Diabetes Management System for

a New Type 2 Diabetes Geriatric Cohort:

Improve the Interaction of Self-management

by

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ABSTRACT

According to the ADA (American Diabetes Association), diabetes mellitus is one of the chronic diseases with the highest mortality rate. In the US, 25 million are known diabetics, which may double in the next decade, and another seven million are undiagnosed. Among these patients, older adults are a very special group with varying physical capabilities, cognitive functions and life expectancies. Because they run an increased risk for geriatric conditions, Type 2 diabetes treatments for them must be both realistic and systematic. In fact, some researchers have explored older adults' experiences of diabetes, and how they manage their diabetes with new technological devices. However, little research has focused on their emotional experiences of medical treatment technology, such as mobile applications, tablets, and websites for geriatric diabetes. This study will address both elderly people's experiences and reactions to devices and their children's awareness of diabetes. It aims to find out how to improve the diabetes treatment and create a systematic diabetes mobile application that combines self-initiated and assisted care together.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION: OVERVIEW OF DIABETES MANAGEMENT

1.1 Overview: What is Diabetes?

Diabetes has been one of the common chronic diseases all over the world. According to the International Diabetes Federation (IDF), there are more than 415 million people suffered from diabetes right now, and another 187 million even don't know that they have diabetes. Besides, the number of diabetes patients will rise to 642 million by 2040. Apparently, diabetes has been a major public health problem that affects people's life. People with diabetes are under different situations while they share one common point that they all have too much sugar, or glucose in their blood, with an above-average level of blood glucose. Based on the causes of high blood glucose, diabetes is divided into two types: Type 1 diabetes and Type 2 diabetes.

Type 1 diabetes, which is also known as young onset diabetes and often breaks out before the age of 35, accounts for 10 percent of diabetes patients. This type of diabetes needs to be treated with the life-long insulin therapy, which means that patients must take insulin for their whole life. These patients cannot produce insulin cells and thus they are completely deprived of the function of insulin. Until its discovery in 1921, there was no better way besides insulin to reduce blood sugar in patients with Type 1 diabetes, leading to most of them died of diabetes with a variety of syndromes. With the discovery and application of insulin, Type 1 diabetes patients can also enjoy their life as people without diabetes do.

Diabetes mellitus is also known as adult Type 2 diabetes. Before they were defined as 'Type 1' and 'Type 2' diabetes, these two were referred to as 'Insulin-dependent' and 'Noninsulin-dependent' diabetes respectively which often led to misunderstandings regarding insulin treatment. Type 2 diabetes often occurs to people aged above 35, accounting for more than 90 percent of diabetes patients. These patients are not deprived of the ability to produce insulin and some of them even produce too much. However, the function of insulin is significantly impaired, which is often known as "insulin resistance". In this case, the patient needs to take certain drugs to stimulate the secretion of insulin in the body so as to achieve the therapeutic effect.

In the US, seven million are undiagnosed diabetics and 25 million are known diabetes patients, which might double in the next decade. Due to the baby boomers, who turned about 65 in 2011, the population of elderly Americans is growing. By 2030, one in five Americans will be a senior citizen, which nearly doubles the 12 percent in 2000. As a very special group of patients, older adults are characterized by varying physical capabilities, cognitive functions, and life expectancies. This significant shift in the country's demographics will impose new pressure and demands on its healthcare system. It becomes even more critical to provide specialized geriatric care because two thirds of people over the age of 65 are experiencing multiple chronic conditions. Moreover, this new growing geriatric generation is under the strong influence of the development of new technology,

which compels the government to reform the medical system to help treat this new geriatric cohort in the next 30 years.

People who have Type 2 diabetes cannot produce enough energy-providing insulin, which means that their body cells can't rely on the glucose for energy and the glucose will stay in the blood. High blood glucose can lead to problems like eye, kidney, nerve, and foot disorders. In addition, people with diabetes are also at higher risk of suffering from severe conditions such as high blood pressure, heart disease, stroke and so on. In fact, 95 percent of healthcare costs for older Americans come from managing their multiple chronic conditions. Generally, the phenomenon of facing several chronic conditions at a time is defined as multi-morbidity, and it is critical to provide geriatric patients with training to handle these scenarios. For example, it can be tough for an old person who suffers from both diabetes and memory loss to use insulin injection needles, blood pressure sensors or mobile phones that record his or her health conditions on time.

1.2 Justification and Significance

Diabetes, especially Type 2 diabetes, is complicated and difficult to be managed, which needs knowledge on multiple issues such as obesity, high blood pressure, sedentary lifestyle and other bad lifestyle habits. At the pre-diabetic state or the start of diabetes, patients could have problems on managing the new lifestyle. The lack of self-controlling and understanding of the complexity of the disease will lead patients to the severe stage which needs patients take life-long insulin

management. Recently, a variety of resources for patients to learn about diabetes management has become available, such as blogs, websites, and apps. However, most of these resources are too general as patients' characteristics and conditions vary. Furthermore, in the early stage of diabetes, patients could have negative emotions because of the lack of knowledge about different conditions, and consequently that will have a negative effect on diabetes management. Thus, to improve diabetes care, it is vital to inform diabetes patients of preventative measures in the early stages.

1.3 Scope and limitation

This research focuses on the goals of diabetes care for both elderly and young adults. Though both of them have similar diabetes care goals, the elderly require an individualized approach which intends to not only maintain their quality of life, but also minimize symptomatic hyperglycemia. This research has the following limitations. Firstly, due to time limits, it only targets a small number of people. But more participants from different fields including clinical managers, nurses, experts as well as elderly people who suffer from diabetes should be involved. Secondly, the average income of families could influence on the efficiency of diabetes treatment. Therefore, instead of just targeting a specific group of people, the study of systematic treatment for elders with diabetes will not just focus on people who can afford all their therapies. This will make the research more realistic and universal and will also provide the possibility of using this research in other medical treatments. Thirdly, compared with the younger generation, recent geriatrics who

are above 60 years old have little experience in using the new technologies such as mobile phones, tablets, and laptops. Accordingly, this research is targeting new geriatrics who cannot live without new technologies in the next 30 years. For this rapidly growing group, a new and thoughtful self-management health system has been proposed.

CHAPTER 2

LITERATURE REVIEW: UNDERSTANDING THE SITUATION

2.1 Overview

The previous section helps understand questions on what is diabetes, what is the problem for US diabetes, especially on Type 2 diabetes (who comprises the prinmary population at present), and what is the trend in the systematic development of diabetes self-management. In this chapter, based on the general understanding of diabetes, more details about diabetes self-management of geriatric people with Type 2 diabetes will be discussed to explore the diabetes self-management more comprehensively.

2.2 Methods: Traditional Diabetes Management

As a complex disease, diabetes cannot be cured by specific methods. It has been found that systematic management of both physical and mental care on patients plays a vital role in diabetes treatment. Due to years of development, five traditional methods such as diabetes education, blood glucose detection, diet therapy, exercise therapy and medical therapy have been approved throughout the world to be contributing to the management of diabetes.

In 1996, Wagner proposed the Chronic Care Model (CCM) which held that chronic disease care needed six elements as the medical system, community resources and policies, self-management, support from healthcare organizations, delivery system design, and clinical information systems. By fully informing patients and

mobilizing their motivations, CCM is prepared to achieve the best clinical outcomes for patients with chronic diseases through collaboration. It emphasizes that patients should join hands with health providers, and medical teams should help patients correct their behavior and manage their health by using self-management strategies (Wagner, Austin, Von, 1996). Afterwards, CCM will gradually be replaced by the patient-centered family health model which focuses on patient-centered interaction, organized continuity of team-based disease management, and information system support for the entire diabetes management (Wagner, Sandhu, Coleman, 2014)

In the diabetes management for the elderly, it is necessary to take into careful consideration all the potential situations that are likely to increase the risk of complications, including severe hypoglycemia. Though older adults can also use some proper approaches recommended for their younger counterparts, treatment plans for elderly should be simplified, and blood pressure goals should be achieved without impairments in functionality and cognition.

2.3 Development: Diabetes Management in a New Era

Technology transforms people's lives and in the time of information and internet, it also changes the world of healthcare, including the ways of diabetes management. In fact, there are a variety of ways for a patient's data to interact with that of other patients, such as electronic health records, medical history and Clinical Decision Support System (CDSS). Among all these new types of medical treatments, CDSS

improves the potential for chronic disease diagnosis and treatment. Over the past 20 years, in developed countries, CDSS has been applied to produce the electronic medical record system which is the basis of chronic disease management. CDSS can provide intelligent, personalized clinical decisions by following standardized and evidence-based guidelines so as to minimize medical errors

Generally, it is believed that the concept of outpatient CDSS should possess the following functions: (1) Identify the areas where the patient can gain the greatest benefit in diabetes management. (2) Identify indicators that have not yet been addressed. (3) Provide appropriate treatment advice. (4) Recommend treatment programs based on the potential benefit. (5) In the face-to-face or other types of situations, identify the best timing to initiate medical experts and patients to make a convenient format which will be used to provide a credible and evidence-based communication as to patients' treatment preferences (O'Connor, Sperl-Hillen, Fazio, 2016).

Due to its five characteristics, CDSS can be used to maximize management strategies by reducing medical errors, increasing management efficiency, and achieving the most possible clinical outcomes. Nevertheless, the implementation of management strategies is still dependent on the existing clinical team. Therefore, due to the differences in prescription habits, CDSS management has its limitations and different implementations of management strategy based on CDSS produce

inconsistent clinical effects. At present, only some of the clinical studies show that CDSS can improve the outcome of chronic disease management, which, however, is not recommended in the guidelines due to its low level of evidence. It still takes long-term observations to further determine the exact validity.

With the development of telemedicine and mobile healthcare, exploratory studies show that diabetes-related small-scale management models that integrate information technology, such as mobile applications, have an advantage in improving glycemic control. The mobile application has demonstrated great potential in diabetes management by providing new possibilities for achieving remote and personalized treatment. In fact, the adoption of one mobile application in diabetes management which is known as "Diabetes Manager" has been approved by the Food and Drug Administration. The effectiveness of a diabetes management application named "Diabetes Control" was evaluated by a public diabetes-related organization. The study which analyzed 300 cases of behavioral interventions of Type 2 diabetes patients for 6 months found that patients with effective exercise, regular medication, active blood sugar level monitoring, demonstrated a further controlled blood sugar with a stable curve. Many independent research and diabetes management platforms have tried to study patient's daily diabetes management through monitoring, which may significantly encourage the patients.

2.4 Conceptual Framework
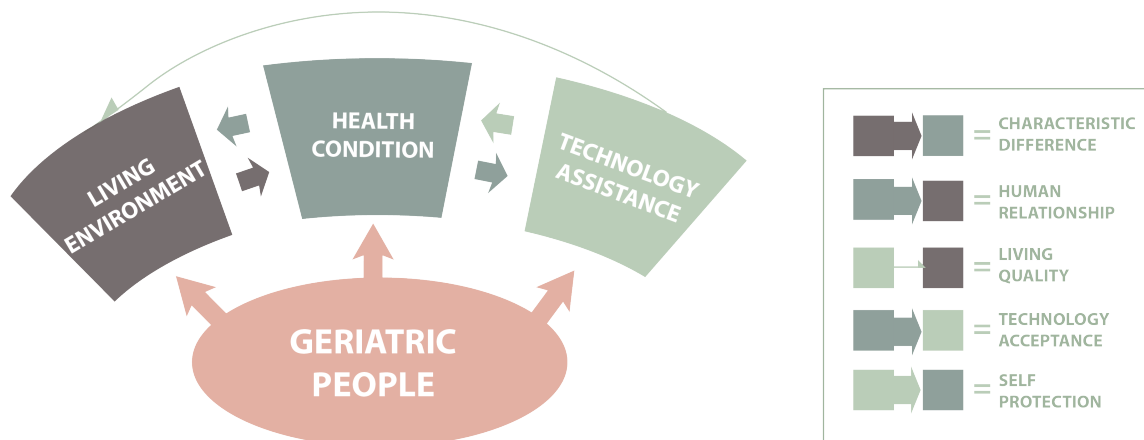
Picture 1: Conceptual Framework

The conceptual framework (Picture 1) above shows the key factors that could affect this research. The target will be people who are above 35-40 years old with Type 2 diabetes. This group of people is not old people now, but they will eventually be in next 30 years. The reason why they are chosen as the target group is they are the largest age group in the population with Type 2 diabetes. Also, this future geriatric group is the biggest group which is affected by the new technology such as mobile devices. The up-and-coming seniors make the outcome of this research more valuable and realistic for the next two decades.

Three different factors will be focused on to explain the situation of diabetes self-management: living environment, health condition, and technology assistance. Living environment means the patient needs a variety of support from family, community, and healthcare providers such as clinic and healthcare workers. This support includes lifestyle intervention, for example, control of weight, practical diet, appropriate exercise, smoking control and diabetes education.

Health condition includes physical health and mental health condition. Moreover, the greater percentage of the population is elderly, that means the higher percentage is also more prone to be diabetic. And because their quality of life is declining, they need more readily accessible diabetes self-management.

Technology assistance means the new trend of technological development in diabetes management, particularly on the online remote healthcare treatment and some new technologies such as machine learning. As a special chronic disease, diabetes management must be managed through the organic combination of offline medical teams and online remote diabetes management platforms in order to optimize long-term management of diabetes.

The ideal diabetes management model can be integrated into effective patient education, the implementation of an accurate diagnosis and treatment to achieve efficient diabetes control resulting in a decline in the occurrence of chronic complications. Indirect medical costs will also have been greatly reduced, and it's even a win-win for service providers and insurance companies.

2.5 Living Environment

2.5.1 Diabetes self-management (Pre diabetes)

The term self-care is used in medical articles and is also widely used in the pediatric diabetes research. However, there is no universal definition or differentiation regarding the expectations associated with self-care between

children, adolescents, and adults (Schilling et al., 2002). Due to the lack of awareness, it is difficult for children and adolescents to understand the importance of the self-care of diabetes. Researchers have also used the term *self-management* to describe self-care, which refers to a person's ability to cope with the symptoms and treatment, physical and psychological consequences and lifestyle changes associated with managing a chronic condition (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002). According to these authors, effective self-care treatment on diabetes should include the ability to monitor one's disease and to understand its effects on cognitive, behavioral and emotional responses (Koller, Khan, & Barrett, 2015).

Peeples and Jane studied the daily self-care or self-management decisions that people with diabetes made and found that the self-management of diabetes patients must involve integrating lifestyle behaviors, treatment decisions, and coping strategies (Peeples, Jane, 2007). The self-management is a big challenge for anyone with chronic diseases. Limited resources, pain, depression, insufficient support is mentioned in the Peeples and Jane's research, which affects the results of diabetic self-management. A qualitative survey, conducted by Peeples and Jane examined that fewer than one-third people with diabetes could manage their illness by themselves. Poor patient-provider relationships and poor access to coordinated care could result in poor self-management and control. Based on the results from Peeples and Jane's survey, it is important to create a more effective method of diabetes self-management. However, self-management doesn't mean patients

12

can take care of themselves alone, but they need to incorporate the resources of community, family and healthcare providers.

Nevertheless, the recent intervention like nurse care-management did not improve patient outcomes (Peikes, Chen, Schore, & Brown, 2009). The poor communication between patients and clinicians as well as between patients and their healthcare provider teams could increase the costs of clinical intervention and reduce the effectiveness of self-management (Jackson, Bolen, Brancati, et al., 2006). Therefore, the communication between patients and clinicians should be more patient-centered with integrated clinical supervision.

2.5.2 Diabetes Education (Pre-diabetes)

As a chronic disease that is difficult to cure, diabetes requires continuous medical care, and its therapeutic effect depends less on the level of care and medication but more on follow-up support. So, diabetes education and management have been regarded as an indispensable part of the treatment of diabetes.

Based on the report from AADE (American Association of Diabetes Educators), there are five key elements in diabetes education.

- Engagement
- Information sharing
- Psychosocial behavioral support
- Integration with other therapies

- Coordination of care across specialty care, facility-based care and community organizations

Also, the emotional response is responsible for the negative effect on the outcome of self-management and education (Powers, Bardsley, Cypress, Funnel, Fischl, etc. al, 2015). Before starting the life of diabetes self-management, patients should work closely with diabetes educators to answer the initial concerns on diabetes.

John, Frank and Carolyn highlighted the importance of diabetes education in the diabetes management (John, Frank, Carolyn, 2013). Diabetes education is the key factor to increase patient awareness, as well as reduce the risk of diabetes-related syndromes (John, Frank, Carolyn, 2013). Additional findings by Funnell also suggest that diabetes self-management education is to support informed decision making, self-care behaviors, and problem saving, which improves the collaboration with health team and improves the quality of life (Funnell et al., 2009). The study of Cosgrove, Sargeant and Griffin found that depression is relatively high in patients with type 1 and type 2 diabetes. Another perspective is that the effectiveness of diabetes education improves the depressive situation in newly diagnosed patients with type 2 diabetes (Cosgrove, Sargeant, Griffin, 2008).

However, the intervention of diabetes education is related to the outcome of diabetes management. The previous diabetes self-management education relies on the telephone conferencing and web-based information which doesn't encourage patients to persevere in taking diabetes education (Dudley, Heiland,

Kohler, Kovic, 2014). The effective intervention with diabetes patients needs strong communication and interaction. Being involved with new technologies like social networks in a virtual environment is an alternative for diabetes education. Because social networks give patients the advantage of better accessibility and reduce the time requirement for travelling to group other health team members (John, Frank, Carolyn, 2013). The engagement of new technology such as mobile applications provides more chance for the patient to communicate with healthcare providers or healthcare professionals and help patients address issues to improve the adherence to self-management (Chen, etc. al, 2013).

2.6 Health Condition

2.6.1 Diabetes Syndrome

Diabetes is easily associated with multiple syndromes. The syndrome includes functional deficits, cognitive impairment, depression, falls, urinary incontinence, malnutrition and other symptoms, seriously affecting the quality of life of the elderly, and become a serious obstacle to control diabetes (Munshi, 2008). Diabetes increased the risk of the senile syndrome. Elderly patients with diabetes not only need regularly check the large blood vessels and microvascular complications, but also pay attention to whether merge with the elderly syndrome (Munshi, 2008). Most instances of diabetes-related implications attribute to increase biologic and behavioral risks such as heart disease, stroke, lower extremity amputations and blindness or visual impairment (US Department of Health and Human Services,2003). For example, diabetic retinopathy leading to decreased vision,

vision loss is likely to cause falls and other injuries. Unlike other chronic diseases, diabetes emphasizes the self-management of the disease. If the patient has cognitive impairment, it is difficult to remember the dose of insulin and injection time so that they cannot monitor blood sugar. Then it is more prone to hypoglycemia. Therefore, patients with Type 2 diabetes with age syndrome, it is best to complete some of the functional recovery training and psychological counselling by accessing to relatives or diabetes companion care and support in order to avoid hypoglycemia occur (Leese, Wang, Broomhall, 2003). More randomized controlled clinical trials glycemic control and treatment strategies should be encouraged for the elderly population associated with the geriatric syndrome.

2.6.2 Barrier to diabetes management

The current diabetes management has similar goals which are related to effective control of blood glucose and blood pressure to minimize the long-term consequences associated with diabetes.

Detection of hypoglycemia is difficult while self-monitoring blood glucose, but it's important because it is the main method for diabetes self-management. Some patients need self-monitoring blood glucose three or fewer times per day. However, this is not always accomplished because of the dissatisfaction with diabetes self-management treatment as glucose testing is painful and inconvenient (Ong, Chua, Ng, 2014). Self-monitoring is associated with a healthier lifestyle and better

disease management, which decreases diabetes-related morbidity and mortality in Type 2 diabetes (Martin, etc. al. 2005).

Patients' perceptions during medical treatment are influenced by the service they received and the communication with healthcare professionals (Lawton, Peel, Parry, Araoz, Douglas, 2005). A good communication between patients and healthcare providers predicts better outcomes of diabetes self-care (Schillinger, etc. al, 2003). Most healthcare teams recognize that they lack effective communication tools and skills in shared decision-making, and this lack of skill could be a barrier to effective diabetes treatment. This demonstrates that poor patient-provider communication is directly connected to poor treatment adherence (Hunt, Valenzuela, Pugh, 1997).

Furthermore, psychological issues such as depression and anxiety could also affect the diabetes treatment. Depression of patients usually stems from the discomfort of treatment devices and lack of encouragement from health care providers. Depression also has a negative impact on the quality of self-management (Timar, Mut-Vitcu, Timar, Oancea and Citu, 2016).

2.6.3 Psychology Issues

Psychological issues are recognized as a barrier to diabetes self-management (Nam, Chesla, Stotts & Janson, 2011). Patient's adherence, attitude and beliefs, knowledge, and even culture and language could result in numerous

misunderstandings of diabetes and its treatment. Furthermore, the patient may fear the insulin injections which would decrease the efficiency of the procedure and the accuracy of blood glucose monitoring. The clinic should understand the psychological issues of patients and give them the advice to improve their adherence to effective self-care decisions. Lastly, it is essential to have healthy collaborative relationships in the management of chronic illnesses such as diabetes.

Patients treated with insulin therapy reported high diabetes-related emotional distress (Hermanns, Ehrmann, Schall, Maier, Haak, Kulzer, 2017). Distress is mostly explained as the burden of diabetes self-management, which behooves healthcare providers to understand the issues of patients rather than ignoring their concern about their diabetes diagnosis and treatment goals (Delahanty,2007). A patient-centered strategy in diabetes self-management plays an important role in the outcome of self-monitoring.

Adherence to clinical practice and diabetes self-management behavior is another key factor of efficiency on diabetes management (Lawton, Peel, Parry, Araoz, Douglas, 2005). In addition, patient adherence to treatment regimens affects the control of blood glucose, for example, failure to keep appointments or take recommended medicine (Nicolucci, Carinci, Ciampi, 1998). On the perspective of patients, poor adherence can be influenced by the patient's misunderstanding,

forgetfulness, and the lack of knowledge on understanding the long-term risk (Stirratt et al., 2015).

Different people with diabetes hold a wide range of attitudes about diabetes treatment which affects the perception of patient-centered diabetes management depending on the needs of patients (Anderson, Donnelly, Dedrick, 1990). In the recent studies on the patients with Type 2 diabetes, about 33% of them were unwilling to receive insulin therapy if it were prescribed (Larkin, Capasso, Chen, Mahoney, Hazard, Cagliero E, et al. 2008). Most patients understand that the use of insulin therapy is managing their disease. However, the typical misconception about the discomfort of insulin therapy could be a detriment to the patient's engagement in self-management of Type 2 diabetes (Davis, S. N. 2006).

2.7 Technology Assistance

2.7.1 Internet and Mobile Interventions

Effective digital interventions including website and mobile have the chance to improve self-management training and outcomes (Pal et al.,2014). The benefit of digital intervention is that internet provides wider audience through websites and mobile phones. Mobile technology has developed rapidly these years. From the report by Pew Research Institute, about 95% of American own a mobile phone, which includes the 77% who own a smartphone (Mobile Fact Sheet, 2017). Furthermore, more than 85% of patients have access to mobile health technology, and mobile health technologies help patients manage their disease better

(Sarasohn-Kahn, 2011). In diabetes management, mobile phones were frequently used to enhance data collection from patients to control blood glucose, which improves patient behavior in diabetes self-care (Mulvaney, Ritterband, Bosslet, 2011). Also, mobile technology connected with wearable accelerometer devices can provide real-time data to support the results of diabetes management. These techniques can potentially provide flexibility in the place and timing of face to face treatment, and it can also provide the clinicians with accurate data on the patient. (Patel, Asch, & Volpp, 2015). Based on a recent analysis, mobile interventions have positive effects on diabetes self-management education in comparison with other formats for patients' knowledge (Pereira, Phillips, Johnson, & Vorderstrasse, 2015).

2.7.2 Diabetes Online Education Resources

Diabetes education plays a vital role in enabling patients to take care of their health. The recent way of diabetes education for self-management is face-to-face group education. However, based on the survey from Cochrane Clinical Answers, the attendance of current group education is weak, which provides digital interventions to increase access to self-management (Cochrane Clinical Answers,2017). Digital education such as web-based learning offers the potential for improving time flexibility (Barrera, Glasgow, McKay, Boles, & Feil, 2002).

The study conducted by Pal shows that the computer-based interventions have a smaller benefit on glycemic control than mobile phone-based information.

Although websites provide the wider audience, mobile phones have better usability than websites and is easier for users to access (Pal et al., 2014). Regardless of the usability and convenience, diabetes education recourses on the mobile phones and websites are necessary to be more accessible, shorter and consist of activities that require less typing. Effective education of medical management should involve experts in all the aspects of diabetes management including educational, clinical, psychological and behavioral diabetes care (Haas et al., 2012).

2.7.3 Remote Medical Care

The population of people over 65 years old is going to increase further. With the growth of a variety of healthcare problems, the elders often require continuous and long-term medical care that increases costs on health care. One research shows that remote medical care such as home care eases the burden of health care services and control costs (Bengtsson, 2017). The research also indicates that a large number of elderly people prefer remote medical care than traditional ways of health care such as hospitals.

Remote medical care or telemedicine refers to the spread of health and medical counseling between different locations through network technology to achieve medical or health care. This research is to explore the role of this new model of diabetes management in promoting patient compliance and improving the outcome of self-management.

The remote management model does not replace the patient's direct contact with the medical staff, but it is a useful supplement to the patient's visit. Maintaining regular contact through the network, the relationship between doctors and patients further harmonizes. And still, the patient's privacy is fully respected and protected. The patient is willing to be more open about their physical and psychological discomfort, which helps restore the patient's self-confidence, helps to strengthen health education content, and improves patient compliance and self-management. The interactive remote diabetes management system provides patients with personalized medical services while fully mobilizing both the subjective initiative and the patient's motivation. This approach in promoting the metabolic indicators can save the patient in treatment time and driving costs. For day-to-day management, this model is a highly efficient method that helps to ease the shortage of medical resources.

The earliest diabetes remote management began in 1988 (Ziminet, Lang, Mazze, 1988). The current diabetes remote management system is mainly conducted through mobile devices to upload blood glucose values, publish information and log onto dedicated websites for diabetes education (Jackson, Bolen, Brancati, 2006). However, these routes lack timely and effective feedback, personalized management and telemedicine interaction between patient and doctor (Cho, Kwon et al., 2006). Therefore, remote monitoring intervention should contain following features that help the patient take useful medical treatment.

1. communication modalities utilized;

2. motivation, engagement, and attrition;

3. self-care advice and communication;

4. real-time features, adaptive intervention design, and feedback.

  (Mulvaney, Ritterband, Bosslet, 2011).

Big Data and Cloud Computing

Chronic diseases such as diabetes require long-term care and regular monitoring, which have abundant data to collect and analyze. Although a medical information system can provide effective data service support, this form of medical operation is expensive. To make medical care more effective, big data can be used for capturing data, data storage, data analysis, search, sharing, transfer, visualization, updating and information privacy (Wikipedia). The trend of equipping big data skills can offer opportunities and innovations to long-term strategies such as chronic illness decision making (Dey, Ashour & Bhatt, 2017).

Cloud computing has drawn extensive attention from both academia and industry. The medical care system with cloud computing skills has an unlimited addressing capacity of the internet transition. The data and information are rapidly organized to realize intelligence system for enabling context related decisions (Dey, Ashour & Bhatt, 2017). The health care system based on cloud computing and big data not only develops access to care but also increases the quality of medical care and reduces the care cost (Frederix, 2009). Cloud computing increases the

efficiency of medical data management and sharing process. Moreover, it enables

the access to healthcare ubiquitous since patients' data can be accessed at any

places and at any time (Raj, 2014).

Ubiquitous-Healthcare

Ubiquitous-Healthcare (UH) is a medical service system that utilizes wired and

wireless networking technology, combined with the Internet and health care to

achieve health management services anytime. The system, which provides

appropriate health care services is not only suitable for diabetes, high blood

pressure and other chronic diseases, but also for the sub-health groups who need

health management. UH uses biological information detectors to monitor user

biological signals and health information, etc., through mobile phones, computers

and other wired and wireless devices. Then, the medical group analyzes the data

and gives feedback to the patient. Through the system, patients can conduct

remote management. The patient can also get a health care quality assessment

based on the medical information provided by the guide of the medical group. In

the UH, the medical team can periodically provide advice to users, supervise the

user to monitor blood sugar and provide the solution on the emergence of the

physical problems. With the rapid development of network technology, it becomes

possible to send high-quality graphics, audio or video through networks. Remote

and mobile medical care and electronic medical treatment have gradually become

the trend of future development in the medical system. As an extension of the

medical information system, UH is expected to provide patients a close interaction

with the medical group in the new medical environment (Yoo, Park, Kim et al., 2009).

2.7.4 Artificial Intelligence

Artificial Intelligence (AI) has been found to have real-life benefits for some fields including medical healthcare. According to the report from Global Market Insights, new market-related AI has a huge growth potential due to easier integration within healthcare systems. Moreover, in the next 10 years, a dramatic reduction in diagnostic and treatment costs will result from the excellent treatment outcomes for patients in various cases using AI as a decision support tool. An AI industry report created by Frost & Sullivan shows that AI is the key to actionable big data in healthcare which includes data collection and analysis and comprehension. The ability of conversion of information by AI can also create many opportunities in healthcare systems. For example, most data today in healthcare is unstructured and difficult to share. AI can create secure electronic data which means not only larger and more complex datasets can be accessed, but also patients' private health data can be safer.

A thoughtful AI design with problem formulation and simulation framework can optimize decisions in complex and uncertain environments. Furthermore, the future model combined with machine learning algorithms is beneficial for personalized medical treatment (Bennett, Hauser, 2013).
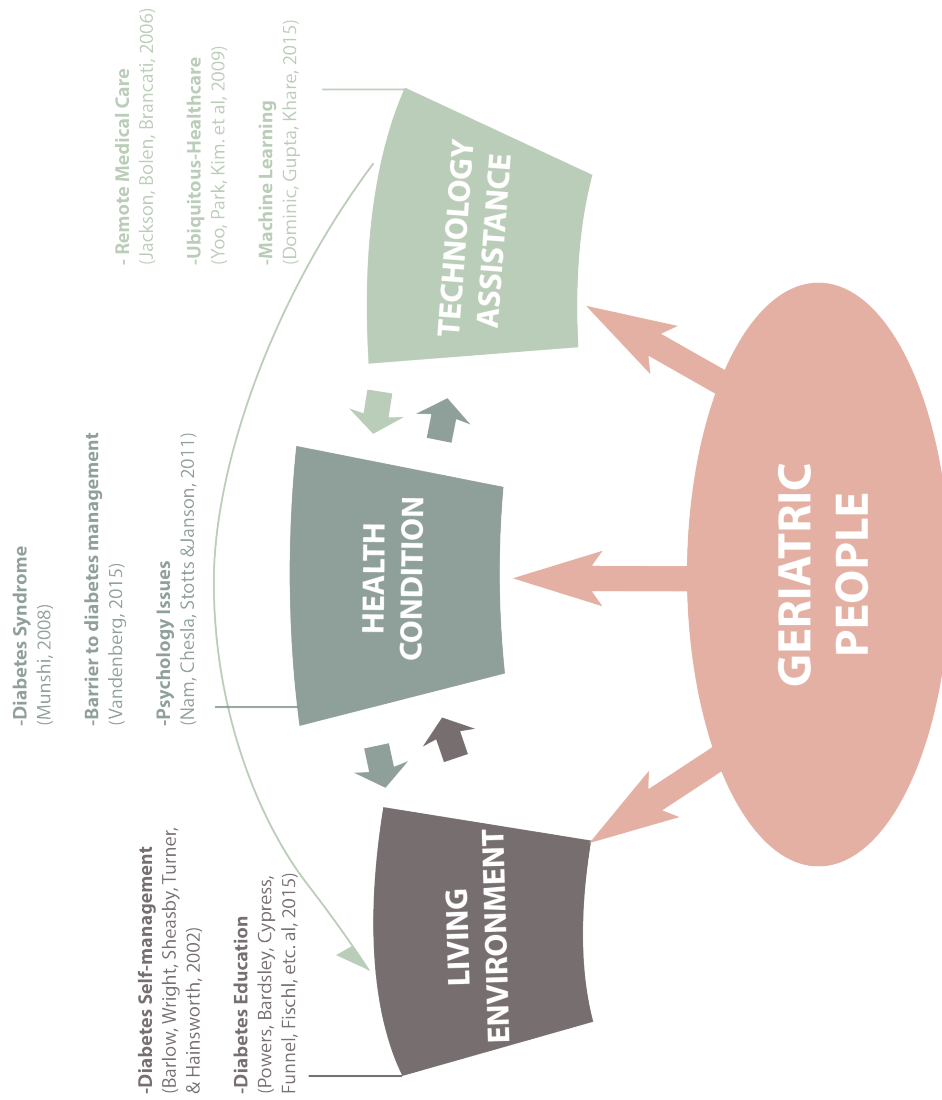
Machine Learning

The machine learning technology could be a valuable asset to diabetes management. Recording data analysis is a crucial step for both machine learning and diabetes management. Moreover, machine learning is good at discovering and displaying the patterns buried in the data which could help predict the risk for patients in diabetes management (Dominic, Gupta, Khare, 2015).

One of the strengths of machine learning is its ability to create a predictive model for diabetes diagnosis to aid clinicians in applying the right preventative measures to the right patient. This will undoubtedly increase the health outcome of the patient and will avoid any depression from the lack of clinician-to-patient communication. Predictive models based on the machine learning technology could predict whether a diabetes patient will need a diabetes examination within the next year, which gives preventive control to patients (Luo, 2016).

Machine learning technology provides diabetes patients risk assessment and preventive measures to improve their health outcome and treatment adherence, which increases the efficiency of diabetes management. In addition, the development of diabetes technology needs more understanding of the psychological and human factors to maximize the benefits of technology.

2.8 New Conceptual Framework

The new conceptual framework is based on the exploratory research in this review. It explains the relationship of three key elements and the specific area and directions this research focuses on.

-Diabetes Syndrome
(Munshi, 2008)

-Barrier to diabetes management
(Vandenberg, 2015)

-Psychology Issues
(Nam, Chesla, Stotts &Janson, 2011)

-Diabetes Self-management
(Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002)

-Diabetes Education
(Powers, Bardsley, Cypress, Funnel, Fischl, etc. al, 2015)

- Remote Medical Care
(Jackson, Bolen, Brancati, 2006)

-Ubiquitous-Healthcare
(Yoo, Park, Kim. et al, 2009)

-Machine Learning
(Dominic, Gupta, Khare, 2015)

TECHNOLOGY ASSISTANCE

HEALTH CONDITION

LIVING ENVIRONMENT

GERIATRIC PEOPLE

= CHARACTERISTIC DIFFERENCE
= HUMAN RELATIONSHIP
= LIVING QUALITY
= TECHNOLOGY ACCEPTANCE
= SELF PROTECTION

Picture 2: new concept framework

28

CHAPTER 3

METHODOLOGY

3.1 Overview

The previous section provides a detailed perspective on the guide for diabetes self-management based on the topics among living environments, health conditions and technology assistance. In this chapter, research questions, research methods, and analysis methods will be discussed to figure out the outcome of the study.

3.2 Research Topics and Questions

3.2.1 Diabetes Self-management

What is the critical step for diabetes self-management?

Rationale: The research question on the critical step of diabetes self-management helps seek the crucial need of diabetes patients. In the review written by Rasbach, (Jenkins, & Laffel, 2014), it indicates the necessity of developing valid and reliable instruments for measuring self-efficiency that are sensitive to long-term change across a broader caregiver base. Future opportunities should also include evaluation of improvements in self-efficiency in Type 2 diabetic patients who have been exposed to recent advances in diabetes management technologies. This study should focus on the process of entire diabetes self-management and emphasis on the existing user experience issues in order to provide values for improving diabetes care.

3.2.2 Diabetes Education

How can online Diabetes Education be more efficient?

Rationale: Discussing the problem of the efficiency of diabetes education is beneficial to understanding inadequacies in the current diabetes education. Diabetes education plays an important role in diabetes self-management. The quality of diabetes education affects patient's reaction and behavior when they meet the emergent situation. When starting the life of diabetes self-management, patients should work close to diabetes professionals to answer the initial concerns on diabetes. In the review from Powers, the early diabetes education with professionals can enhance the confidence to adopt self-management. Emotional response is also responsible for the adverse effect on the outcome of self-management and education, which should be taken close consideration. (Powers, Bardsley, Cypress, Funnel, Fischl, etc. al, 2015).

3.2.3 Barrier to Diabetes Management

What is the barrier to Diabetes Management?

Rationale: Understanding the barrier to diabetes management can help find patients' issues during the diabetes self-care. The wall to the diabetes management such as psychological problems and bad patient-to-health provider communication can affect the effectiveness of self-management. Psychology issues such as depression and anxiety could affect the diabetes treatment. Depression of patients is from the discomfort of and devices and lack of encouragement of health care providers. Depression also has a negative impact on decreasing the quality of self-management of diabetes (Timar, Mut-Vitcu, Timar,

Oancea and Citu, 2016). Bad communication and interaction comes from the lack of tools and skills in counseling and shared decision-making. This research should identify and evaluate the barrier to diabetes management and provide the solution for patients who suffer from these issues.

3.2.4 Remote Health Care

How does Remote Health Care improve the interaction during diabetes management?

Rationale: The increasing aging population often require continuous and long-term medical care because of a variety of healthcare problems. A recent report by Bengtsson said that a large number of elderly people prefer home care with remote monitoring rather than traditional ways such as hospitals (Bengtsson, 2017). Differ from traditional ways of medical care, remote health care decreases patient inconvenience on the time and space by sharing information through the internet. The study about diabetes management should figure out advantages of remote health care to maximize its value in diabetes self-management.

3.2.5 Machine Learning

How does Machine Learning improve the interaction during diabetes management?

Rationale: As the trend of future development, machine learning plays a crucial role in the varieties of fields included health care and medical management. Based on the strength of machine learning, it creates a predictive model for diabetes

diagnoses helps clinicians target preventive interventions at the right patients (Luo,2016). Most data today in healthcare is unstructured and hard to share. Artificial intelligence including machine learning technology enables collecting and integrating a variety of data. By analyzing data, machine learning technology outputs real-time results for different tasks, which saves time for both patients and health providers.

3.3 Research Method

The methodology in this study includes a literature review, a pilot study of questionnaires and interviews which conduct quantitative and qualitative research to test patients' behavior on the acceptance of and satisfaction with medical devices.

The pilot study will be conducted by interviewing and questioning the patients around diabetes hospitals and clinics, then analyzing mass data to explore and understand patients' acceptance of daily diabetes treatment.

Survey

The survey will be conducted with closed and open-ended questions. The purpose of the survey is to generate standardized, quantifiable and empirical data that can represent a large population (O'leary, 2010). The survey provides a glance at the self-management experience of patients who have diabetes.

Response categories such as Likert-type scaling will be used in the survey. 5-point Likert scaling is used to measure the respondent's attitude toward different statements in order to reflect their feelings toward a given item with a symmetric agree-to-disagree scale.

Interview

Semi-structured interviews are used to explore patients' perceptions and knowledge of diabetes self-management. The advantage of semi-structured interviews is that it can help investigators find unexpected results during the process of the interview. Semi-structured interviews allow participants to communicate informally so that they have the freedom to express their views in their terms, which can provide reliable and comparable qualitative data.

3.4 Sampling Strategy (Robson, 2011)

Non-random sampling will be used in the survey and in the interview. In this research, non-random sampling is used to credibly represent the population of diabetes patients. When working with populations that are hard to access like people have a specific disease, non-random sampling is the best option (O'leary, 2010).

Purposeful sampling enables the recruitment of people based on the study rather than the recruitment of numerous, random individuals which could make the result of research less persuasive. Furthermore, the qualifications of the research

population are beneficial to producing findings that represent objectives related to the study.

3.5 Analysis Method

Quantitative data analysis will be conducted for survey responses. By comparing data from selected samples, quantitative data analysis using graphs can test various hypotheses about the relationships between different variables, and allows investigators to determine characteristics of a population from sample data.

Qualitative data analysis will be used to reduce and make sense of vast amounts of information in the interview (O'leary, 2010). Qualitative data analysis pays more attention to the spoken word, context, consistent and contradictory views, and frequency and intensity of responses. Another reason why qualitative data analysis is used is that most research samples are specifically selected. Transcriptions of interviews can help investigators find the deeper opportunities for research findings.

3.6 Method Justification Table

Research Questions	Method	Justification & Rationale
What is the barrier to diabetes management?	Literature Review	Literature review of current articles and books will provide generalized data and knowledge on related topics
How can online Diabetes Education be more efficient? What is the critical step for diabetes self-management?	Survey	Questionnaire survey will create a mass collection of data regarding the behavior of patients on medical devices

How does Remote Healthcare improve the patient-doctor interaction during the diabetes management? How does Machine Learning improve the patient-doctor interaction during the diabetes management?	Interview	The interview will provide information on patient's daily management on diabetes.

Table 1: Method Justification Table

CHAPTER 4

RESEARCH FINDINGS

4.1 Overview

Based on the research questions discussed in chapter 3, surveys and interviews are conducted to answer the questions about the new interaction for geriatric cohorts with mobile apps. The qualitative research not only provides a general overlook at the real need of diabetes patients, but also discovers the opportunity of improving the diabetes applications in the existing market. The following chapter will indicate the results of each research question and analyze the connection between research findings and research questions, which is important for future design.

4.2 The Figure of Survey and Interview

Figure 1 shows the survey questions and answers that are related to the research. All the questions are set to explore the experience of diabetes patients and find the opportunity of design on the interaction of patients and current diabetes treatment. To meet the needs of the study, problems about psychological issues, technical support and social support are considered in the survey to understand the three factors, living environment, health condition, and technology.

Categories Indicators	Score
1.What is your age?	
18 to 24	2
25 to 34	15
35 to 44	8
45 to 54	4
55 to 64	6
65 or older	3
2. In general, how would you rate your overall mental or emotional health?	
Very good	8
Good	9
Poor	4
3. My emotional and mental health directly affects my diabetes self-management. (strongly disagree=1 and strongly agree =5)	
1	0
2	6
3	10
4	4
5	1
4. In a typical day, about how many times do you monitor your blood glucose level?	
One time	0
Two times	1
Three times	7
More times	13
5. What's kind of medical devices your used for helping your diabetic treatment?	
Insulin injection	12
Blood glucose monitor	21
Mobile diabetes applications	6
Online Diabetes blogs or websites	13
Other	3
6. In general, how many times do you contact your doctor or family members about your health each week?	
One time	4
Two times	2
Three times	10
More times	4
7. How will you rate efficiency of your medical devices during your diabetes treatment? Rate 1 as weakest effect, rate 5 as strongest effect?	
1	2
2	7
3	8
4	4
5	0

Figure 1 The data of Survey Questions and Answers
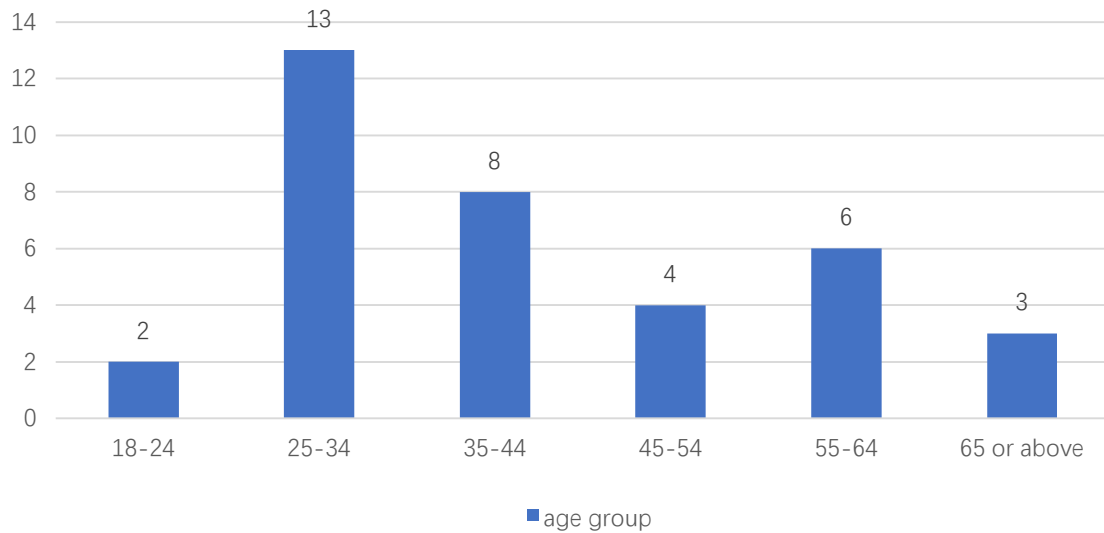
4.2.1 Research Participants

Chart 1: The Number of Participants

There are a total of 36 people who participant in the survey. Because the sample of the survey is randomly picked, not all of them will meet the participant requirements. The target sample age is above 35 years old. However, the population of the research participants includes 15 people who are under 35 years old, which does not meet the requirements of the target sample. Therefore, the valid number of participants is 21 (n=21). 8 of the remaining 21 participants is 35 to 44 years old which are recognized as younger adults. They will be the deciding factor in this research because they are the age group whose lives are most affected by the development of mobile technology.

4.2.2 Quality of Emotional and Mental Health

Chart 2: The rate of emotional and mental health
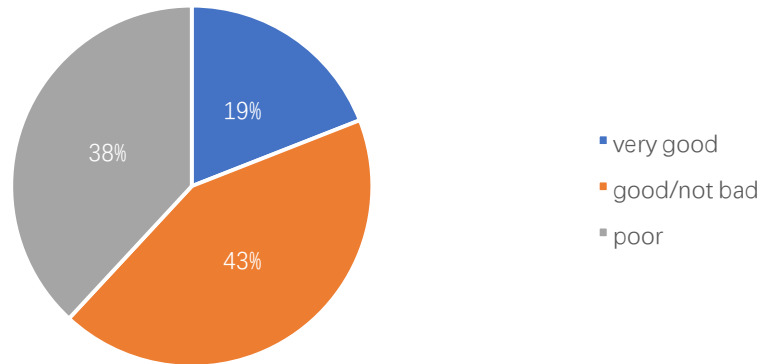
43% of participants feel satisfied with their emotional and mental health. However, 38% of people suffer from psychological issues during diabetes management. Only 19% of patients are satisfied with their mental health.

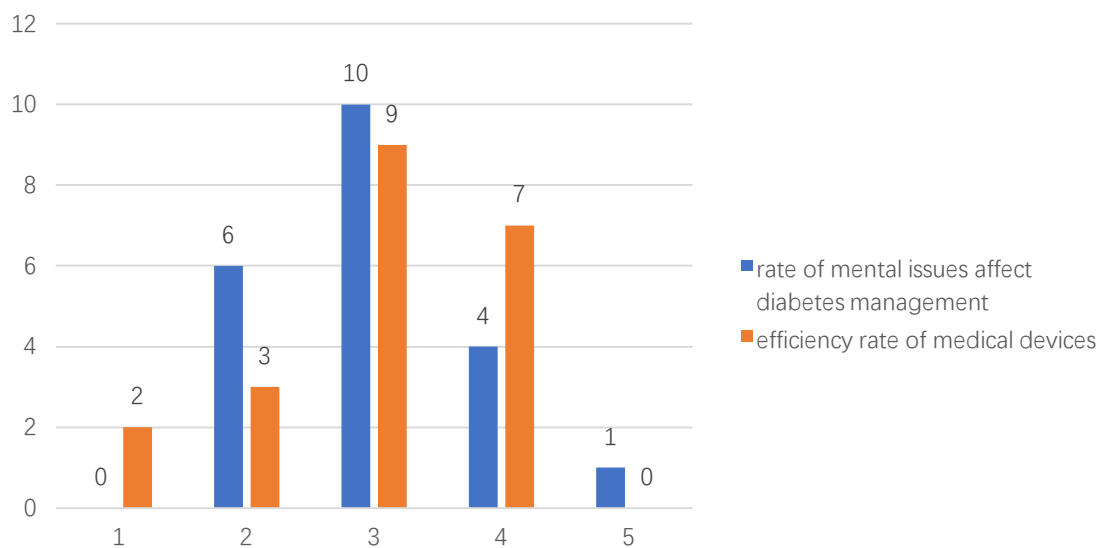## 4.2.3 Relationship between Mental Issues and Devices Efficiency

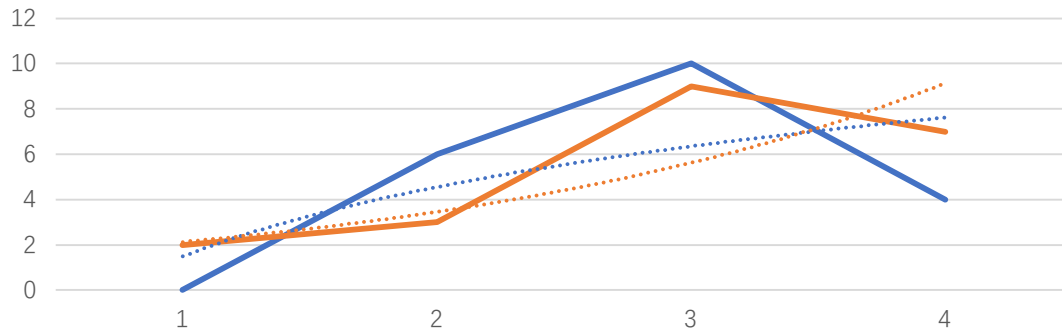Chart 3： Comparison of metal issues and diabetes treatment efficiency

Chart 4：Comparison of metal issues and diabetes treatment efficiency

— rate of mental issues affect diabetes management
— efficiency rate of medical devices
······ Log.（rate of mental issues affect diabetes management）
······ Expon.（efficiency rate of medical devices）

These two charts compare the rate of comparison on emotional and mental issues and diabetes treatment efficiency. These two charts show that the lower rate of metal issues shows a higher rate of device efficiency.

4.2.4 Diabetes Treatment Devices

Chart 5:Types of using of medical devices

■ insulin injection ■ blood glucose montior ■ mobile apps ■ online blog ■ other

40
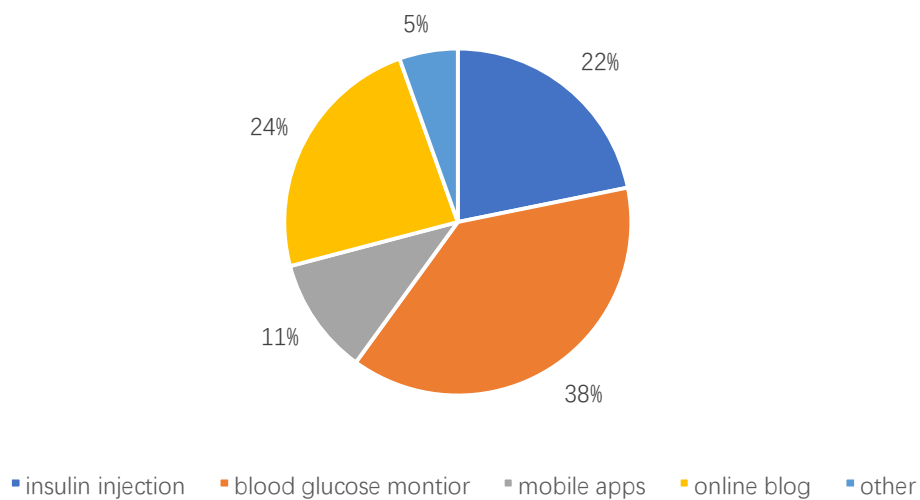
38% of participants use a blood glucose monitor which helps them manage their disease. 11% of patients will choose to use mobile apps which means mobile apps still have room for development in the future. There are 24% of participants who use online blogs and resources which give them more news, experience and knowledge from other patients who have similar problems. And last in this category, 27% of patients prefer using insulin injection and other medical resources.
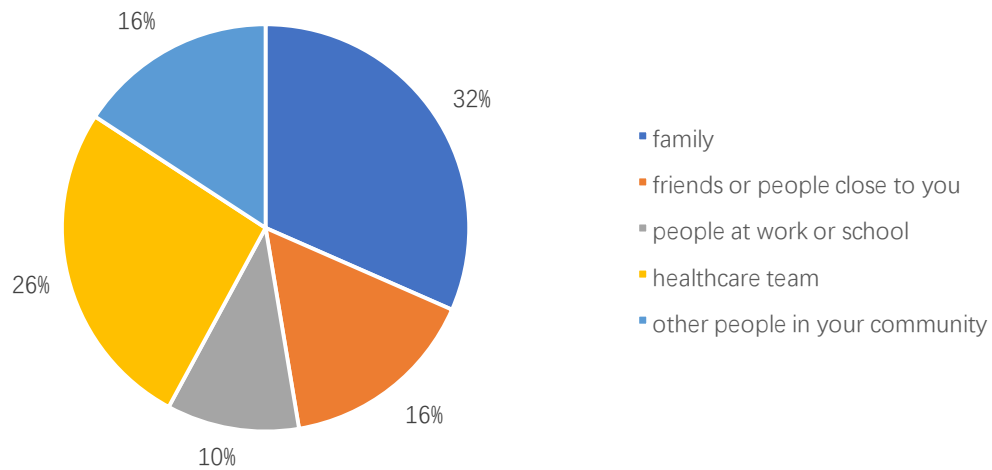
4.2.5 Quality of Self-management

Chart 6:The Frequency Rate of Support

- once a month
- twice a month
- three times a month
- more times
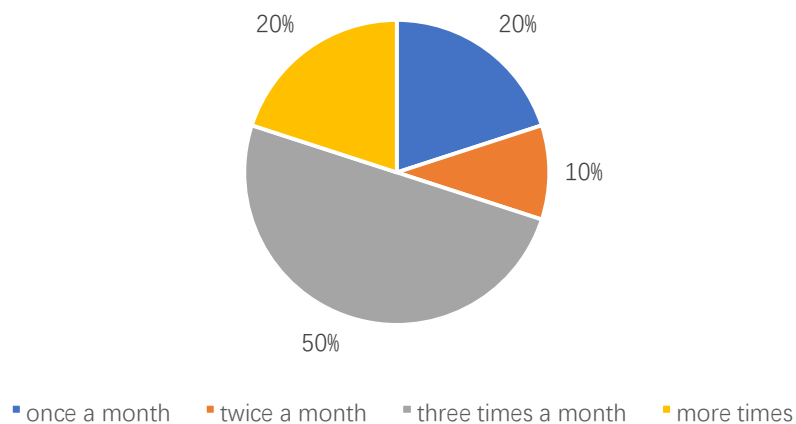
The monthly check-up and support are beneficial for patients who wish to avoid the risk of diabetes syndromes. There are 20% of people who think that one to two times a month is enough for them. However, 50% feel having a check-up three times a month is safe, but it may be a little too much for the elderly. And 10% need support more than three times a month from doctors, friends and family. It means older people need a lot more time for a routine health check. Furthermore, it seems regular communication is a core part of daily diabetes management.

Chart 7: The Types of Supportive Group

16%
32%
26%
16%
10%

- family
- friends or people close to you
- people at work or school
- healthcare team
- other people in your community

The relationship between the healthcare team and family is important for patients in diabetes management. Most patients (32%) choose family and 26% choose a healthcare team as a supporter. There are both 16% of participants ask friends and people in the community for help when they need. Proportionally, a very small amount of participants (10%) will communicate with their friends at work or school because diabetes is still a disease and requires private space.

4.2.7 The Efficiency of Diabetes Education

Chart 8:The Efficiency Rate of Diabetes Education
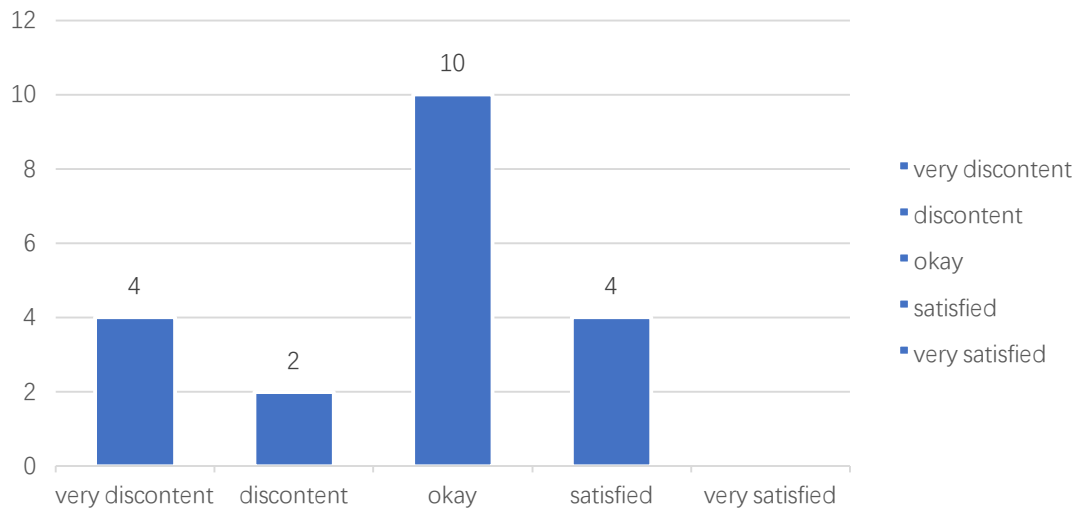
This 5-point Likert scale shows the efficiency rate of diabetes education. 5 meaning very satisfied, and 1 meaning very dissatisfied. 80% of the participants (n=16) are not satisfied with diabetes education. *"I have no idea how to change my way of living…I mean when I was diagnosed with diabetes I have to reduce much favorite food such as meat and soda. But I have no ideas which food I can eat and which foods I can't eat. I need more time to get used to this."* Patients need a long period to gather enough knowledge on how to take care of themselves. However, the current standard of diabetes education cannot meet the need of patients. One of the interviewees stated the following: *"Honestly, I tried several times group education. But results are not good enough…I mean sometimes I feel really tired and bored when listening to diabetes lessons…even I know that knowledge is good for my health."* In addition, some of them said the reason why they think the reason diabetes education is not good enough is that there is too much useless knowledge

online. For example, one interviewee said, *"There are so many applications about diabetes in the app store. I don't have any ideas which application is good for me. Also, my doctor didn't give me any recommendations on using mobile applications."* In addition, Patients cannot distinguish which knowledge they should listen to and which they should ignore. *"To get enough knowledge on self-management, I followed many bloggers in the Wechat. I can't believe I could receive hundred information about diabetes a day…eh…Honestly, most of them are similar and repetitive. And you know most of this information is words without graphics. I always felt so tired when reading a long page article, especially on this small-screen mobile phone."* Without suggestions from professional health providers, patients do not have sufficient knowledge for choosing suitable education resources. Moreover, information on mobile applications should be easy to read. The usability and convenience of mobile applications should be considered to improve the effectiveness of patients taking online diabetes education, especially on the mobile phone.

Table1: Functional Table of diabetes application

App	Data record	Knowledge updates	Disease consulting	Output device	Reminder alarm
Dnurse	✔			✔	✔

Control Diabetes	✔	✔	✔		
Dexcom official	✔			✔	✔
Diabetes in Check	✔				✔
Fooducate	✔	✔			✔
Health2Sync	✔				✔
mySugar	✔				✔

Glooko	✔	✔			✔
MynetDiary	✔	✔			✔
carbscontrol	✔	✔			✔

To understand the recent trend of diabetes mobile application design, a review of 10 different applications in the app store has been conducted. There are five factors concentrated on in this review, including data record, knowledge updates, disease consulting, the output device and reminder alarm. Among the most popular diabetes applications in the app store, there are very few applications have the function of remote healthcare. A Chinese diabetes application named "Control Diabetes" provides the Type 2 diabetes patient with a chance to consult healthcare providers from home. Most of the existing applications in the US focus more on the basic methods of diabetes management such as blood glucose monitoring, health grade reminders and news updates.

Dnurse is a Chinese diabetes management mobile application that is designed to connect the patient's mobile device with their blood glucose monitor for more convenient accessibility. Dnurse contains five different features including blog communication, alarm reminder, blood glucose monitoring, data management and online store. Dnurse only has one basic function for diabetes management because it is only used with a blood glucose monitor. However, this basic function, monitoring and recording blood glucose levels, does not satisfy patients during self-management.

Control Diabetes is another Chinese diabetes management application that has some special features which make it more professional than other diabetes applications. The health assessment is based on the blood glucose data assessment system from the US Mayo Clinic. It can create health reports for patients to help them understand their health status. It can also provide patients tasks to manage their disease with more scientific understanding. Doctor consultation includes professionals in diabetes all around China. Patients can ask questions to deal with emergency situations anytime and anywhere. Furthermore, the diabetes knowledge database contains an abundance of resources about diabetes. Patients can find the suitable material to improve their skills for self-management. One weakness of Control Diabetes is that the knowledge database is not smart enough which means it doesn't push the right knowledge for different patients.

Dexcom official application has a similar function as Dnurse. It is used with a Dexcom blood glucose monitor. Most of its features are blood glucose monitoring, data recording and reminder, but it lacks some functions such as doctor consulting which makes the application fit fewer patients' characteristics.

Health2Sync, Diabetes in Check and mySugar are three similar applications which are used for blood glucose data recording and creating health assessments. These three applications let patients look deeply at their metrics like blood sugar, blood pressure and weight. Patients can also make a health diary that can help to discover what causes different symptoms.

Different from other diabetes management mobile applications, Fooducate, Glooko, carbscontrol and Mynetcontrol manage diabetes in various ways. Patients can check all the data, such as medication usage, carb counts, weight and blood glucose in one application. Health grades and reports from these applications help patients better understand how they can change their bad life habits.

For the future design of diabetes mobile applications, remote healthcare should be based on online medical consultation. The diabetes r knowledge filter system that helps users find the specific information that fits their personal health should also be considered to improve the interaction when diabetic patients are using mobile apps to manage their disease.

CHAPTER 5

CONCLUSION AND DISCUSSION

5.1 Introduction

The previous chapter shows that surveys included new and adapted questions from validated questionnaires that assess health-related quality of life, self-management, attitudes/beliefs, social support and priorities for improving diabetes care. Questionnaires were conducted online, or in person. Moreover, face-to-face interviews were conducted as well. Based on the research data results, this research finds a lot of opportunities for innovation in mobile diabetes management.

5.2 Living Environment

For geriatric people's diabetes self-management, there are a variety of factors that should be considered. Firstly, making resources available about knowledge related to diabetes self-management for elderly people can reduce the risk of diabetes syndromes (see section 2.5.1). However, based on the results of interviews and surveys, the common denominator is that the resources from websites, mobile applications and magazines are not useful enough. Some of the patients feel that most of the material they learned about diabetes was similar and repetitive. None of these resources are pushed to cater to a patient's specific health status. (see section 4.2.7). Secondly, the support from family members, friends and healthcare providers should be correctly positioned to help patients recognize the symptoms. When taking self-management, elderly people need the intervention of family members and caregivers to help them address their health problems such as

visual/hearing impairments, memory loss and fear about their mortality (see section 2.5.2). Respondents in the survey present that family members and clinicians are the two major groups they want to rely on (see section 4.2.5). Therefore, the connections between patients and family or patients and clinicians should be integrated into the new diabetes management design.

5.3 Health Condition

Both physical and mental issues of elderly people influence the quality of diabetes self-management. Diabetes management should take care of patients in different conditions. At the start stage of diabetes, patients will experience negative feelings such as distress, depression and anxiety (see section 2.6). At this stage, the appropriate knowledge will improve the patient's cognition and ability to face different conditions (see section 2.5.2). Also, the better communication between patients and professions has a positive effect on the diabetes treatment (see section 2.6.2). New diabetes interaction design should include the features that open lines of communication between patients and doctors, and provides more knowledge about sophisticated conditions.

5.4 Technology Assistance

The diabetes treatment for Type 2 diabetes needs more focus on multiple conditions such as weight, blood pressure and carb control rather than insulin injection (see section 2.2). Based on the previous research, the development of new technology could be the opportunity for improving the interaction between

patients their disease management. The Internet of things helps record the patient's daily health data and share the data with the caregivers, which helps the caregivers understand the cause of different syndromes in time. Moreover, the Internet of things such as cloud computing and big data connect patients, clinicians, family members and friends together, which provides patients more confidence to take diabetes self-management in the early stages of diabetes (see section 2.7.1). The artificial intelligence technology especially machine learning provides a smart system for deeper analysis of symptoms and health status. Machine learning technology could predict the potential risks and create health reports based on the data from patients, which permits them to experience a highly-efficient and friendly diabetes treatment (see section 2.7.2).

5.5 Design Implications
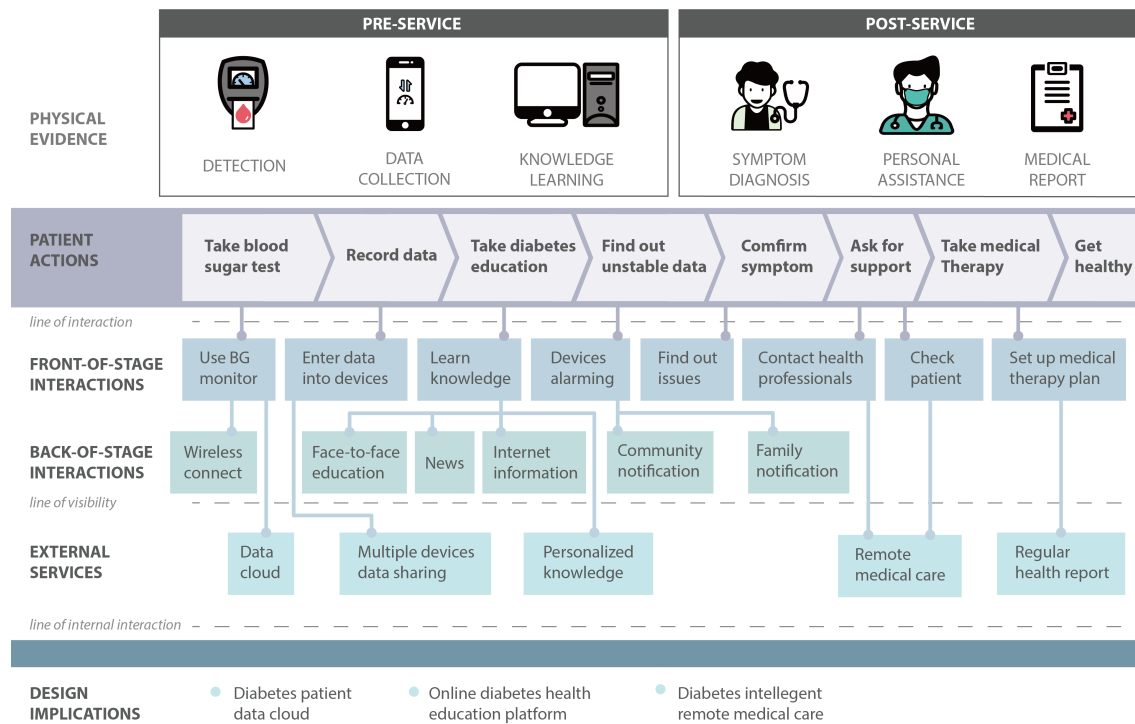
DIABETES MANAGEMENT
SERVICE BLUEPRINT

Diagram 1:Service Blueprint

This research is order to improve patients' interaction during self-management. To satisfy the demand of patient, service blueprint was conducted as an effective tool for designing the delivery of service prior to the actual delivery. The service blueprint is a feasible solution, which is used to overcome service challenges between users and service providers (Harvard Business Review, 2017). Service blueprint can show the structure of a generalized process of services. In addition to the details of the process, service blueprint can be used to identify the failures points and opportunities in a service operation. In the diabetes management service blueprint, there are 5 key elements included comprising the structure of service blueprint.

- Physical Evidence: This step shows physical interfaces and service providers in the diabetes management.

- Patient Actions: Steps, choices, activities and interactions that patients performs.

- Front-of-stage Interaction: Actions that happen directly given the diabetes patient.

- Back-of-stage Interaction: Steps, activities that happen behind the scenes to support the diabetes care.

- External service: Internal steps, interactions support service provider to offer effective solutions to the weakness of current diabetes management.

Based on the literature review and research results, the whole service process of diabetes management should have two different stages: pre-service stage and post-service stage. At the pre-service stage, diabetes patients need to take blood sugar test, record data and take diabetes education. In the steps of front-of-stage and back-of-stage interaction, patient needs use blood glucose monitor to check their blood glucose level, then record the data they achieve from blood glucose test. After the test, patient needs take some face-to-face courses, read news and internet information to increase their knowledge on diabetes management.

The result of the survey shows that diabetes patients use multiple devices including mobile devices, personal computers and blood glucose monitor to

adopt diabetes management. Therefore, to make abundant data effectively used in different devices, a cloud-based data sharing system should be designed.

Because of complaints from patients, the current diabetes education isn't effective enough. *"There is too much useless information on diabetes on my mobile. I can't make decisions whether they are correct or not."* Face-to-face education, news and internet information can't satisfy specific patient's needs. A more intelligent diabetes education platform is necessary to provide patient personalized education resource.

At the stage of post-service, patients find out the unstable data. Then patients have to confirm what symptoms occur because of the unstable data. When patients have no ideas what happens to them, they will need help from others such as health professionals, family members and community. During the steps of front-of-stage and back-of-stage, patients will receive device alarming on the unstable data. Then they need to find out issues and contact professionals to check symptoms. After checking patients, health professionals make health reports and conduct therapy plan for patients to get healthy.

Through the interview, participants reflect the need for regular support from different people. *"Sometimes I just feel unsupportive, and I will feel so much better if I can talk to someone."* The communication between patient and health professionals is ineffective. "You know, *it takes a long time to make an*

appointment with doctors in the hospitals…But I want an instant check." The

remote medical care with health professionals involved should be used to break

the barrier of time and space.

5.3.1 Diabetes Patient Data Cloud

Diabetes patient data cloud provides unlimited space to store and analyze data.

The data cloud gathers data from wireless devices, To handle the personal

medical requirements, diabetes data cloud should offer real-time analysis that

can be essential to detect the conditions and respond consequently. Moreover, to

reach instant health checking and medical reports from health professionals,

diabetes patient data cloud should share patient's data on various devices. The

key contribution of data cloud is that it allows patients and health professionals to

access the healthcare data from anywhere at any time.

5.3.2 Online Diabetes Health Education Platform

When the patient is identified as diabetes, they need to get the medical knowledge

of diabetes. Online diabetes health education platform can provide a series of

diabetes-related multimedia teaching resources. The platform is able to educate

diabetes patients through medical images and audio. In order to give patients

opportunities to choose their own learning space, online diabetes health education

platform should allow being applied to the internet through multiple devices such

as mobile phones and personal computers. People with diabetes can learn about

diabetes through this network anywhere. Additionally, the diabetes health

education platform should include a dedicated information platform that allows patients to have a closer interaction between patients and medical group through the platform to improve the outcome of self-management and adherence. The personalized education resource is also important for diabetes self-management. With the machine learning technology, diabetes online health education platform can create appreciate education resources for various of patients, which makes diabetes education more efficient and valuable.

5.3.3 Diabetes Intelligent Remote Medical Care

Diabetes intelligent remote medical care is based on the remote monitoring and machine learning technology. To break barriers of the limit of time and space, remote monitoring aims at detection and assistance in different emergency situations for patients at home. The service should allow patients access to consultations and treatment with medical professionals online. It saves patients time of waiting for an appointment and improves the quality of medical care. To solve issues of bad patient-health provider interaction, an intelligent medical report should be made to fit individual's exclusive behavioral and characteristics. Machine learning technology can create a suitable medical plan for diverse situations based on the patient's requirement.

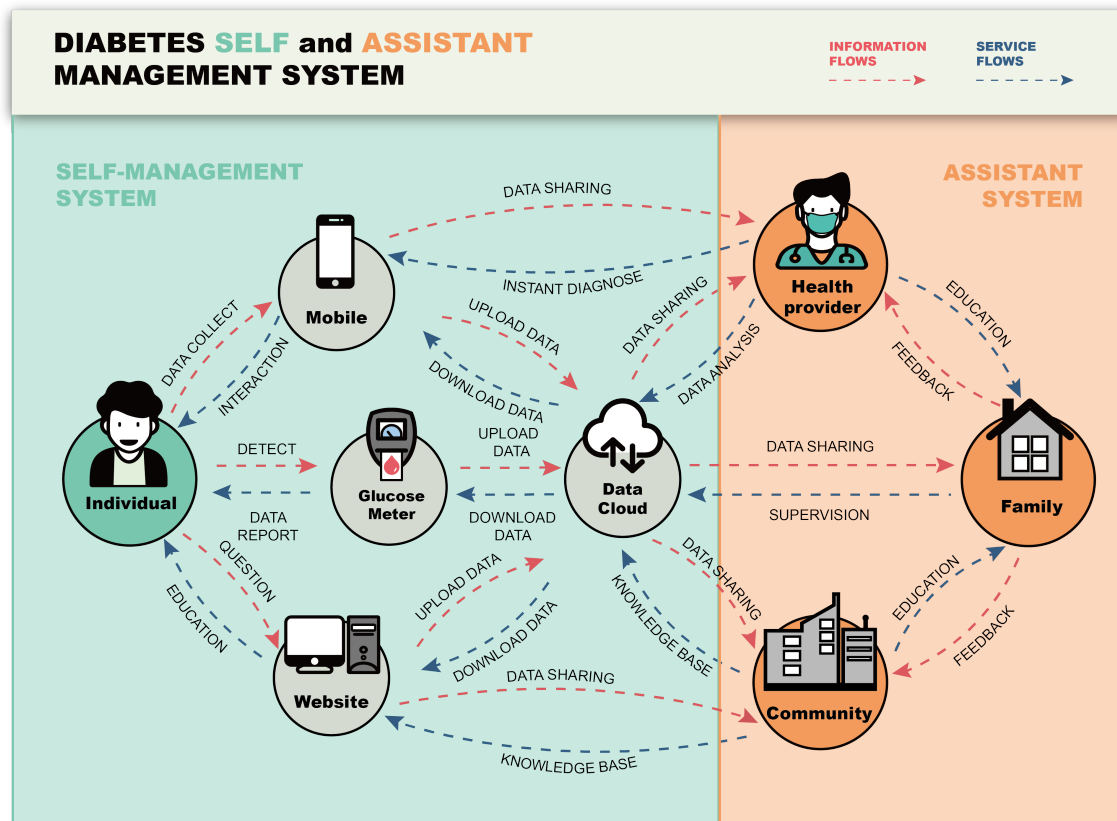## 5.3.4 Diabetes Self and Assistant Management System

Diagram 2: Diabetes Self and Assistant Management System

Diabetes self and assistant management system is a patient-centered system to increase the quality of diabetes management. The self-management system can access the existing healthcare system including mobile, glucose meter and website. All the patient-based health information is gathered in data cloud and shared with the assistant system including health provider, family members and community.

The data cloud utilizes a medical information system to store and analyze the transmitted information and then sends it to a medical group consisting of health

professionals, community family members of the patient. The medical team comprehensively interprets and analyzes the results and sends the solutions back to the patient wirelessly. The medical report from health providers is integrated with patient's situation in the data cloud. Then data cloud shares the best solution plan to each device so that patient can adopt self-management as soon as possible.

The mobile information technology-based diabetes management system is clinical and effective in saving medical workers' working hours, effectively improving the efficiency of medical workers, and effectively improving the quality of communication and interaction between patients and medical workers. In the future, the diabetes management system can be extended to other healthcare fields, such as remote management of gestational diabetes and the remote management of hypertension. It can also be used for monitoring diabetes complicated with depression. The rapid development of information technology and remote and mobile medical technology will bring a new round of changes in the medical service model, while patients will experience a more personalized, professional and convenient medical service system.

5.5 Future Research

This research discusses the general challenges patients will experience during the diabetes self-care. Based on the results of research, the quality of early education, the quality of communication between patients and health professionals and the

effectiveness of medical devices are three key elements affect the quality of diabetes self-management. However, this study doesn't focus on symptoms of aging. More research should be done to better understand the effect of aging on diabetes regarding complex elderly diseases. Future diabetes management system should incorporate diabetes patient data cloud to store and analyze abundant patient information and data. Smart technologies that learn from the user should be integrated into healthcare system through diabetes patient data cloud. Personalized diabetes education resources should be accessible on the online diabetes health education platform to provide effective knowledge for different patient's needs.

Because of the limit of time, there is a small number of participants involved in the study. Most of the participants are diabetes patients. In the future design, health professionals should be joined in to give the research a different perspective on diabetes management. It is also necessary to conduct a qualitative study that includes a large number of participants to reduce the possibility of random samples and make the result of study more reliable. In addition, it is essential to design and conduct an experiment or user test on the diabetes mobile applications. Right now, the review of the existing mobile applications help understand the opportunity of medical applications, but user test of mobile apps could increase the usability of mobile application and create a better interaction between patients and mobile devices.

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APPENDIX A

RESEARCH SURVEY AND INTERVIEW QUESTIONS (1)

1.What is your age?
18 to 24
25 to 34
35 to 44
45 to 54
55 to 64
65 or older

2. In general, how would you rate your overall mental or emotional health?
Excellent
Very good
Good
Fair
Poor

3. My emotional and mental health directly affects my diabetes self-management. (strongly disagree=1 and strongly agree =5)
1
2
3
4
5

4. In a typical day, about how many times do you monitor your blood glucose level?
One time
Two times
Three times
More times

5. What's kind of medical devices your used for helping your diabetic treatment?
Insulin injection
Blood glucose monitor
Mobile diabetes applications
Online Diabetes blogs or websites (online support groups)
Other

6. In general, how many times do you contact your doctor or family members about your health each week?
One time
Two times
Three times
More times

7. How will you rate efficiency of your medical devices during your diabetes treatment? Rate 1 as weakest effect, rate 5 as strongest effect?
1
2
3
4
5

APPENDIX B

RESEARCH SURVEY AND INTERVIEW QUESTIONS (2)

1. How supportive have the following people been in helping you..?
   Your family
   Friends or people close to you
   People at work
   Healthcare team
   Other people in your community

2. How is the efficiency of online diabetes education?
   1
   2
   3
   4
   5

3. What is the most tough problem you met? And how you solve it?

4. What's function needed for diabetes management?

5. What diabetes syndromes will happen because of diabetes? And how?

6.What is the change of have diabetes?

7. What problems are ignored in daily life?

8. How is your communication with diabetes online platform and patients?