to randomised controlled study for period longer than three months. The literature was reviewed and then selected based on relevancy.

3. Literature Reviews
Two approaches commonly used to influence patient decision making on diabetes self-management are self-monitoring of blood glucose (SMBG) and empowerment-based diabetes education. Evidence for the effectiveness of these approaches and overseas models of Internet-based DMSS were reviewed to support the proposed development of an Internet-based DMSS.

3.1. Evidence for the Effectiveness of Diabetes Self-Management Tools

3.1.1. Glycaemic Control and Internet-based Self-Monitoring of Blood Glucose (SMBG)

The measurement of HbA1c is perceived as the gold standard for monitoring glycaemic control and gives an indication of the risk of developing diabetes-related complications [2]. SMBG provides immediate feedback to patients about the effects of food choices, activity and medication on glycaemic control. It is an important tool that guides the day-to-day management of blood glucose.

The use of an Internet-based blood glucose monitoring system (IBGMS) in adult patients with type-2 diabetes treated with insulin demonstrated significant improvement in HbA1c at six months [9]. Participants were instructed to report their HbA1c results on a secure website every two weeks and the results were presented in a graphical format for easy interpretation. The results were monitored by an endocrinologist, who provides feedback on insulin adjustment, testing frequency and gives encouragement. Consistent results were demonstrated in other IBGMS studies [10, 11] and its long term effect was proven to be superior to conventional diabetes care for controlling blood glucose and achieving glucose stability. Interestingly, similar studies [12, 13] on adolescents with type-1 diabetes mellitus who were followed-up by a study coordinator and a practice nurse for six and nine months respectively via a telemedicine support, had failed to demonstrate a statistically significant difference in glycaemic control compared to non-intervention groups. However, both studies reported that telemedicine support is feasible and acceptable to patients.

Timely and personalised interaction between patients and healthcare providers was reported to increase patients’ frequency in blood glucose monitoring over a web-based DMSS [14].

3.1.2. Structured Education and Empowerment

Patient empowerment is defined as helping patients discover and develop the inherent capacity to be responsible for one’s own life [15]. It is designed to facilitate self-directed behaviour modification by providing patients with the knowledge and skills, and the responsibility to effect change. The empowerment approach helps diabetic patients to set realistic goals and make behaviour changes such as weight loss, nutrition, and physical activity, to better manage their life long condition. The foundation principles of empowerment [16] suggest the greatest impact on the patient’s health and well-being is a result of their self-management decisions and actions during the routine conduct of their daily lives. Because patients are in control of their daily self-management decisions, they are responsible for those decisions and the resulting consequences. The healthcare professional is therefore only there to ensure that patients are empowered with the knowledge to influence self-care decision making.
Empowerment-based diabetes self-management education programs have reported improved glycaemic control and reduced risk in diabetes-related complications at the end of three- to six-month trial periods [17, 18, 19]. Education delivered was about medication adherence, medication use problems, self-monitoring of blood glucose and lifestyle modifications. Improvements in diabetes-associated self-efficacy and self-care were also noted. There was a significant increase in participants’ confidence to manage their diabetes and they felt motivated to take action to maintain optimal blood glucose levels. Conversely, improvement in glycaemic control in studies [20, 21] of longer trial periods up to three years were insignificant compared to conventional care.

A self-management education program led by community pharmacists who received diabetes management training reported similar results [22]. Patients who were newly diagnosed with diabetes reported that they gained a lot of knowledge from the program. In contrast, patients who had had diabetes for a number of years reported that while the program did not increase their knowledge on diabetes, it increased their motivation to improve the management of their diabetes. The intervention group, delivered by pharmacists who received credentialed training, was associated with greater improvement compared to the group delivered by pharmacists who had not received the same level of training [23]. It was noted that improvements declined at about six months after initiation of the study, followed by a rebound at twelve months of no intervention and yet another decrease at 24 months during follow-up [23, 24].

All of the studies acknowledged the essential role of the experienced and trained diabetes educators in the delivery of the programs. It was noted that medical information and physiological facts solely do not warrant patient empowerment and self-management. Educational strategies such as interactive teaching, problem solving and individualised education are the best strategies to increase patient involvement in self-management [25]. Continuous and personalised feedback is also an important factor that influences patients’ engagement in educational programs [26].

### 3.2. Overseas Models of Internet-based Diabetes Management Support System

DMSS demonstrated in this section are web-based computerised decision support systems (DSS) being used by clinicians to give feedback or advice on insulin dose; they are also accessed by patients to use as a tool for self-management of diabetes. Other features of these systems are to facilitate knowledge dissemination and communication between the patients and the facilitators. By using the system, patients can record and experiment their own blood glucose data, adjusting insulin doses or meal sizes, and thereby learning how to manage various situations through their experience. Data being entered in the system is presented in tabular/graphical format and translated into meaningful recommendations. Among all of the studies, patients were supported throughout the trial period by a trained health professional and personalised recommendations were given to patients in a timely, regular manner. Table 1 gives an overview of overseas models of Internet-based DMSS.

<table>
<thead>
<tr>
<th>DMSS</th>
<th>Study Features</th>
<th>Evidence</th>
<th>Reference</th>
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<tbody>
<tr>
<td>DiasNet</td>
<td>Denmark, 2006</td>
<td>Increase in confidence</td>
<td>[27]</td>
</tr>
<tr>
<td></td>
<td>Six-months n = 7</td>
<td>Improved diabetes self-management</td>
<td></td>
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<td></td>
<td></td>
<td>Increased awareness of food choices</td>
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<td>Closer follow-up of diabetic patients</td>
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<tr>
<td>Regional DMS</td>
<td>Finland, 2006</td>
<td>Improved cardiovascular risk factors</td>
<td>[28]</td>
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<td></td>
<td>Twelve-months n = 175</td>
<td>Results achieved with fewer patient visits to doctors</td>
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<td></td>
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<td>Improved glycaemic control equivalent to usual care</td>
<td></td>
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<tr>
<td>Karlsburg Diabetes Management System (KADIS)</td>
<td>Germany, 2006</td>
<td>Improved glycaemic control</td>
<td>[29]</td>
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<tr>
<td></td>
<td>Three-months n = 49</td>
<td>Superior than continuous glucose monitoring system</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>alone</td>
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<tr>
<td>Computerised Enocrinologist-supported system</td>
<td>USA, 2005</td>
<td>Improved glycaemic control over a two-year period</td>
<td>[30]</td>
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<tr>
<td></td>
<td>Three-years n = 4138</td>
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4. Discussion

This literature review identified some key factors when the development of DMSS or diabetes self-management interventions has shown to be important for successful outcomes. Self-management interventions were effective when paired by a health professional that underwent diabetes specific training, but the success of empowerment strategies was limited to six months only. All of the overseas Internet-based DMSS models that were studied demonstrated improvement in glycaemic outcomes, but the generalisability of the evidence is limited due to poor study design. At the end of this section, a discussion of the knowledge management (KM) concepts is carried out to further understand how patient decisions and diabetes outcomes can be influenced by self-management interventions through effective knowledge dissemination.

4.1. Results from this Literature Review

Evidence from this review suggest both IBGMS and empowerment-based education are effective tools for achieving glycaemic control when the self-management interventions were paired by a health professional that underwent diabetes specific training. Short-term improvements were achieved using empowerment strategies but its success declined within about six months after the initial intervention. Timely, interactive and personalised information was recognised as key factors for the successful outcomes, and which should be integrated in the development of DMSS.

Conflicting evidence was found between the type-1 and type-2 diabetes patients using IBGMS, and between the newly diagnosed diabetes patients and patients who had diabetes for years in education program, could be due to differences in their tacit knowledge of diabetes. The findings suggest that although IBGMS and empowerment strategies have independently shown to be useful in disseminating knowledge to patients with diabetes, individual patients have very different requirements in their needs of diabetes knowledge, and hence the human touch is essential to ensure the knowledge being delivered is customised to their need [31]. Community pharmacist-led interventions were shown to have a positive impact on patient self-management in community settings, but prior training remains the key for successful outcomes.

The computerised endocrinologist-supported system from the USA is the only study that assessed the long term effect of Internet-based DMSS over a large sample size, which reported improvement in glycaemic control over two years. Evidence from the other Internet-based DMSS studies in Table 1 was limited due to poor study design. There is a lack of robust evidence on the effectiveness of Internet-based DMSS that used both IBGMS and empowerment-based education strategies in the management model. An exploration of knowledge management concepts is therefore carried out under section 4.3 to further understand the role of diabetes self-care tools in glycaemic management and whether it would lead to positive health outcomes.

4.2. Limitations

Most participants in the IBGMS and empowerment-based education studies were self-refferred through responding to recruitment advertisements, flyers or medical records. This procedure of selection introduced bias to the findings by attracting people who are likely to be motivated to improve diabetes. Similar selection bias is also noted in the overseas DMSS models in Table 1. In addition, small sample size and short trial period, particularly the DiasNet and the KADIS models, are major limitations in the study design leading to poor generalisability of the evidence.

Secondly, significant improvement in findings only reflect the success of intensive intervention during the study period, it does not necessarily project the same outcome in real life situations where patients’ decisions are not bounded by the study condition, but independently bounded by the circumstances of everyday life. The long-term effect on diabetic patients outside the study environment is uncertain.

4.3. Implications of Knowledge Management in Diabetes Self-care

Knowledge Management is the capability by which communities capture knowledge that is critical to their success, constantly improve it, and make it available in the most effective manner to those who need it, so that they exploit it creatively and add value as a normal part of their work [32]. Sveiby [33] defined knowledge as a capacity to act. It is a process in human faculty that concerns the translation of what is known into an action, which is often based on past understanding and/or experience. Knowledge is increased through interaction with information. Human capital encompasses two types of knowledge; tacit and explicit knowledge. The tacit and explicit knowledge can be conceptually distinguished along a continuum, and the interaction between tacit and explicit knowledge is the process of
knowledge conversion [34]. Tacit knowledge covers knowledge that is unarticulated and comprises of feelings, sensations, experiences and ideas that cannot be easily captured or represented out of context. Explicit knowledge is more structured and easy to share; it can be expressed, translated and communicated between people.

In the context of diabetes management, blood glucose is tacit knowledge that is being converted into explicit knowledge when it is translated into meaningful recommendation to patients via a decision support program. During the process of interpreting blood glucose results and adjustments of insulin dose and food choices, patient acquired new knowledge in self-management by viewing and experiencing explicit knowledge. Continuous interaction with the information generates new personalised knowledge that is important to influencing on their future decision of self-management. This is a knowledge conversion process known as internalisation, the process of explicit-to-tacit knowledge, as opposed to externalisation in the process of tacit-to-explicit knowledge [35]. A patient empowerment strategy using individualised interactive educational learning is an internalisation process of knowledge conversion that causes improvement in tacit knowledge; therefore, a patient becomes intrinsically more capable in diabetes self-management. The knowledge-process-action cycle continues in the presence of new knowledge along the tacit-explicit continuum, after successful conversion, and in the absence of new knowledge input the process will slow down until new knowledge is introduced again. This explains the short-term effect of empowerment strategies. Sustainability could be improved with the presence of health professional support, not only that a personalised solution is being offered to patients regularly, but also new evidence-based knowledge can be introduced as a result of continuing professional education requirements of health professionals. Personalisation of knowledge is important for optimising solutions for individual patients and is therefore an important factor for successful knowledge management in clinical practice [36].

Knowledge dissemination is also important for its effect on individual decision making. The mechanism of decision making is perceptual and bounded by prior knowledge and experience [32, 37], effective knowledge dissemination mediated by a DMSS changes an individual’s knowledge and experience through ongoing action, practice and reflection. Effective knowledge management leads to better self-care practice, which is the key for getting the disease under control and delaying the onset of complications.

4.4. Development of Internet-based Diabetes Disease Management Support System

The main clinical problem in diabetes management is the knowledge gap between what is being perceived as best practice by health professionals and what is actually being done at the patient’s level [5, 6]. This is because health professionals and patients have very different backgrounds of tacit knowledge and so they hold varying beliefs and values in disease management, which could result in variation of practices and expectations.

A knowledge-based DMSS combining the use of IBGMS and interactive empowerment-based education led by a health professional specialised in diabetes care could help close the knowledge gap by facilitating the dissemination of knowledge, and through better knowledge translation patients’ capacity to act on diabetes issues is enhanced [38]. The proposed DMSS provides a medium for diabetes patients to connect to their health care providers, and enables them to communicate directly and promptly over the network. As the literature states that empowerment strategies were successful for only six months, through the effective communication medium patients can continuously receive personalised support and encouragement from their care providers to keep them engaged in a self-management program. Patients’ access to quality relevant knowledge is also enhanced through improved relationships with their health care providers. Following SMBG, automatic feedback to patients regarding the effects of food choices, activity and medication in relation to blood glucose results, helps translate the knowledge so that patients can readily apply it to their day-to-day self-management practice. This information being accessible over the Internet means easier access and more convenience for patients to use, which can be particularly useful for patients who live in a remote suburb or do a lot of travelling.

When considering the development of a DMSS, it is important to integrate the “Closing the C.A.R.E. G.A.P.S. F.I.R.S.T.” suggested by Orr [39], the acronym for the capacity to deliver in a coordinated fashion the integral clinical, administration, research, education functions of healthcare. It should facilitate closing the communication gaps on an ongoing basis, between all the key stakeholders in optimising care, GPs, allied health services, patients and their supports. The system should also be fast, intuitive, robust, stable and trustworthy for successful and sustainable implementation.

The Internet has emerged as a potentially effective medium for information and knowledge exchange. Critics argued that whether levels of engagement in Internet programs are sufficient to promote and sustain behaviour modification [40]. Other factors not considered in the context of this review but are important to the development of a DMSS included: national policy, government funding, information and communication technological aspects, stakeholders’ perspectives, cost-effectiveness, security and privacy issues and the stability and reliability of such a system.
Table 2 – Health knowledge Systems – Closing the C.A.R.E. G.A.P.S. F.I.R.S.T. [39]

<table>
<thead>
<tr>
<th>C.A.R.E.</th>
<th>Clinical Administration Research Education</th>
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<tr>
<td>G.A.P.S.</td>
<td>General Practitioner Allied Health Services Patients Supports</td>
</tr>
<tr>
<td>F.I.R.S.T.</td>
<td>Fast Intuitive Robust Stable Trustworthy</td>
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</table>

4.5. Diabetes Disease Management Support System led by Community Pharmacists

While evidence shows that clinical DSS provides technical support in decision making, the human touch is essential to ensure that evidence-based and personalised recommendations are delivered at the moment of care [31]. Health professionals who receive diabetes-specific training are a critical source of explicit knowledge and it is evident that diabetes management provided by them is more likely to achieve positive health outcomes. Research has shown that improvements in diabetes outcomes tend to decline within six months after initial intervention. Regular personal interaction is necessary to support the ongoing knowledge-process-action cycle, and thus to sustain improvements over the long term.

The Ministry of Health has recently called for better, sooner, more convenient healthcare services for patients in the community [7]. GPs and nurses have been the primary care providers for diabetes management services, and many other long-term medical illnesses that also require ongoing personal follow-up. The new direction enables other health professionals in the community to share responsibility and effect care collaboration through better access to health information and advanced information and communication technologies.

The community pharmacist is recognised as one of the most trusted and accessible health professionals in primary care [8]. With the assistance of a DMSS, pharmacists could expand their role and act as the point of contact for providing analysis of blood glucose, advice on insulin dose adjustment, customised diabetes lifestyle advice and empowerment-based education. Integration of community pharmacists in the multidisciplinary team caring for patients with type-2 diabetes has shown to be effective and well accepted by GPs and patients [41]. It is important to address that the proposal of a community pharmacist-led DMSS is not intended to exclude GPs and nurses from the care of their diabetes patients; in fact, GPs and nurses could remain in touch by monitoring their patient’s progress over an Internet connection, and the system could free up their time to provide more quality diabetes services to their patients.

5. Conclusion

Based on the study of knowledge management, the proposed Internet-based DMSS led by community pharmacists has the potential to close the existing knowledge gap between health professionals and patients in diabetes management if the pharmacists involved have been trained with diabetes-specific knowledge. However, as not all pharmacists have been trained in diabetes care, it is difficult to conclude whether Internet-based DMSS led by community pharmacists can close the knowledge gap.

Despite successful outcomes of IBGMS and empowerment-based education interventions independently, there is a lack of robust evidence on the effectiveness of current Internet-based DMSS models that have integrated both intervention strategies to manage diabetes. The effectiveness of these interventions on diabetes self-management over the long-term is also uncertain.

Further evaluation of Internet-based DMSS led by pharmacists specialised in diabetes care using a longitudinal study is warranted to investigate the long-term effects of such development on diabetes outcomes. The community pharmacist is not the only, but a potential and acceptable primary healthcare provider to facilitate the management of Internet-based DMSS, and together with GPs and nurses to provide better, sooner and more convenient services to diabetes patients.
6. Acknowledgments

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