Improving Diabetic Self-Management using Glucose Buddy

By

Maria Khatoon Ahmed

A Thesis Submitted in Partial Fulfillment

of the Requirements for the Degree of

Masters of Health Science - Health Informatics

In

The Faculty of Health Sciences

Program

University of Ontario Institute of Technology

September 2013

© Maria Khatoon Ahmed, 2013
ACKNOWLEDGEMENTS

First and foremost, I thank the Almighty God, Allah for this opportunity and bestowing upon me knowledge and patience to complete this work.

I would like to express the deepest appreciation and gratitude to my supervisor Dr. Jennifer Percival for motivating me and encouraging me to learn all that I know today. Her expertise, insight and competence have allowed me to be where I am today. Without her patience, constant guidance and support this thesis would not have been possible.

I would also like to thank my committee members Dr. Fletcher Lu and Dr. Jeff Moretz who have provided me with valuable feedback and serving on my supervisor committee.

Finally, I would like to thank my family, friends, and co-workers for their persistent enthusiasm, inspiration and encouragement which made this process possible. Their faith in my ability, my knowledge and my skills have pushed me learn to my full potential and accomplish my dreams.
# TABLE OF CONTENTS

1. Abstract ................................. 2

2. Introduction ............................ 2
   a. What is Diabetes? .................. 3
   b. Self-Management .................. 7
   c. Technology ....................... 9
   d. Canada Health Infoway .......... 11
   e. Privacy and Security .......... 13
   f. User Interface Design ........... 13
   g. Research Question ............... 15
   h. Significance of the Study ....... 15

3. Literature Review ..................... 16
   a. Technology and Health Care ... 17
   b. Electronic Health Records ...... 22
   c. Diabetes and Self-Management .. 27
   d. Diabetes and Technology ...... 29
   e. User Interface Design .......... 30
   f. Technology and Age Groups .... 33
   g. Privacy and Security .......... 35
   h. Gaps in the Literature ......... 38

4. Review of the Application .......... 42
   a. Personal Experience and Review 43

5. Methodology ........................... 46

6. Results ................................. 54
   a. Demographics ..................... 54
   b. Device and Comfort ............. 57
   c. Personal Privacy and Security .. 58
   d. The Application ................. 59
   e. Privacy and Security .......... 66
   f. Online Review ................... 70

7. Discussion ........................... 74
List of Tables and Figures

Tables

1. Table 1. Blood Glucose Levels for Diabetics ........................................... 5
2. Table 2. Comparing Diabetic Applications .............................................. 43
3. Table 3. Comparison of the unknown benefits to diabetics and effectiveness of the application ................................................................. 63
4. Table 4. Comparison of the benefits and effectiveness of the application .... 64
5. Table 5. Effectiveness of the Application .................................................. 65
6. Table 6. Online Reviews ........................................................................... 71

Figures

1. Figure 1. Glucometer for blood glucose reading ...................................... 7
2. Figure 2. The technology acceptance model ........................................... 19
3. Figure 3. Touch user interface design ...................................................... 32
4. Figure 4. Intelligent user interface design. Putting the saved data into a chart format ................................................................. 32
5. Figure 5. Zoom user interface design ....................................................... 33
6. Figure 6. Glucose Buddy Application logo ............................................. 44
7. Figure 7. Glucose Buddy home screen .................................................... 44
8. Figure 8. View of the log screen header .................................................. 45
9. Figure 9. Students associated faculty ...................................................... 55
10. Figure 10. Type of personal device as indicated by each user ................. 56
11. Figure 11. Security feature on each participants personal device ............. 59
12. Figure 12. Usability of the application .................................................... 61
13. Figure 13. The benefits versus the reliability of a free application in health care 62
14. Figure 14. Comparison of the benefits of the application to diabetics and recommendation of the application ............................................. 63
15. Figure 15. Sharing of the application with healthcare providers and level of comfort with providing them access ........................................ 66
16. Figure 16. Comparison of using the Glucose Buddy in health care by health care providers, and sharing the results .......................................................... 67
17. Figure 17. Security of the Glucose Buddy application by participants .......... 68
18. Figure 18. Recommended security feature of the Glucose Buddy application as indicated by participants ................................................................. 69
19. Figure 19. Confidence level with security of persona information on the Glucose Buddy application ................................................................. 70
20. Figure 20. Functionality options requested by online reviews .................. 72
21. Figure 21. The Glucose Buddy application and add log screen for blood sugar 76
22. Figure 22. Viewing the history of the weight entered by users .................... 79
23. Figure 23. A quick glance view when launching the logs by list ................. 80
ABSTRACT

Diabetes is a chronic condition that requires regular ongoing monitoring. This quantitative descriptive study looks at utilizing the application “Glucose Buddy” designed for diabetic patients, available on Apple devices, and identified if the application is easy to use for any type of user and the security of the application to protect potentially sensitive health data. The navigation and ease of use of any application should be simple for any type of user (Bay & Ziefle, 2005). The study only required that the individual was able to interact and cognitively accept the application. Results show that 91% found the application easy to use and navigate without a tutorial. Our results indicate that the application is beneficial for newly diagnosed patient’s as it provides a graph format for viewing and allows them to enter in basic data related to their diabetes.

**Key Words:** Diabetes, Glucose Buddy, Self-Management, Ease of use, Technology Acceptance Model.
INTRODUCTION

The health care system in Canada has provided health services for the community. Health services are sought out by the participants in the community when disconnects occur in activities of daily living, health, and quality of life for the individual. Health care in Canada is based on a publicly funded system whereas in the United States it is based on a private system, thus requiring more focus on equality and accessibility of care for all (Health Canada, 2004). A publically funded health care system means that most basic health care services are provided free of charge and equally to all individuals. Health services therefore are costly to the government and efficient use of funds by the health care organization can sustain the health care system.

There have been increasing costs related to health care services over the past few years due to the growing number of chronic conditions (Vogeli, Shields, Lee, Gibson, Marder, Weiss, & Blumenthal, 2007). A chronic condition can be any long term illness or condition that impacts ones quality of life. An estimated 80% of Canadians are living with a chronic condition (Ministry of Health and Long Term Care, 2007). With the support of the health care system and the individual’s active participation, a chronic condition can be maintained and individuals can live a good quality of life without major health complications. Chronic illnesses are a high priority for health care systems because they are costly, complex to manage, and could result in substantial disability (Young, et al, 2007). Costs for chronic illness care are approximately 55% of total health care costs and rising (Ontario Ministry of Health and Long Term Care 2013; Young et al, 2007). As a result, it is essential for individuals with chronic conditions to learn how to maintain and manage their illness at home, in order to decrease the costs to the health care organization. This is not done in isolation though, and needs ongoing support from the health care team. Patients often lack key skills and information they need to self-manage their illness (Young et al, 2007). It is therefore essential to educate these individuals with regard to self-management and maintaining health outside of health care organizations to keep the costs to a minimum. This would not only improve autonomy for patients with chronic conditions, but would also decrease costs to the health care system due to these chronic conditions. The focus of this paper will therefore be on a chronic condition, in
particular, diabetes, in which there is not enough insulin produced by the body. An individual with this chronic condition is able to continue living a healthy lifestyle if the condition is managed correctly. For individuals who live with diabetes, managing their illness independently can help decrease costs to the health care system and improves quality of life.

What is Diabetes?

Diabetes is a chronic condition that affects millions of people worldwide (Lewis, Heitkemper, & Dirksen 2006). It has been estimated that by the year 2020 there will be a 48% increase to health care costs due to diabetes and over 1.3 million people will have this chronic condition (Ontario Ministry of Health and Long Term Care, 2007). Most often, the diabetic population includes those at an older age, those with obesity, those who live a sedentary lifestyle, and those who are genetically predisposed to diabetics (Canadian Diabetes Association, 2012). The prevalence of diabetes is increasing in our health system, due to the associated complications and unmanaged and uncontrolled diabetic levels. This results in increased costs to the health care system as a result of treating the complications. Diabetes is the 5th leading cause of death today and continues to rise amongst society (Faridi, Liberti, Shuval, Northrup, Ali, & Katz, 2008). There are many reasons for the admission and readmission of diabetic patients to a health care organization, including a lack of knowledge of how diabetes works in the body, and how it should be managed, how to maintain normal glucose levels, and clinical interventions needed to prevent further complications. This section will discuss what diabetes is, including the different types of diabetes, risk factors, and how it can be managed.

In the body, when a meal is consumed, as food is broken down into carbohydrates and fat, it releases glucose in the body and blood stream. As a result, the pancreas starts to produce insulin, which then absorbs the excess glucose in the blood stream and stores it as glycogen. During exercise or physical activity, the glycogen is then converted again to produce energy which is released out of the body. Glucose is absorbed from the blood stream, by the insulin produced in the body, to be used as a form of energy (Lewis, Heitkemper, & Dirksen, 2006). Normal blood sugar levels are between 4.0 and 5.9 mmol/L (Diabetes.co.uk, 2013). Throughout the day we consume meals that the body
stores as glucose and later utilize this glucose to expend energy. So what is the cause of diabetes? Diabetes is defined when the liver does not produce insulin, or enough insulin, to absorb the glucose in the body (Lewis, Heitkemper, & Dirksen, 2006). This causes high amounts of sugar in the blood due to the lack of absorption of carbohydrates and fats from the blood stream. With diabetes, there is often little to no glucose being absorbed and stored as glycogen thus resulting in the high levels of sugar in the blood. The results of high levels of blood glucose in the body can lead to a variety of symptoms if not treated, such as heart disease, kidney disease and nerve damage.

There are three types of diabetes that exist: Type I, Type II and gestational diabetes. With Type I diabetes, it often begins at an early age due to the lack of insulin made in the body. The body makes little to no insulin to absorb the glucose during meal times. Without external interventions, the levels of glucose in the blood stream continue to rise. As a result, with this type of diabetes, patients are required to take an external source of insulin via insulin needles. This type of diabetes cannot be prevented and is often linked to genetics.

Type II diabetes often occurs later on in life when the body does not make enough insulin. While the body does produce insulin, with this type of diabetes, there is often not enough to absorb all the excess glucose ingested during meals. The individual’s body is unable to make enough insulin to keep up with the absorption of glucose and thus requiring intervention. With this type of diabetes, interventions are often in the form of oral medications, and if levels remain high, may also be used in combination with insulin. Type II diabetes differs from Type I in that it occurs later on in life, can be prevented, may be related to genetic factors, obesity, or health problems, such as high cholesterol and high blood pressure (Lewis, Heitkemper, & Dirksen, 2006). It is the most common type of diabetes and can be prevented through proper diet and regular exercise.

Finally, with gestational diabetes, it occurs only during pregnancy when there is a high level of blood glucose content in the body. Gestational diabetes affects 3-20% of pregnant women (Canadian Diabetes Association, 2012). With this type of diabetes the body cannot handle changes related to the growth of the baby and therefore does not produce enough insulin causing a rise in blood glucose. Untreated, the baby could be at risk of increased birth weight and there can be difficulty related to labor (Canadian
Diabetic Management 5

Diabetes Association, 2012). Once the pregnancy is complete and the baby is born, this type of diabetes subsides, but the individual is now at an increased risk for Type II diabetes.

Regardless of which type of diabetes that one has, in order to continue to live a healthy lifestyle, the diabetic level must be managed through glycemic control. Monitoring the range for diabetic blood glucose is how an individual is able to control their glucose levels on a regular basis, ensuring a balance between meals, activity and medication. Table 1 below (Diabetesco.uk, 2013) indicates what the normal range of blood glucose levels are before and after meals.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Glucose Levels for Diabetics</td>
</tr>
<tr>
<td>By Type</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Non-diabetic</td>
</tr>
<tr>
<td>Type 1 diabetes</td>
</tr>
<tr>
<td>Type 2 diabetes</td>
</tr>
</tbody>
</table>

Note: From Blood sugar level ranges, 2013, Diabetes.co.uk

There are several risk factors related to the cause of diabetes, which can be categorized as modifiable and non-modifiable risk factors. With Type I diabetes, since there is no way to prevent it from occurring, it is therefore a non-modifiable risk factor. The non-modifiable risk factors for Type II diabetes include age, weight, and family history that cannot be changed; the modifiable risk factors include dietary habits, blood pressure and cholesterol levels, things that the individual can change or factors that they can control to prevent getting diabetes (Lewis, Heitkemper, & Dirksen, 2006). While one can be predisposed to Type II diabetes, there are several ways to decrease the risks of this disease, such as by monitoring dietary habits and maintaining an active lifestyle. Currently, there is no cure for diabetes. Instead, the disease may be managed through lifestyle changes, which include dietary modifications, exercise and monitoring of blood glucose levels on a regular basis (Lewis, Heitkemper, & Dirksen, 2006). With these changes and ongoing monitoring of this chronic condition, the individual is able to live a
good quality of life at ease. Diabetic management requires taking an external source of insulin or oral medications to keep blood glucose levels at a normal range. By not managing blood glucose levels, one is at a greater risk of developing further complications such as heart disease, stroke, kidney failure, coronary artery disease and blindness (Lewis, Heitkemper, & Dirksen, 2006).

Current methods of diabetic management involve taking your blood sugar regularly, monitoring what you eat and regularly exercising; all which can be done by the individual alone. There are several mobile devices that can assist with blood glucose monitoring, such as glucometers and insulin pens (Canadian Diabetes Association, 2012). To determine the blood glucose of the patient, the individual takes a small drop of blood on a strip which is inserted into a glucometer as noted in Figure 1. The glucometer then displays a number on the monitor, which is the blood glucose level at that time in the body. When managing this condition, diabetics are encouraged to take their blood glucose level using such devices before meals, in order to prevent hyperglycemia (high glucose level) from occurring (Canadian Diabetes Association, 2012). Each level of blood glucose reading may vary on both a day to day basis, and between each meal. It is therefore essential for the individual to ensure ongoing monitoring to maintain optimal health. Each individual may do this differently and at different times of the day depending on their own personal preference. Methods of tracking can include writing it down on paper, entering it into a spreadsheet at regular intervals and using both a manual method and electronic documentation combined. The risks of not managing or tracking diabetic glucose results and not making changes to daily habits and lifestyles increases the risk of complications and admissions into an acute care facility. During regular check-ups with a health care provider, the glucose results that are documented overtime become important to share in order to prevent complications from occurring and putting the health of the individual at risk.
With the new advances we see in technology, there have been numerous programs developed to aid in managing long term diabetes and tracking changes to blood glucose levels in order to prevent further complications from occurring. As we move forward and progress with new equipment and programs daily, it is now a norm to be using this technology to aid in improving our health. Using electronic tools such as health applications, excel spreadsheets, and electronic sharing, we can help long term diabetics with self-management and decrease hospital costs related to diabetes and diabetic associated complications.

**Self-Management**

Diabetic management involves ongoing monitoring and care for patients. More than 95% of diabetic care is done by the patient, and health professionals have very little control over how patients manage their illness between office visits (Mahfouz, & Awadalla, 2011). It is therefore essential for patients to know and understand how diabetes works and how to maintain their blood glucose levels in the acceptable range. Self-management entails that the individual take on a primary role into their health and be actively engaged (Anderson & Christison-Lagay, 2008). The health care provider in this situation would be identified as a secondary provider who provides support to the individual to ensure that blood glucose levels remain within normal limits, while the primary is the patient who manages and maintains on a regular basis, their own blood glucose monitoring results. A patient’s involvement in managing their diabetes daily is
therefore essential in order to maintain their quality of life (Mahfouz, & Awadalla, 2011). Without self-management, there is a high reliance on the health care system, thus increasing health care costs and decreasing patient independence.

Individuals with diabetes are able to continue to engage in all the activities they previously did before being diagnosed with diabetes. But now, with this diagnosis, they need to consider their health when making meal time decisions. They need to regularly monitor what their blood glucose levels are and keep them within a normal range, in order to prevent associated complications from occurring such as heart disease, kidney disease and diabetic comas. Although this may seem like a major change in their life, it can easily be learned and adopted if the individual is willing. This is also known as self-management.

For the purposes of this research, self-management will be defined as the ability to maintain a healthy lifestyle while living with diabetes. This includes making lifestyle modifications, dietary changes, blood glucose monitoring and exercising. For diabetics, self-management involves frequent self-monitoring of blood glucose, education and medication administration (Mahfouz, & Awadalla, 2011). Having good self-management techniques means that the individual can live a healthy lifestyle without having to be admitted to an acute care facility or needing to seek medical attention due to diabetic related complications. There can be no interruption to their lives if managed appropriately.

Without self-management, there is a greater risk of obtaining an associated complication due to diabetes that could decrease the quality of life for the individual. Unfortunately, as Type II diabetes is sometimes developed later due to these unhealthy lifestyles, it requires an additional amount of effort in order for the individual to change what they have always been doing. These complications can lead to the individual being admitted to an acute care facility and requiring ongoing care until they can learn to manage their health. It is thus essential that individuals learn the importance of self-management and be able to track and adapt these techniques into their lives.
Technology

The digital age has brought upon many advances both publically and privately. As it continues to grow we are presented with numerous benefits, such as communication and information sharing, and challenges, such as privacy and confidentiality. As we continue to evolve, technology has become part of our everyday lifestyle. Technology in the private sphere has been focused on communication, sharing electronic information, and the use of social media (Fitzgerald, Wright, & Kazmierski, 2010). In the public domain, it is used to advance customer support, decrease manual processes and improve productivity (Pearlson & Saunders, 2010). Technology is a tool used to support processes and decisions but does not replace work (Thielst, 2007). While technology can prove to be beneficial and most efficient, there also needs to be a clear connection for the user to interact with the device and not depend on it for clinical judgment and decision making. Technology should not guide and dictate the work that employers do, but employers should use the technology to support the work that they are doing, to ensure productivity and positive outputs (Pearlson & Saunders, 2010). If used correctly, technology implementation in any organization can be effective and efficient in producing positive outcomes. For example, identifying patterns of high risk behavior early allows for health care providers to create effective interventions.

The effects of using technology in an organization can benefit both the employee and employer. A significant amount of learning occurs in the workplace as we perform a broad range of tasks (Torkzadeh, Chang, & Hardin, 2011). The employee learns skills, and can make better informed decisions. They learn to achieve tasks using their best judgement, improve their workflow and productivity. As they interact with technology to accomplish tasks, they learn more about their job and become more innovative in carrying out responsibilities (Torkzadeh, Chang, & Hardin, 2011). They are able to develop new and creative ways that both improve their way of thinking and may even exceed expectations. Technology enabled job learning is both a new form of labour and an increasingly acceptable measure of return on investment (Torkzadeh, Chang, & Hardin, 2011). For organizations, this means that they are able to make a profit and get the most use out of their employees. For employees, this means that they are able to increase their learning and increase their productivity. They have better job performance
which can lead to better and positive outcomes. With the proper utilization of technology, health care providers can teach diabetic patients how to self-manage this chronic condition to improve their health outcomes in an efficient manner.

Since the 1970s there has been a rapid pace of advancement in computer technology which is being used in every aspect of our lives (Bernstein, McCreless, & Cote, 2007). It is imbedded in every aspect of the work we do allowing us to communicate with others, share pictures, videos, and experience, and gather information. Technology is a critical aspect in shaping our future and improving our ability to collect, gather, and share information in a timely fashion with others. Information technology has become more affordable, powerful, reliable, accessible and versatile (Bernstein, McCreless, & Cote, 2007). The accessibility of technology has impacted society in a variety of ways and allowed us new ways to process and manipulate data for knowledge.

Technology is also used as a form of communication in order to share information effectively with those who require the most updated information for positive outcomes (Pearlson & Saunders, 2010). It ensures that all necessary information is shared for those who need access to it. Not only does technology help with communication, it is also known to help in decision support, work integration, and customer service (Torkzadeh, Chang, & Hardin, 2011). It helps with the communication between providers and accessibility of retrieving the information in a timely fashion. Health care objectives often revolve around wanting to have the best patient experience, and improving the health of those who seek medical attention. The new developments in technology can impact the quality of care that individuals receive and therefore, integration of technology to manage health should be considered. For diabetic patients, this can be beneficial to support them through the process of self-management. Sharing information electronically with the health care provider ensures that there is open communication and ongoing support. Risks and issues are identified early by the health care provider and changes are made to improve one’s health and continually support the self-management of this chronic condition.
Canada Health Infoway

Our health care system has seen many technological advances and changes over the past few years. One organization that is playing a significant role in this transformation is Canada Health Infoway. Canada Health Infoway, was developed in 2001 and is committed to creating an integrated electronic health record that will improve our health system and the quality of care we provide to the public (Canada Health Infoway, 2012). Canada Health Infoway works together with governments and territories across Canada to support and sustain technology standards in health care and work as a basis for providing the technology blueprint for an electronic health record (Canada Health Infoway, 2012). The goal of Canada Health Infoway is to develop a collaborative electronic health record that utilizes technology to enhance health care. The purpose is to allow for easy and quick access to care, decrease wait time and make informed decisions on behalf of patient’s in a timely fashion. Having this historical health data readily available for clinicians to view and access can lead to beneficial outcomes.

Currently, the focus of Canada Health Infoway projects has been towards developing electronic records and technology implementation into a majority of hospitals, and organizations such as family doctors’ offices and some community clinics. In Ontario, they have started to develop integrated projects such as telehealth and public health surveillance programs that utilize technology for health care needs (Canada Health Infoway, 2012). These projects often begin as pilot programs in one province and as issues arise or gaps in the program are identified, they are modified and managed and finally incorporated in other health care systems across the provinces. These projects are funded by the individual provinces with the support of Canada Health Infoway, with the intention to support the overall development of an integrated electronic health record for the patient. While there are numerous projects implemented and evaluated on a regular basis, these projects such as Telehealth, work at addressing issues early on and support the sustainability of the health care system across Canada.

In terms of diabetic management, Canada Health Infoway has developed a diabetic registry that tracks diabetic patients, regardless of what type they have (Canada Health Infoway, 2012). The diabetic patients are asked to register themselves onto this registry in order to identify themselves as a diabetic patient. This information can then be
accessed by health care organizations across the country when required. The purpose of the registry is for providers to identify if they have a diabetic patient and gather their health data related to their diabetes from the registry without having to ask the patient each time they visit a health care facility. This might be beneficial in emergency situations where access to diabetic information is required in a timely fashion. The diabetic registry gathers information such as indentifying the individual as a diabetic patient, and what type of diabetes they have. Patients are simply asked to self report onto the registry by signing up online. No other information has been provided at this time about the registry.

There is little information on how the diabetes registry will be used by health care providers and the public after registration. For diabetic patients who are entering their personal data into the registry, they may have a concern regarding the privacy and confidentiality of their data, and ensuring that it would not be used to cause them harm. They also do not know if this is a mandatory registry in which they are required to enter in their information and why the registry is made mandatory, or if it is not mandatory, what the purpose of the registry is and how it can benefit them. For diabetic patients, who do not wish to use the registry, may also want clarity on how this will impact the care that they are receiving from their health care provider. For example, if they do not use the registry, will it decrease or limit the resources or education they have access to compared to those who do use the registry? There is also no information on how this will improve diabetic management for patient’s and decrease associated complications related to their illness. Finally, Canada Health Infoway has not identified who will have access to this information and how patients can control what information is put on here, or how it will be managed and updated. If this information were to be accessed or shared with others who should not have access to it, this would result in a privacy and security breach to the patients health record. For example, an employer who gains access to this information may not hire a diabetic patient knowing that they will be using health benefits on a regular basis to manage the blood glucose levels.

Projects developed by the Canada Health Infoway, such as the diabetic registry are developed to support individuals in the community providing them with better access and resources to health care via technology (Canada Health Infoway, 2012). The goals
are to support both health care providers and diabetic patients via technology. For diabetic patients, they are looking at how to use technology to improve patient participation and improving self-management. In addition, the participants at Canada Health Infoway are providing leadership, resources and support for the use of technology in health care (Canada Health Infoway, 2012). Canada Health Infoway encourages and supports the use of technology for improved self-management and for better patient outcomes.

Privacy and Security

There are certain laws in place in order to protect the privacy of personal health information. As we explore more into various technologies and its application in our lives, including health maintenance, it is important that we take every necessary precaution and due diligence to ensure that this information is stored securely and safely. Patients have a right to their privacy and confidentiality of their personal health information as required by law in the Personal Health Information Protection Act (PHIPA) (Ontario Ministry of Health and Long-Term Care, 2004). PHIPA was developed to protect the private health information of individuals including gathering and sharing the information in any way. Unfortunately, due to the rapid pace of technology, the law often falls behind on keeping up with these fast changes (Fitzgerald, Wright, & Kazmierski, 2010). Organizations need to have an ongoing review process in place to keep up with technology changes and address the new laws that arise. As we improve our current technology and constantly change to improve our overall health care system, it becomes more difficult to maintain security in the electronic world. Consumers expect health care professionals to uphold this security at all times. If consumers are to invest in technological health products, they also expect these products to have some sort of security measure to ensure that it is not shared with others without consent.

User Interface Design

One vital component when looking at technology and health care is the user interface design. User interface design is known as the user experience and interaction with technology (Garza & Kock 2007). The goal of user interface design is to ensure that
it is simple and efficient for users. It allows users to easily navigate and access information using technology and applications in the electronic world with ease. Improving the ease of use is therefore an essential aspect for many users, and technology producers use this as a key feature to sell their products in a competitive market.

The user interface design has an important impact on how effective a technology or program will be. If the technology and application is complicated, difficult to navigate and unclear, it is unlikely that the application or technology would be accepted and widely used by users. For the health care industry, this is beneficial because it saves time for the clinician in that it is easier to gather information and navigate applications with ease in a quick efficient manner. Not only does the user interface design need to be effective, it also needs to meet the needs of end users who will be using the product. If consumers are not satisfied in terms of functionality and user interface design, there is a higher chance of the product being ineffective and inadequate (Garza & Kock, 2007). The benefits of user interface design are also beneficial for the creators of the program. The intent of a user interface design is for ease of use for the user, and not for the applications itself. There is no cost associated with managing and maintaining a user interface design (Garza & Kock, 2007). The lower the costs associated with the user interface design, the easier it is to share and learn. Once it is developed and learned by end users, improvements are made, but it does not require extensive training as the basics has already been learned by the user the first time.

Overall, if technology in health care does not improve health, then none of the above mentioned benefits would be of importance. Programs can be developed and created by vendors, accepted by consumers and health care providers, adopted and utilized, but without effective reliable results in improvement in health or management of a healthy lifestyles, the technology created has been done in vain. As user acceptance is necessary as a required intermediate step towards effecting patient health, this study will be exploring free applications available for public use, to determine barriers to the use of mobile applications for diabetic self-management and identify areas for future development. Considerations of user interface design and how important it is for users to maintain privacy and security while contributing to their electronic health record will be the primary focus of this study.
**Research Question:**
Is the application “Glucose Buddy” easy to use, in terms of navigation and user interface design, and does it improve knowledge about daily self-management techniques that contribute to health care practices for diabetic patients?

**Significance of the Study**

The purpose of this study is to determine the efficacy and user-friendliness of the free Glucose Buddy application available on iPhone/iPod/iPad devices. In addition, it will assess its privacy and security features of the application in order to see if this impacts how a user might use the application. Finally, the research would look at if the application could potentially be used for diabetic patients. By evaluating what is currently available to the public, the study will hope to identify why one may or may not choose technology to self-manage and also identify gaps in the example application. It can also provide an understanding of what patients would like when using technology to manage their diabetes and not just from a health care administrator perspective.
LITERATURE REVIEW

A literature review of the previous studies for health and quality of life was done to identify why the area of chronic care has not utilized available technology to improve their health services, including diabetic management. Technology in health care has mainly focused around managing acute health issues by clinicians but not as much on chronic conditions. The focus of most research studies have been done on managing long term illness such as cancer or kidney failure and technology, but not diabetes. A search was done via the UOIT library website on the following databases CINAHL, ProQuest, Ovid and the EBSCO host database. The following key terms were used to conduct the search alone and in combinations: “diabetes” “self-management techniques” “technology in health care” “technology and diabetes” “web-based applications” “diabetic management” “privacy” “security” “mobile devices”. Key terms including “Glucose Buddy” were included, but did not yield any results. As the research was focused on finding scholarly research that was previously done on this topic and most updated information in terms of technology, limits on the search included finding scholarly peer reviewed articles that were published after 2008. Using articles previous to 2008 may not always be accurate or up to date in terms of the latest technology that has been developed. Articles found previous to 2008 were focused on the development and historical timeline of how technology has evolved in health care. The search resulted in over 30,000 articles which was then reviewed and narrowed down to the ones that were applicable to my research. The results were narrowed down based on the design of the study, focusing on chronic conditions, including diabetes and technology. They were also narrowed down if the study did not include any of the Apple devices. Unfortunately, this did not yield any results and this limitation was then removed. Many of the research studies developed and implemented their own device and electronic application. Apple devices are quite popular amongst the population and have had numerous different types of devices developed. Focusing on one type of brand would have eliminated the need to include the various operating systems and how they differ from each other.

Studies were also categorized into themes to identify key elements such as technology and health care, diabetes and self-management, diabetes and technology, user
interface design and privacy and security. In addition, grey literature was searched, to get information regarding the Canada Health Infoway project and the application of study, Glucose Buddy. This was done on the Canada Health Infoway website and the Glucose Buddy webpage. Grey literature is unpublished articles, such as government websites and the internet, but provides relevant quality information for this research. Lastly, information was collected from various websites such as Health Canada, The Ministry of Health and Long Term Care, and e-Health Ontario to get updated information and status of current projects in the health care industry related to diabetes. Overall, approximately 50 articles and website were reviewed to conduct this literature review and develop a foundation for this research.

Technology and Health Care

The development and utilization of technology has also impacted health care in a significant way. It is becoming more prominent in the health care settings particularly in acute care (Kabachinski, 2011). Technology in health care includes a variety of products in both clinical and non-clinical areas to support health care practices. For clinical practice, products are used to support and enhance the care that is provided. Different types of health care products are being developed to assist with these processes to ensure that the best possible outcomes are reached (Bernstein, McCreless, & Cote, 2007). The technologies created within health care are advanced and require knowledge training and understanding. Technology includes tools such as an Electronic health record or EHR, clinical decision support tools, hospital information management, laboratory equipment, new medical and surgical devices and other biomedical inventions (Lee & Meuter, 2010). In order to provide quality health care utilizing technology, it needs to be taught and learned by employees in order to be effective. Technology is a tool and needs to therefore be learned. It is a tool in many forms to improve effectiveness and efficiency in activities of daily living and in the professional workplace (Thielst, 2007). Without understanding how this tool works and how it can be beneficial there is no value to its application in health care. Clinicians need to have a clear understanding of how the tool works, weighing the benefits versus the risks of using or not using the technology, and only then can the clinician apply the technology in an effective method and receive positive
outcomes. Once the technology is adopted and implemented it then needs to be evaluated and reviewed on a regular basis. It needs to be modified as new research and studies are conducted and technology improvements are made in order to meet the ultimate goal of a better quality of health care for the community. Although technology plays a major role in developing our health care system it is not without its flaws.

Adoption of information technology was a key driver to improving the quality, safety, and efficiency of health care delivery in hospitals (Hikmet, Bhattacherjee, Menachemi, Kayhan, & Brooks, 2008). While the adoption of technology is essential for an organization, users (such as physicians and clinicians) need to accept the technology for it to be utilized in the health care setting and effective in producing positive outcomes. One way to measure this is using the technology acceptance model (TAM) that has been developed by Fred Davis (Davis, 1989). People tend to accept or reject technology based on if it will help them perform their job better or not (Davis, 1989). Specifically the technology acceptance model assesses end-user acceptance of a technology for a health communication purpose (U.S National Library of Medicine, 2012). If the users do not accept and adapt to the technology that is introduced within the organization, it will not be used. TAM describes two elements that influence ones intention to use technology: Perceived ease of use and perceived usefulness in relation to how it will enhance his or her job performance (Chib, Lwin, & Jung, 2009; Davis, 1989). Perceived ease of use can include how comfortable the user is with the technology and that they feel that it is easy to use. With perceived ease of use, the user is more likely to have a positive attitude towards the technology. With a positive attitude, there is a higher intention to use the technology as well. Perceived usefulness is indirectly linked to ease of use of the individual. Users are more likely to find the application useful if it is easy to use. With Perceived usefulness, the individual is more likely to also likely to have a positive attitude and a higher intention to use the technology Perceived usefulness of technology can have positive impact to both the user and the organization. First, it would lead to user satisfaction and increased use of the technology by users as they feel that it is beneficial and impacts the outcomes (Chib, Lwin, & Jung, 2009). Secondly, users would be more likely to recommend the technology to others to use and provide positive feedback (Chib, Lwin, & Jung, 2009). Figure 2 identifies the technology acceptance model. When
implementing technology, it is also important to understand which factors may hinder the implementation of technology so that it can be addressed during the implementation process and to encourage acceptance. Factors that may inhibit adoption include technological familiarity, usability, relevance and individual motivations (Chib, Lwin, & Jung, 2009). Therefore, when implementing technology and encouraging acceptance, these factors are addressed to support clinicians through the process by allowing them time to use the technology and provide feedback for improvement.

![Figure 2. The technology acceptance model (TAM) From Hu, Chau, Sheng, & Tam (1999).](image)

The implementation of technology is effective only when it is done correctly. Technology is constantly changing and evolving (Thielst, 2007). As a result, we constantly need to evaluate the technology that we have within the health care system to ensure that we are staying up to date at all times in order to be providing the best possible quality care. In the article by Bernstein, McCreless, & Cote, (2007) and Lee, & Meuter, (2010) they both identified constant factors that are required to successfully integrate information technology in health care. The constants identified in the articles provide
some basic guidelines for when we are evaluating, modifying or adopting new technology. The first constant identify is budget (Bernstein, McCreless, & Cote, 2007 & Lee, & Meuter, 2010). Technology is fluid and frequently being modified in order to provide the best of its functions. It provides users with new and improved ways to provide care in an effective manner.

In order to change or improve the technology within a health care organization, budget must be set aside to accommodate for this. Budgeting can include costs for adoption, implementation and ongoing maintenance which can over time, become costly. Costs can be divided into two categories: Upfront costs, and hidden costs. Upfront costs are expensive, and most often unanticipated costs exist for items such as information technology, support, additional hardware, training and over-time pay (McBride, 2012). These are costs that are expected by the organization and often accounted for. For implementation of an EHR in a small organization, costs can be from US $247,000 and for a bigger hospital can start from US $1.3 million (McBride, 2012; Thompson, Velasco, Ferdinand, Classen, & Raddemann, 2010). Hidden costs could include upgrades and maintenance, extra hardware and additional support for adoption and implementation and in the first six months of an implementation reached US $8,994 for an average work week per physician (McBride, 2012). Without proper budgeting into technology, the tool becomes outdated and the quality and efficiency of the health care system declines. It is therefore essential to know where the costs to an EHR are from and how it can be maintained and managed over the long term.

The adoption and implementation of technology in health care does not replace the clinical skills of the provider, but should work to support and guide the clinician to provide the best possible outcome for the patient. Health care providers need to be able to learn how to use the technology in order to guide their care and not allow technology to dictate the care that they provide. Thus, the second constant identified was supportive leadership (Bernstein, McCreless, & Cote, 2007). Communication is a key tool in successful projects, and the implementation of technology is no different. Technology can impact all areas of a hospital organization including financial and human resources (Bernstein, McCreless, & Cote, 2007 & Lee, & Meuter, 2010). When implementing an EHR into an organization, it affects all the clinical areas in addition to support services.
and non-clinical areas to support the services that are being provided. It therefore requires supportive leadership in all areas. In order to meet the organizational goals, the leadership teams need to communicate key information to front line staff that can directly meet the needs of the organizational goals. If there is no support for the changes being made, implementing and utilizing changes will be ineffective. Providing support to clinicians to identify the validity and the benefits of the EHR in meeting organizational goals increases the likelihood of technology acceptance by users. The implementation needs to be a corporate goal that all staff share in order to be successful.

A third constant identified was project management. Project management involves having an organized plan with specific deadlines and target dates for each milestone in order to meet the overall goals. All changes in technology, regardless of how small or how big, can impact anyone at any given time. Each change made needs to have goals and outcomes to be achieved. Setting the change as a project will allow the organization to establish priorities, manage and track changes, and achievements overtime (Bernstein McCreless, & Cote, 2007; Thielst, 2007). Additionally, having a project timeline allows multiple people to be working on the same project, meeting the same deadlines and ensuring communication with the team on a regular basis. Issues are identified early and decisions are made quickly to ensure that the overall timeline of the project is met. As each project milestone is met, there can be an evaluation and feedback with the implementation of the current milestone and with the implementation of the next milestone, modifications made to the primary milestone can be implemented.

Finally, technology implementation needs to maintain safety and privacy (Lee & Meuter, 2010). Safety is a key factor in the implementation and the ongoing process of information technology in health care. Preventing unauthorized access needs to be addressed, yet the ease of sharing information with outside providers also needs to be taken into consideration. Safety requires a balance of health care providers adopting various technologies to meet the complexities of today’s health care demands, regulatory requirements and consumer expectations (Lee & Meuter, 2010). Providing a safe yet effective system that benefits all that are involved must always be top priority and due diligence must be evident to ensure safety measures are in place.
More organizations are also using technology to share information with others within the health care organization. Technology devices are used to store electronic health records (EHR), thus replacing paper records. EHR’s are an online version of a paper chart for the patient that seeks medical attention within an organization. The information and medical history of the patient are stored within the electronic devices and use specific medical programs to display this information. EHR’s are now common in large provider organizations and many smaller organizations have adopted focused informatics tools for the EHR (Young et al, 2007). A majority of health care organizations have some type of EHR either fully integrated or partially integrated into their organization. No longer are providers using paper records that may get lost, get misplaced or increase the risk of privacy breaches. Instead, they have now shifted to EHR's as a primary tool. Electronic records have also made it easier to share information and maintain patient confidentiality, by putting documentation in one central location and requiring them to log on.

Information systems implementations have been reported to provide significant benefits to health care organizations, such as better data quality, availability, accessibility, connectivity, exchange and sharing of information (Mantzana, Themistocleous, & Morabito, 2010). In order for clinicians to access this information, they are often required to log in using a secure password that tracks what they do on these electronic devices. Electronic health data can be shared with health care providers in different departments and between the interprofessional team. Electronic health records are becoming easily shared within the organization. Having EHRs decreases the risk of duplicate information and decreases the risk of not having information in a timely fashion. Once the data is gathered and entered into the electronic health record, it is shared amongst all the care providers and easily accessible, and does not require the information to be asked numerous times. For example, when a patient gets admitted into the hospital, they may be asked if they are taking any medication and their health history. When other clinicians provide care later during their stay, they can access this information and not have to ask the patient again or re-enter this onto a different form decreasing duplicate documentation. Having quick and easy access to electronic health
information can ensure that patients get the care that they need when required without having to wait for clinicians to access or gather this information.

Electronic health records also decrease the risk of privacy breaches (Myers, Frieden, Bherwani, & Henning, 2009). Paper charts are no longer flowing from one location to another and between clinicians. Clinicians access computers in which they are required to log in using a secure password. Everytime electronic charts are accessed, they are tracked and logged within the background. There are flags that can be put on certain high risk charts that require increase monitoring. While these types of security measures are beneficial, for public programs, there has been no tracking or monitoring of access for users.

Comprehensive well implemented electronic health records, with advanced clinical decision support have the potential to reduce errors with medications and to increase the quality, efficiency and reliability of information transfer (Sittig & Singh, 2012). Having EHRs encourages the clinician to be aware that there could be relevant data in the patient chart that could impact their care. This can help with decision making and encourage open communication between clinicians. There is increased responsibility and accountability that encourages clinicians to work to their maximum scope of practice and provide the best possible care for the client. It also encourages clinicians to take responsibility and accountability for their actions in order to discourage inappropriate care or care that is not deemed beneficial for the patient.

During emergency situations, this is valuable for when a health care provider needs to gather the patient history in a quick efficient method which is available only in an electronic health record. Clinicians would have a health history and provide care and update this information as required. If patients were able to access this information electronically and update this as it changed, this would also impact the care that they receive during an emergency situation. During emergency situations, health care providers would have updated information such as allergies, current medication and health history at hand, and would be able to provide better individualized treatment for the patient. They would not have to guess this information or ask family members, which could be time consuming.
The mobility of technology has also had an impact on health care organizations. Mobility penetrates almost every aspect of our modern life and has quietly reached a level of cultural acceptance and dependence (Shrestha, 2012). It has become a norm to have accessible mobile technology for use at our fingertips without question. It has become easily integrated in what we do on a regular basis. Mobile technology is easy to access and utilize and is becoming an essential tool in our lives. Having access to mobile technology allows patients to access mobile functions while on the go. It allows for easy accessibility from various locations around the world. This mobility has also contributed to improving production and workflow within organizations. Patients can continue to access information and work while being off site using secure server settings. In order for this to occur, organizations need to ensure that mobile devices are functional and reliable and are incorporated into the workflow in such a manner that they enhance output (Shrestha, 2012). Without access to functional devices clinicians cannot carry out the work that they intend to do to the best of their ability. They may miss out on making critical decisions when the technology is not functioning effectively and is not reliable. One of the challenges identified was that not all health care organizations are up to date with mobile technology or are not fully integrated (Shrestha, 2012). As we move into the future of health care technology this will continue to grow in the health care industry and become more tailored (Shrestha, 2012). Technology devices also improve the clinical decisions for clinicians and provide better ways to gather and track critical data.

In terms of health care, there has been an increasing use of these services by both health care consumers and health care providers. Consumers can access health care information on the internet in order to learn about their particular health care needs or gather general health information (Bernstein, McCreless, & Cote, 2007). Consumers can go on the internet and search for acute or chronic conditions, view symptoms and various treatment methods. They can search all kinds of health information using the web by a simple search. They can use it to guide their health without actually seeing a health care provider. Unfortunately, this information may not always be accurate and correct. Looking up symptoms may lead to a variety of diagnoses and it is necessary to have a clinician eliminate other options. The individual may not understand what the various conditions are and which one is valid. The user may then self-diagnosis a health
condition which may not be accurate due to the limited understanding of health conditions. If the user decides to act upon a self-diagnosed illness and take preventative and treatment measures it could increase the risk of harm to the individual. They may have self-diagnosed incorrectly, they may take over the counter medications that interact with the current medication that they are on, and there could be a worsening of condition.

For a medical condition to be diagnosed there are certain criteria that need to be evident. For example, for one to be diagnosed with diabetes, the A1C or a fasting blood glucose must be done to check blood sugar (Canadian Diabetes Association, 2012). Symptoms of diabetes could include dehydration and weight loss. If a user were to find information about health with regard to these two symptoms and act upon it by taking oral hypoglycemics, which decreases blood glucose, it may cause harm if they are not an actual diabetic (Canadian Diabetes Association, 2012). Weight loss could simply mean that the individual is eating less than the body requires and not drinking enough water. Therefore, it is always required that while a user has access to health information, they should not self diagnose. They should use the information for gaining a better understanding of their health conditions, but leave the diagnosis to the health care professionals. It is also important for health care organizations to know what health care consumers are doing to manage their health outside of the health care industry. With this information, the provider is better able to provide them with appropriate health care plans, resources and education (Pearlson, & Saunders, 2010).

The implementation of technology in health care is not limited to the clinical aspect, but may include the business side, such as finance and payroll information, billing and community involvement (Bernstein, McCleless, & Cote, 2007; Lee & Meuter, 2010). The healthcare industry can use technology effectively in a variety of areas if used correctly. They need to use it as a tool to support, guide and enhance their practice. Technology should not dictate how health care professionals carry out their practice.

Health care providers will use technology to manage patient health information effectively while they are in the hospital using health care services. Outside the hospital, patients are required to manage their own health. For patients with chronic conditions, such as diabetes there is no system or tool that currently allows for standardization across health care in Canada, which allows them to track and share their information with health
care providers electronically. Each time a patient visits a different health care facility or clinic, they are again required to provide basic historical information about their care and treatment. For patients who access and utilize homecare services, health records are still maintained by the organization providing services and not by the individual user. By allowing patients to utilize the different types of application available to enter in their personal health information, it becomes easier to share with providers electronically. For clinicians to have this information in the EHR, they can detect at an early stage high risk patients and provide interventions early.

While there is plenty of research on EHR's including the adoption and utilization of health records in health care, there is little research on personal health records or PHR. A Personal Health Record or PHR can be defined as a health record that the patient has access to and can utilize as a source of gathering information about their health or health results and track their health status (Canada Health Infoway, 2012). This not only empowers the patient to manage their health but also improves communication between the provider and the practitioner. An example of a PHR currently being utilized and implemented is at Sunnybrook Health Sciences in Toronto (Canada Health Infoway, 2012). Although this is currently being implemented, there has been no review of how the PHR can be used across all organizations. The PHR is still limited to individual hospital organizations and are not linked to all health care services that the individual uses.

“Patients managing diseases like diabetes or cancer can use MyChart to consolidate the wealth of information related to their condition. This includes clinical and personal health monitoring information like test results, symptoms, mood, diet, exercise plan etc. Consumers also have access to self-management tools to monitor and track own health status and share it with a clinician prior to a visit” (Canada Health Infoway, 2012)

While the outcomes of health care are to provide efficient and quality care to the patient, there is often no space for the patient to share their findings or information with the health care provider using technology. Most of the research has focused on electronic health records for patients for health care providers. Communication of health information is done between providers and there are clear steps to adopting, implementing and evaluating EHR’s for organizations, but not individuals. For diabetic patients who utilize a self-management tool, this is a critical gap that has not yet been
addressed. The process of sharing information with health care providers and providing ongoing updates is still a manual and tedious process for many. To date, there has been no clear algorithm or method on how this can be done electronically with health care providers.

*Diabetes and Self-Management*

Diabetic care is a lifelong illness that requires ongoing care. The concept of self-management was identified as essential to diabetic management (Anderson, & Christison-Lagay, 2008; McCleary-Jones, 2011). It requires a balance of managing meal intakes, exercise and monitoring blood glucose levels to maintain them at the optimal range. Having good self-management techniques can improve health outcomes and improve quality of life (Sieber, Newsome, & Lillie, 2012). The process of self-management requires that the individual learn about making healthy choices during meals, exercise daily and monitor blood glucose levels (Anderson, & Christison-Lagay, 2008). There is a current focus on homecare that allows the patient to live at home and maintain their life, and having health care professionals provide care in that area, when required or for check-ups (Ralston, Hirsche, Health, Mullen, Cheadle, & Golberg, 2009). This is known as the patient centered medical home where the medical care needed is provided in a patient home, in collaboration with the patient, health care team, and when required the family (Patient-Centered Primary care collaborative, 2007). A patient centered medical home is where medical care provided occurs in the setting of the patient’s home, as opposed to a clinic or hospital setting. The purpose of providing and encouraging homecare is to decrease the length of stay in hospital, increase bed space for those that are acutely ill, and prevent hospital acquired infections (Patient-Centered primary care collaborative, 2007).

In the articles by Anderson, & Christison-Lagay (2008) and McCleary-Jones, (2011) they focus on literacy and self-management outcomes. Self-management is done at the individual level and focuses on more actions and behaviours (Anderson, & Christison-Lagay 2008). It requires that the individual actively engage in making changes to their lifestyle and not just learn theoretical knowledge. Teaching self-management techniques requires an integrated approach. It needs to be at a literacy level for all
individuals of different ages and ethnic backgrounds to understand, and with the involvement of different health care providers, such as physicians, nurses, and dieticians (Anderson, & Christison-Lagay, 2008; McCleary-Jones, 2011). With proper education with regards to self-management, there would be increased understanding by the patient and higher probability of compliance.

Each health care provider brings a different perspective to health care and is specialized in certain areas. For example, having a dietician who can explain about nutritious meals can encourage the patient to make healthy meal choices. Nursing can provide information on blood glucose monitoring and how the body functions, thus allowing patients to monitor blood glucose levels adequately. Physicians may discuss about how diabetes impacts the body as a whole, therefore allowing the patient to know how to care for themselves and have an overall complete self-management technique. Health care providers can then be seen as a support system, but do not provide daily care to these patients. Patients are required to take charge of their health, in order to achieve their optimal quality of life. This would demonstrate that patients are able to learn about their health and participate in self-management, and also understand when to access health care resources as necessary.

Those who do not manage their diabetes at all require numerous interventions by health care providers and tend to have more hospitalizations and decreased quality of life (Patient-Centered Primary care collaborative, 2007; Ralston, Hirsche, Health, Mullen, Cheadle, & Golberg, 2009). It is therefore essential for one to ensure that they take care of their health to avoid readmissions to the hospital, which can not only mean a decline in a patient’s health status, but also contribute to increased costs to the organization. One of the flaws with the studies done by Anderson, & Christison-Lagay, (2008) and McCleary-Jones, (2011) is that they both studied groups that were at high risk of uncontrolled diabetes. They also focused on ethnic and racial minorities with diabetes only (Anderson, & Christison-Lagay, 2008; McCleary-Jones, 2011). Education programs were based on low literacy groups and those who have little to no education with regard to diabetes. Diabetes is not limited to low literacy groups and can range between all individuals. As there is a genetic link to diabetes, most patients are able to understand a little about diabetes when initially diagnosed. To date, educational programs have been more focused
on providing treatment options and not how treatment can be incorporated into their lives (Sieber, Newsome, & Lillie, 2012). Patients are not given information on how to continue their life while maintaining health. Health care providers often provide care specific to their diabetes and not to the holistic person. For example, a dietician may discuss foods that are high in sugar and provide health alternatives, but may not consider dietary needs such as cultural specific foods and cultural traditions that impacts diet. As a result, the individual may find it difficult to integrate their illness management techniques that they have learned into their daily lives.

Diabetes and Technology

Another concept identified was the use of technology to assist with diabetic management. Previous studies have shown a positive correlation between the use of web-based technologies and an improvement in self-management techniques for diabetic patients (Faridi et al. 2008; Ralston et al. 2009). Using technology to manage Type II diabetes showed improvements in the quality of life of patients and decreased associated complications (Holbrook, Thabane, Kesavjee, Dolovich, Bernstein, Chan, Troyan, Foster, & Gerstein 2009). The studies done by Faridi et al. (2008); Holbrook et al. (2009); & Ralston, et al. (2009) all created or developed web-based technology programs that allow users to monitor and track their diabetic habits or changes on a daily basis. In the study done by Ralston et al. (2009) diabetic patients were set up with a web based care manager that supported and shared diabetic information electronically. The care provider was the central point of contact for the patient related to their diabetes. It allowed patients to enter in blood glucose levels and medical information to share with the care provider (Ralston et al., 2009). In the study done by Faridi et al. (2008), participants were asked to use their mobile device to share their diabetic information. In this study, they also received feedback that was related to their data results directly to their phone. Lastly, the study done by Holbrook et al. (2009) was more tailored to the process and overall management of diabetes. Patients were asked to use the web based system to share medical information with clinicians. They were phoned for appointment reminders and were mailed paper copies of the results to take to their appointments (Holbrook et al, 2009). The process of sharing information electronically benefits both the health care provider
and the participant. Issues can be addressed and common goals can be set in collaboration with each other allowing the participant to become more actively engaged in their management of diabetes.

One of the differences in the articles was that Holbrook et al. (2009) focuses more on the process and management of diabetes whereas the studies done by Faridi et al. (2008) and Ralston et al. (2009) focused on using technology to encourage self-management. While both Holbrook et al. (2009) and Ralston et al. (2009) both used web based technology, Faridi et al. (2008) focused on cell phone based technology. Using a cell phone was effective in that it allowed users to carry it and log on at any time while. The findings were consistent with each other in that diabetic patients were more inclined to maintaining their quality of life and managing their diabetes with the implementation of technology compared to those who did not use technology or applications.

Limitations to the studies included not having a user-friendly technology available to patients, using research specific applications that require extensive training for health care providers and participants and constant involvement with the health care provider to explain both the technology and the chronic condition (Faridi et al. 2009; Ralston et al., 2009 & Holbrook et al., 2009). All of the programs implemented required that the individual have knowledge and training of how to use the specific program in order to capture and share their diabetic information. There are few guidelines on how the technology acceptance model is applied in this setting. This study will therefore identify how the Glucose Buddy application is accepted by users, without any education and teaching.

User Interface Design

When implementing new technology for both patients and health care professionals, user interface design must also be considered. Technologies provide support for human-to-human interaction mediated by computers, which is done via a user interface (Garza & Kock, 2007). From a patient perspective, for programs to be effective, it needs to be well designed and user friendly (Garza & Kock, 2007). Using the technology acceptance model, a well-designed application would be one that is easy to use and perceived to be of value in job performance. User interface design can therefore
be defined as the ability to provide ease of use and access to technology including navigation, inputting information and retrieval of information. The application needs to be detailed enough in order to capture the data that needs to be collected and have no glitches, allowing the application to work as it should. Similarly, the application should also be simple enough so that it does not require extensive knowledge and training with navigation being not cumbersome. It should allow for easy access and sharing of information between different health care providers and allow access of information on different devices. At the same time, it should also maintain and enforce security, privacy and confidentiality measures to prevent unauthorized access into personal health information (Chaisson, Forget, Biddle, & Van Oorschot, 2009). If the application lacks basic functionality, such as how the program works, or is too complex to navigate, such as going through multiple screens to view or enter data; the application may be rejected and deemed ineffective by users (Longo & Kane 2011). Not only do adequate user interface designs improve the usage of the application, it is also shown to increase excitement in the task and knowledge sharing (Garza & Kock 2007). Consumers are more likely to use the application if it is user friendly, as well as share the application with other users highlighting the ease of use. The application should be simple enough in that it can ease access to technology allowing the user to quickly learn its functions and benefits, but should not be simple enough allowing for security breaches to occur.

There are three major types of user interfaces that currently exist. Touch User Interface or TUI requires the user to input the data through the sense of a touch using a touchpad or touchscreen display, and the output is obtained through the same source (Lei & Wong, 2009). With this type of interface design, the user can select where they want to enter the data by touching the box on the screen, and can proceed to enter in the data. They are not taken to another page but are able to do it directly on the screen they are in Figure 3. Intelligent User Interface or IUI is the type of an interface that assists in improving the efficiency of the user interaction by representing the model and giving a better understanding of the user’s needs (Gribova, Kleshchev, & Shalfeeva, 2010). With IUI, the entered information is displayed in a format that the user can gain knowledge and understanding from and be able to make better decisions. With this format, it helps the
user make future decisions based on the data that was entered and displayed in a format to demonstrate a pattern, or sequence (Figure 4).

![Direct access to all key functions](image)

*Figure 3. Touch User interface design from Google images (2013)*

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
<th>Name</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>92.0 mg/dL</td>
<td></td>
<td>Before Lunch</td>
</tr>
<tr>
<td>BG</td>
<td>159.0 mg/dL</td>
<td></td>
<td>Before Breakfast</td>
</tr>
<tr>
<td>M</td>
<td>6.0 units</td>
<td>Humulin N</td>
<td>Before Breakfast</td>
</tr>
<tr>
<td>M</td>
<td>11.0 units</td>
<td>Humulin R</td>
<td>Before Breakfast</td>
</tr>
<tr>
<td>M</td>
<td>2.0 units</td>
<td>Humulin R</td>
<td>Before Bed</td>
</tr>
<tr>
<td>BG</td>
<td>73.0 mg/dL</td>
<td></td>
<td>Before Bed</td>
</tr>
</tbody>
</table>

*Figure 4. Intelligent User Interface design. Putting the saved data into a chart format to see changes to the Blood glucose results. From Skyhealth (2011).*
Finally, Zooming User Interface or ZUI are the interfaces where the user can change the level of scale of the output that is generated by the system, which will enable them to focus on certain areas of the scale (Lei & Wong, 2009). With ZUI the user can zoom to specific frames in the application or focus on certain areas and provide detail. The user can also zoom out to get an overall view from the initial entry to the last entry of the data as shown in Figure 5. These types of user interface designs are convenient and simple for users. It allows users to analyze data more closely, but also over the course of the data entry, provides information to make better decisions and finally, allows entry of data in a simple effective manner. To date, studies such as Faridi et al. (2008); Holbrook et al. (2009); & Ralston, et al. (2009) have not identified the different type of user interface designs that their application had utilized, and which one or the combination would be the most effective. With the Glucose Buddy application, it uses a combination of all three types of interface designs. This research study will identify if each of these three types of user interface design help or hinder one’s ability to use the application for motivation of self-management.

Technology and Age Groups

Age has also played a factor in how one accepts, learns, and utilizes technology. To date, there have been limited studies to show which age group learns best with new
technology and which groups have identified little to no learning. While the older generation can learn about technology, they are given a wide range of new technology on a daily basis which impacts the working memory and decreases learning (Jamieson, & Rogers, 2000). There has been an increased use of technology with the younger generation, and as a result, there has been an assumption that since the younger generation has grown up with technology they are able to learn how to use it and navigate on the devices quicker than any other age group (Bay & Ziefle, 2005). In addition, the assumption is then made that the older generation do not adapt to technology changes, and are often resistant to change. Technology is a rapidly evolving system and in health care, impacts processes and practices of the organization which older employees are not flexible to (Mantzana, Themistocleous, & Morabito, 2010). They resist change to their practices that they have been doing over the years and do not adapt well with the introduction and adoption of technology into the health care setting. Yet, to date, no studies have identified if these assumptions to the different generations are valid. Very little research is done to see if children who have grown up in the world of technology are actually better at using technology (Bay & Ziefle, 2005). In addition, there is very little research to support that older adults cannot learn technology if they are given the proper education and training (Mantzana, Themistocleous, & Morabito, 2010).

In the study conducted by Bay & Ziefle (2005), children were given mobile devices and required to complete a certain number of tasks, such as entering in a phone number, retrieving a phone number, changing a contact and sending a text message. The age group of study was children between 6-14 years of age. The length of time to complete each task was measured, as well as the number of incorrect steps that were taken and why they were taken were also recorded (Bay & Ziefle, 2005). The study concluded that navigation and user interface design played a key factor in using technology regardless of the age group.

In the study conducted by Mantzana, Themistocleous, & Morabito (2010), they identified that the reason older adults in a health care organization had difficulty learning new technology was due to a lack of training and education. The study was conducted using a variety of education and training techniques and continuous ongoing training of technology (Mantzana, Themistocleous, & Morabito, 2010). The study found that
categories of older learners have different skills, requirements and capabilities and in order to be effective, there needs to be a well-organized training process and ongoing support (Mantzana, Themistocleous, & Morabito, 2010). It concluded that older employees can learn new information technology systems if the education is done in a variety of methods that is flexible to the learners.

In the study conducted by Jamieson & Rogers (2000), they tested out the working memory of both the younger and the older generation with ATM machines. Participants were given a variety of tasks to follow in order to complete a full transaction. The study concluded that older adults did indeed have slower performance and did worse than the younger generation, related to the unfamiliarity of technology (Jamieson, & Rogers, 2000). The study also found that even after extensive instructions and over 50 retrials of the experiment, older adults continue to be slower and less accurate with the technology (Jamieson, & Rogers, 2000). Most of the older adults require ongoing support and extra training before they can begin to use technology in everyday tasks.

Although children have grown up in a world of technology, this does not determine how efficient and technology savvy they will be with electronic devices. In addition, training the older employees may take significantly longer, but this does not mean that they cannot be trained to change. If given the time, the support and the procedure, older adults may be able to learn just as well as the younger generation on how to use technology and incorporate it into their daily practices. Education and training regarding technology needs to be tailored to the older adults in order to be effective while the younger generation may not need as much support and education.

*Privacy and Security*

The integration of technology in health care has rapidly evolved and as more organizations integrate technology there are increased areas of concerns and risks that need to be addressed. There are an increased number of networked medical devices than hospital beds, and it is estimated that as technology increases, there will be approximately two medical devices per bed (Vockley, 2012). The increased mobile technology in health care has its benefits and downfalls. Mobile electronic technology comes with increased risks related to privacy, and confidentiality, therefore requiring increased security.
measures needing to be in place (Vockley, 2012). Like any other industry that owns and uses technology to function, health care is no exception to security breaches. Health care is the second most vulnerable to data breaches behind business and the number of breaches in health care has increased by 32% since the utilization of EHR’s (Vockley, 2012). As we become more sophisticated with technology, the risk of breaches also becomes easier electronically. This shows that it is crucial for the health care industry to ensure that they do the best that they can in order to prevent a security breach from occurring.

Basic security measures often include user authentication and data encryption. These unfortunately are not always enough. Health information is private and requires extra measures to be put in place. Security for mobile apps needs to go well beyond the baseline practices around user authentication and data encryption (Kabachinski, 2011). When considering wireless technology for health care systems, the focus should be on assessing and managing all the risks associated with wireless medical devices and systems (Witters, 2006). As health information is extremely confidential, it is necessary to have more than just basic security measures in place.

Many organizations do not feel that they can be breached causing them to take a laid back approach. They use off the shelf technology, such as Microsoft word or basic wireless products that make it easy to infect and hack (Vockley, 2012; Witters 2006). These products need to be adequately designed and tested to fit the needs of the medical challenges and ensuring valid protection (Witters, 2006). As these products are off the shelf, they are more vulnerable to hackers, viruses, glitches and other breaches that we do not know about. Strict security mechanisms must always be in place to prevent malicious interactions with the health care systems (Ng, Sim, & Tan, 2006).

Security measures need to be in place not just to keep outside user out, but also to keep those who do not need access to medical information from having this access. Staff may access information that they do not need access to, while outsiders may want to collect personal health information in order to cause harm to those who are in the hospital or cause harm to the organization itself (Vockley, 2012). Only staff that has access to this information should be able to view it. For example, when celebrities go to hospital for treatment, only those who are providing direct patient care should be viewing this
sensitive data. There have been privacy breaches where other hospital staff, who have not been the care provider, viewed, accessed and shared this personal information with the media without consent.

There are legal issues that can arise for not maintaining the security of personal information by the health organization. Unfortunately, many organizations do not know how vulnerable they actually are until after an incident occurs (Vockley, 2012). They may take precautions but do not realize that they are still vulnerable until after they have been breached. Finally, health care organizations need to take security measures seriously in order to prevent real consequences from occurring.

Not having proper security measures in place can cause numerous consequences to the individual and the health care organization. The impacts of security breaches are real and can affect a small population, one department or section of the hospital, or the organization as a whole. If a virus in a piece of medical equipment is identified it may cause the device to shut down. The device could be critical to patient care thus causing the department to shut down as well in order to repair or remove the virus (Vockley, 2012). It can impact staff causing time away from work and decrease hospital revenue to get the technology replaced (Vockley, 2012). Such a breach could be costly to the organization and could reduce trust by patients in the health care system.

Not only do security breaches impact the organization, it can have real effects on patient care as well. Using wireless technology can cause a slowdown of technology devices leading to a critical incident, wrong therapy or missing vital information (Witters, 2006). It takes time for technology to return to its original state of optimal functioning and this time could be crucial to patient care. Not only can it impact the organization but it could also cause delay or inaccurate diagnosis or treatment in patient care (Kabachinski, 2011; Vockley, 2012). Maintaining the health of individuals is a key factor in providing health care services to the public, and if there was delayed treatment and improper patient care, this could potentially cause harm to both the patient, as well as trust in the health care system.

Patients may suffer due to inadequate measures being put in place to protect health information. Staff enjoy having access to the organizations email and patients records outside of the organization or while on the road (Vockley, 2012). This access is
beneficial for numerous health care providers who travel as part of their job and need frequent access to this information. This can increase the risk of breaching private information that should not be shared. Staff may lose their mobile device; the device can be breached or hacked causing the information to be vulnerable to those who should not have access to it. While travelling, it could then be difficult to identify who gained access to the data and how to recover it back.

Studies such as Kabachinski (2011), Vockley (2012), and Witters (2006) have shown that there are a variety of risks associated with using technology and have listed ways to prevent it. Security breaches should always be taken seriously and precautionary measures should always be in place and reviewed on a regular basis. Some preventative security measures include not storing sensitive data on wireless devices, not broadcasting wireless routers, allowing only authorized devices to connect to wireless networks and providing and managing mobile devices that staff use outside of the organization (Kabachinski, 2011). While these are simple security measures that could be implemented, it is still crucial for organizations to share these measures with staff and enforce the requirements of privacy and security for compliance.

Education of staff needs to ensure that they are aware of the risks in order to be careful when accessing private information outside of the organization. Education and communication with the team and staff is also crucial in the prevention of risk to patient data (Vockley, 2012). There is no way to clearly prevent security breaches from occurring, but these steps can aid in making it difficult to breach personal health information. Each study identified that organizations are at risk for breaches of personal health information and that privacy and security measures need to be put in place (Kabachinski, 2011; Ng, Sim, & Tan, 2006; Vockley, 2012; & Witters, 2006). Even with preventative measures put in place, privacy and security measures still need to be monitored. Security and privacy measures need to be therefore reviewed on an ongoing basis to maintain patient data confidentiality and assess for actual or possible breaches.

Gaps in the Literature

The first gap is that technology in health care has mainly been focused on hospital organizations and not for individual use. It is focused on acute care services in order to
Diabetic Management

manage and improve workflow to patients. Adoption, implementation and maintenance of technology have been focused from a health care perspective and not from a self-management perspective. It does not look at using technology in community settings and implementing changes in the health community setting. Community setting health care is quite different from hospital settings as they are more mobile and diverse in nature (Holbrook et al, 2009). There is no guidance of how to implement technology in the community in order to be effective. Community health care workers, on a regular basis, work closely with patients, who have chronic conditions such as diabetes, but over time, as the individual tries to resume normal activities, the support from health care providers is decreased and they are then sent to their family physician for regular follow ups. It is then, that the individual is able to fully understand if they are able to self-manage their health and identify barriers to their quality of life. The community setting health care is more specific to patients and can vary from individual to individual. There is no consistency for care provided for patients out in the community or information on how technology can be adopted into their health management to be shared with health care providers. Chronic conditions are life long and there are few studies done on how to manage these effectively using electronic devices.

Furthermore, technology in health care is from a health provider perspective and very clinically focused. It does not look at what patients need or from a patient perspective. It does not meet the needs of the patient in order to make their health outcomes better or involve them in their care. It is used to encourage communication between health care teams but not include the patient in the team. Using technology as a tool of communication can therefore be beneficial to support self-management and improve on the patient-health care provider relationship.

Previous research discusses the importance of self-management techniques, but use technology that is specific to their organization or program. They all state that there needs to be more research done regarding this topic (Faridi et al, 2008; Holbrook et al, 2009; & Ralston et al, 2009). Previous research that has looked at diabetes applications have used or developed their own program and assessed its effectiveness. Unfortunately, each program developed is not available to the public at the current time, and is still within the research phase. Although it is useful to identify the impact that web based
technology has on health care, to date, there has been no evaluation done on free programs available to the public on iPhones/iPods/iPads devices at this time for diabetic patients. In addition, most of the studies conducted were based in the United States, and to date, no studies in terms of application of technology for diabetics have been done in Canada. As a result of the gaps and inconsistencies identified, this research is going to evaluate a program/application that is available to the general community members. It will also assess how useful the application is and if it can be incorporated into the health care system to support and maintain the patient’s electronic health record.

The user interface design also needs to be considered when wanting to effectively implement new technology into any business or organization. Staff or users should be able to easily navigate through the program, and it should also appeal to the user. Unfortunately, the studies on user interface design do not identify what aspects of technology are appealing to users or why some applications are rejected. It may be related to a variety of factors that vary from application to application. Technology applications must also appeal to different users of different age groups. As noted, there are no standard measurements to identify at what age one becomes comfortable with learning about new technology and applications. There have been few studies that determine which age groups are quicker at learning new technology and applications. To date, there has been no proven theory that those who grow up with technology are more knowledgeable and skilled at using technology than those who are older. The applications of technology, if relatively easy to use, navigate and understand, can therefore be learned by all individuals, regardless of age. A more in depth understanding of this concept needs to be identified. Comparisons will be made in this study for participants in the various age groups to identify if any particular age group needs a longer period of time to complete the task than those in a younger age group.

Finally, security and privacy measures need to be considered. Health information data need to be kept private and secure from unidentified users or outside access. Sharing of personal health information needs to be done only with the permission of the user. Not incorporating security measures can cause real health or organization related consequences and therefore this needs to be taken seriously. The studies identified on security and privacy recognizes that there are risks that exist and that measures need to be
put in place. It did not identify if consumers were aware of these risks, and how comfortable they are with their information being accessed outside of the organization by health care providers. It also did not identify if users were aware when security breaches occurred to the organization and where their health information is kept. When looking at health applications for diabetics, it is therefore essential to verify that privacy and security measures are in place to minimize the risk of data breaches. This study will therefore look at the adoption, implementation and outcomes of a diabetic application from a patient perspective, its ability to improve self-management techniques, review the user interface design and finally review the privacy and security of the application.
REVIEW OF THE APPLICATION

There were a number of health applications available for users related to diabetes. A survey was done to identify which of the available glucose monitoring application was freely available to use and the number of stars received for the application, as it was more likely to be used by participants if it was highly rated, to be used in the study. When looking at the various applications that exist, devices were compared based on performance and scope of the application, as well as its operating system. Table 2 compares diabetic applications. Currently there are over 17,000 health-related smartphone applications available for consumers (Kirwan, Duncan, Vandelanotte, & Mummery, 2012). In the study done by Kirwan, Duncan, Vandelanotte, & Mummery (2012), it was identified that the smartphone applications can improve glycemic control with Type 1 diabetes. The Glucose Buddy application has many functions and is available for free. While there are other free apps, they do not have most of the functionality that Glucose Buddy has, such as syncing with a desktop, graphing and desktop analysis without additional cost. Also, the Glucose Buddy application is compatible with all the different types of devices and operating systems. The Glucose Buddy application is a data storage utility for people with diabetes (SkyHealth, 2011). It allows for diabetic patients to use their iPhone application, log information, calculate their blood sugars, set reminders and print information out to a health care provider. This is a free application for diabetic users with any type of diabetes. Information entered into the application includes blood glucose readings, meal intake, medication taken, such as metformin and exercise participated in. Each entry in any of the mentioned areas is considered a log entered into the application. As of April 19, 2013 there have been over 15 million logs uploaded onto the website (SkyHealth, 2011). The application is therefore quite popular for users as it received an average of 4.4 stars from approximately 500 users.
### Table 2
Comparing Diabetic Applications

<table>
<thead>
<tr>
<th></th>
<th>Glucose Buddy</th>
<th>Diabetes Log</th>
<th>Wave Sense</th>
<th>Islet</th>
<th>Diamedic</th>
<th>Track 3</th>
<th>Diabetes pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>2.99</td>
<td>5.99</td>
<td>7.99</td>
<td>11.99</td>
</tr>
<tr>
<td><strong>Meds Entry</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Graphing</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Food Entry</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Exercise Entry</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Syncs with Desktop/Web</strong></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Desktop graphing</strong></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Desktop Analysis</strong></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Desktop Sync Cost</strong></td>
<td>Free</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.99</td>
</tr>
<tr>
<td><strong>Platform</strong></td>
<td>Windows/ Mac OS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Windows</td>
</tr>
<tr>
<td><strong>Stars</strong></td>
<td>4.4</td>
<td>2.5</td>
<td>3.1</td>
<td>N/A</td>
<td>3.5</td>
<td>3.3</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Number of Reviews</strong></td>
<td>500</td>
<td>171</td>
<td>687</td>
<td>No users</td>
<td>139</td>
<td>39</td>
<td>176</td>
</tr>
</tbody>
</table>


*Personal Experience and Review*

When searching the application, it was easy to find and download onto my device. After installing, I was quickly able to locate it on my device using the Glucose Buddy logo (Figure 6). The logo was simple design showing a blood drop as a picture and a magnifying glass.
After viewing the application online, I was able to download it easily onto my device. Upon opening the application, it launched onto the dashboard with icons such as the one below in Figure 7. From there it was fairly easy to understand and use. I was able to enter in personal data such as my date of birth (DOB), gender, the type of diabetes I had, my height and weight and it even allowed me to enter in my email address so that logs could be sent to the email. I was only able to enter in one email address at a time and send the information to only one individual. If the user had an email address for the health care provider, it could be sent to them instead. The application only allowed one email to be sent at a time, so if there were numerous providers who required this data, it would need to be done one at a time.

When entering in logs all I had to do was click on the plus button and it brought me a flow sheet which allowed me to select and enter in the data in the log under various
tabs as noted in Figure 8. For each tab, it asked the date and time of the entry, at what time during the day the entry was done (before breakfast, at lunch, evening, etc.). For each of the separate tabs it asked in addition to the above, the blood glucose level, what medication was taken, consumed food in grams, any activities performed in minutes, and A1C results. This helps the individual continue to monitor and ensure that their blood glucose levels are within the normal range on a regular basis, but also separates them out in the various tabs for easy entry.

![Figure 8. View of the log screen header](image)

The next icon was the weight icon. In here I was able to enter in my weight, view the history and graph it. Weight is a key factor to predicting Type 2 diabetes; therefore weight management is an essential area for Type 2 diabetes to ensure that it is maintained or decreased. This section was good to help identify if overtime, my weight will increase or decrease.

Reminders were based on two options. The simple reminder was an alarm clock to identify when an event is going to be due. A reminder ‘coordinated with event’ was linked to the time of day that the activity was to occur. For example, I set a reminder for “before breakfast” to check blood glucose and the reminder was to occur 2 hours after the event.
METHODOLOGY

The purpose of conducting this research study was to determine the efficacy and user-friendliness of the application “Glucose Buddy,” which is available for free download on the iPhone, iPod and iPad devices. The reason for studying this was to see if the general community has an affinity to electronic devices in health care. The application Glucose Buddy is free to download to any user in order to assist with managing blood glucose levels. The study was also designed to compare the research results to the reviews online, and identify if users found this to be easy to use as well as beneficial in supporting their self-management. Diabetes is a chronic condition that requires constant ongoing monitoring and care. Since technology is mobile and easily accessible, having access to track their diabetic information 24/7 should encourage patient’s to review their glucose levels and manage it in order to have an optimal quality of life. Lastly, it was to assess the privacy and security features available with the Glucose Buddy application and to identify if this feature will influence their decision in utilizing this program. Therefore, by evaluating the efficiency and user-friendliness of the application, we can see if technology can have an impact on diabetic self-management, and overall, those with chronic conditions in the future. For the purposes of the research, it is predicted that the research participants will all be able to find the Glucose Buddy application effective for health management and not require any additional education.

This section will review the method, design and discuss the population and sampling size of this study. In addition, it will look at the outcome measures, followed by the data analysis method.

The type of study that was conducted for this research was a quantitative descriptive study. A key factor with diabetics for a healthy lifestyle is self-management. The rationale for a quantitative descriptive approach was because it provided the ability to identify if a relationship existed between the two variables, self-management and the health application Glucose Buddy and how strong this relationship was. The study in particular was to be able to generalize the results of the study, based on a sample population and identify if it could benefit diabetic patients with self-management. The independent variable was technology, and specifically the application Glucose Buddy and
the dependent variable was self-management and chronic conditions. It was geared towards identifying if technology and in particular, the application Glucose Buddy, assisted with diabetic self-management, and its effectiveness to the public. The overall design of this study was to gain an understanding of how appropriate these applications were, if these applications met the needs of the public, and if these applications had a positive effect on diabetic self-management. Using a quantitative method was not to gain an insight into the details of experience with the application, but to identify if there was a relationship that existed between technology and one’s health.

The application Glucose Buddy is available on any of the Apple devices and has many features which may be beneficial to the management of diabetes. This application has many benefits including, data entry for blood glucose results, meals and exercise, syncing capabilities with desktop computers and allowing patients to monitor their inputted information within a simple graph form to view changes. The graph form contains many variables to be logged including medications, food, exercise, etc. The Glucose Buddy application also allows patients to connect with others and discuss diabetes management on the application itself. This application has received much recognition by *Wired Magazine, Diabetes Health, and American Diabetes Association's Diabetes Forecast Magazine* and has been ranked as the number one diabetes application by Founder of TuDiabetes.com. Due to this being one of the most well-known diabetes self-management applications, this makes it a good free application to evaluate if technology will have an effect on diabetic self-care.

The reason for choosing Apple devices was due to the high number of individuals who often prefer Apple devices over other mobile devices. Apple has a high number of users for their products and increasing numbers of physicians are using mobile devices at the point of care including iPhone or iPads (Kabachinski, 2011). The application can be used on all mobile devices or on desktops. The reason for using the application on the mobile device was due to the mobility of technology. Although the sample study is within a school of technology where all staff and students have access to laptop devices, mobile devices were chosen since it can be carried around at all times. Users tend to have more accessibility to their phones instead of their laptops. Participants in the study were asked to identify the type of personal device that they had. Asking for the type of
devices that users had could identify if they own an Apple device and could download the application on their own.

Participants were based on a random non-probability convenience sample, which was obtained from University of Ontario Institute of Technology (UOIT). This study was aimed at observing how this application will impact students. The application is available to use for all users, regardless if they are diabetic or not. Therefore, the sample was obtained from consumers who would be able to place a valuable input on the pros and cons of the application itself, which was being offered to diabetic patients for self management. The reason for choosing random sampling was to be able to identify if university students would use health applications for their health. A convenience sample was used in order to get the most conveniently accessible students. This type of sampling method is quick, easy and inexpensive. Using a convenience sample allowed the research to access students who were readily available at the time of the study. Lastly, UOIT is a school of technology which encourages technological advancements. By conducting the study at UOIT, participants had access to mobile data, as well as had some basic knowledge regarding the use of technology. The sample population was taken at the north campus of UOIT in areas such as the library, cafeteria and in the hallways of the UA and UB buildings. Samples were taken at different times of the day, including the evenings and weekends.

A total number of 50 students from UOIT, from various programs/facilities, took part in the research. All participants were easily accessible and voluntarily provided written consent prior to participating in the study and completing any study related questionnaires or procedures. Study subjects included both males and females, between the ages of 18-30, with no selection requirement on race or culture. The pediatric and adolescent population was not the focus of the research study, as their knowledge of basic technology may not be of reasonable levels to manipulate the program. In addition, as this study was focused on university students, it was unlikely to find participants under the age of 18 in university. The upper age limit was applied to exclude mixing the different generations together. The study wanted to focus on a smaller age group of participants to identify how well they adapt and utilize technology in their daily lives. In addition, due to majority of students who attend university directly after high school, it is
unlikely to obtain a group of university students who are over the age of 30. Finally, they may also have more knowledge of having diabetes and knowing how to manage it and may not be open to understanding how technology can change their ways for chronic conditions. Although, these two limitations restricted generalization of the results being obtained, it provided valuable insight into the security of the system, and its contribution to our electronic health care record. It also help model a way to develop a blueprint that continues to improving our diabetic management with technology. Participants who did not wish to use an Apple device, were uncomfortable using the iPad/iPhone/iPod devices provided, did not have any basic working knowledge of the iPad/iPhone/iPod devices, could not complete the survey in English, or those who were hospitalized or out of UOIT at the time of the study were not eligible to participate in the study.

The study was conducted in person at UOIT. A letter of invitation was given out to participants at UOIT in all faculties and all programs. All staff, students and volunteers were invited to participate, and they may have been related to the student and supervisor as an instructor-student relationship. Participants were provided a copy of the consent form, which was reviewed with them by the researcher. The consent form explained the purpose of the study, the risks and benefits and the study procedure. All participants voluntarily provided consent by signing the consent forms, prior to their participation in the study. Once this was signed, participants were asked to complete the primary questionnaire. This questionnaire collected demographic information of the participant including their age and gender. This demographic is beneficial in identifying the needs of users between the ages of 18-30 and how they interact with technology and health applications.

This survey also asked students what department and faculty they were associated with. Students from the various faculties and departments have different levels of education and knowledge skill sets. For example, students from the Health Science department would better understand the applications effectiveness as it relates to health and medical conditions, whereas those students in the Engineering or Business and IT program may be more likely to not know how effective this application is for diabetics but have a better understanding of the privacy and security of the application and ease of use. Participants were asked to explain their level of comfort and proficiency with using
technology in general, prior to their involvement in the study. These criterias were used to distinguish between the use and effectiveness of the program and technology. UOIT provides laptops to all students registered and students are expected to use the laptop for course work and excellence in academics. An assumption was made that as these students are all from UOIT and use technology on a regular basis, they would be comfortable with technology.

There were some sampling biases which arose while conducting the study. Sampling biases included using a convenience sample, implementing a self survey method and using a non diabetic sample population. Using a convenience sample was effective in obtaining participants who were willing to participate in a quick and easy manner, but unfortunately, this method was not going to be representative of the population. This limitation also restricted the ability to generalize the findings of the result to the target population. Another sampling bias that could have occurred was that those who were currently using the Glucose Buddy application or a similar diabetes management application, may not provide honest nor unbiased feedback as per another application they were using as a result of the self survey. Furthermore, as this study is particular to a diabetic application and no participants were diabetics, this could have impacted the results of the study. Diabetic patients may have the same feedback in terms of the use and navigation of the application, but have the additional insite to its effectiveness in managing all areas required for self-management to occur successfully. The research may not be able to accurately capture the perception from a diabetic patient and the implication it may have on their diabetes management. However, the data gathered from this sample population would still be valid in terms the use of application in health care, and how the electronic applications, available for public use, may influence health decisions. While health applications are intended to support health decisions, without a simple user interface design, user acceptance and perceived benefits, the application is not likely to be used (Bernstein et al, 2007; Chib, Lwin & Jung 2009; Garza & Kock, 2007; & Hu, Chau, Sheng & Tam, 1999). While the study did try to find participants who were diabetics, these students may not have wanted to participate or were not available during the time the the study was conducted. Lastly, those who may have general knowledge on Health Sciences may provide a biased view of usability, by
having an understanding of the disease and may overlook the basic diabetes information, which may be provided by the application. Opposite to this, those who have little or no understanding of what diabetes is and how it works may not understand the benefits of the application or how it works.

As this study was based on the use of Apple devices only, participants were given the option to download the application on their own personal device, if it was an Apple product, or to use the one provided by the researcher with the application already preloaded. Participants were requested to navigate through the system, without any aid from the researcher. Navigation included entering the Glucose Buddy application and finding out where data is entered. Data included blood glucose levels, exercise time, meal plans and other demographic information. Participants were not given any real data to enter but had the option to enter in real or fake data. Navigation included being able to view the entered data and find links to share this with others. While it was not necessary, participants had the option of entering additional information into the application. There were no time restrictions to how long participants had to use the application, and were asked to use the application based on their own time and comfort.

This application is meant to be self-explanatory, simple and straightforward to use, therefore no training or explanation was provided to any of the participants. Participants have the option of entering data into the application but this is not a mandatory requirement as part of the research study. After completing the navigation section of the research, participants were required to complete two additional surveys. The first collected information regarding the ease of use, accessibility of the program, ease of use of the program and the comfort level using the likert scale. This purpose of this survey was to evaluate the application in terms of its use as well as using the benefits for self-management of health. The second survey focused on the functionality, security, privacy, confidentiality of the program and its relation to health information. There was no time limit allocated to participants as to how long participants needed to complete all the questionnaires. As this application was free to use, it was assumed that students were more likely to use the program for health management if there were no costs associated to it. Additionally, participants who used other applications to manage their health, would find the Glucose Buddy to also be beneficial to diabetics. This is related to their
experience with health application and understanding the benefits of tracking health data. Therefore, participants who stated they had used different applications to manage their health would be more likely to utilize Glucose Buddy as well as recommend the application to others.

After using the application myself, I found that the application was fairly easy to use and understand. The home screen layout was simple and easy to read. Additionally, there were certain areas of the application that I did not think would easily be understood by the participants such as body metrics and reminders. Users were more likely to want to have a security feature on the application as it contains personal health data, regardless if they have a security feature on their personal device or not.

Upon completion of the study, participants were asked if they were interested in participating in a draw. If participants agreed to participate, they were asked to complete the “agree to participate in draw” section of the thank you letter, in order to be entered in the draw. The names of the participants from the draw were not linked in any way to the surveys that they completed for the research. If participants chose to drop out of the study at any time, and still wished to participate in the draw, there were able to do so without any penalty. The prizes consisted of one $100 iTunes Gift Card, one $50 Tim Hortons Gift Card, and one $25 Cineplex Entertainment Gift Card. The study took place over a two month period from October to December 2012. The draw was scheduled to take place on December 7th, 2012 and winners were notified by email.

Finally, feedback was gathered from online reviewers from different websites as well as individual reviewers who have used the glucose buddy application. Online critiques were from numerous different sites. Although this study was focused on Apple devices, results of the online review included using the Glucose Buddy application on any type of device or desktop computer.

Limitations to the study were based on each participant’s perception of what the instructions were asking them to complete. Participants were asked to provide their opinion based on how they understand the program; each individual was asked to provide their own opinion on how they feel the program works and how secure it may be. Each person understands and interprets the program and questions differently, and this may have provide discrepancies in the results. Another limitation was that the sample was
based on a convenience sample, and participants may not have been representative of the population. Participants were given the option to spend as long as they needed, but may not have understood what most diabetics may want to achieve when looking for a diabetic application to work with.

Data analysis for the demographic questionnaire was obtained using a nominal scale (qualitative data). Dichotomous nominal data was used to measure gender. The focus of the study was on the relationship between the dependent variable and the independent variable and if the application Glucose buddy was easy to utilize. This would help one understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed.

Information related to the application was measured using the ordinal scale. This scale allows objects to be placed in a rank order. This type of measurement describes order, but does not describe the relative size or the degree of difference between the items measured. Numbers were assigned to objects representing the rank order of the assessed items. The reason this type of scale was used because it allows a total pre-order of objects. This scale allows information to be sorted in a single line with no ambiguities.
RESULTS

The Glucose Buddy application has the potential to improve self-management techniques for diabetics, and therefore needs to be reviewed in terms of its efficiency as an application and its ability to support self-management. This presentation of the results will first summarize the demographics of the participants that were collected in the initial questionnaire. The second part of the results section will discuss the comfort level of participants with technology, and the privacy and security of the application, followed by the results of participant feedback with regard to the Glucose Buddy application itself. The results of the study are based on a total of 50 participants from UOIT. There were no participants who dropped out of the study and on average the total time for completing the study was around ten minutes.

Demographics

The demographics of the participants was an important criteria to gather in order to categorize the participants involved in the study and identify where areas of gaps were occurring in terms of the results, such as a knowledge gap, varied interpretations of what the questions mean and how they understand it, or no understanding of the technology or diabetic health. All of the participants for the study were between the ages of 18-30 with 33 males and 17 females. Participating students were all easily accessible and available in public areas during the different times of the day that the study was conducted. There was no distinction made for those who were full-time or part-time.

The research study also asked what program students were from. While there was a mix of students from various faculties, this is not representative of the full UOIT population as the study did not include students from the downtown campus which is home to the Faculty of Education and Social Science nor were there equal students from each of the departments in the north campus. It is noteworthy that the students from the downtown campus were not included in the study because they may have had valuable feedback based on their educational learning. These students may have a different perspective on viewing the application or may have also been at risk for diabetes and were not included. For diabetic patients, education is an important aspect to diabetes in
order to teach participants about self-management. The feedback provided by these students could have contributed to how the application is supporting the educational process. The research study was focused on trying to gain an understanding of the navigation and ease of use of the Glucose Buddy application for all participants. The study did have a sample population from the various different faculties, but none of the previous research studies identified knowledge background as a key factor for self-management. The research study did not find any notable difference between students from different faculties and how they answered the research questionnaires. Figure 9 indicates the various faculties participants were from, with majority of participants being from the Faculty of Engineering which was 30% followed by Business and IT and Health Science at 22% each. The Faculty of Engineering also has a majority of male students which could have explained the large number of male students in this sample study.

![Faculty](image.png)

*Figure 9. Students associated faculty.*

The types of personal devices that each user indicated they had, varied from one device to multiple devices. Some participants had one Apple device, while others had multiple Apple devices, and finally participants also had a combination of Apple and
non-Apple devices. Figure 10 shows the different types of devices that users had with iPhones being the most popular type of device by 36% of participants. Only 18% indicated that they did not have any type of Apple device, but did have another type of personal device. As this study was specific to Glucose Buddy on Apple devices, the study did not ask what the other types of device were.

![Type of Device](image)

*Figure 10. Type of personal device as indicated by each user.*

In terms of using any type of health application to manage their health, 38% of participants said that they had used an electronic tool such as Glucose Buddy to manage their health, while 62% had not used any electronic device to manage their health. The other 2% of participants did not identify if they had used any type of electronic device for managing their health. In terms of diabetes, none of the participants had diabetes personally but 46% of the participants had a family member with a history of diabetes while 12% did not know and 42% stated that they did not have a family history nor had it themselves. Those who did state that they had a family member with diabetes did not identify who the family member was and how this family member managed their diabetes. They also did not indicate the type of diabetes that the family member had. Regardless, using a non-diabetic population of study still provides valuable data that
could indicate the effectiveness and usefulness of the application in general. The navigation and ease of use of any application should be simple for any type of user regardless of their health (Bay & Ziefle, 2005). Since TAM focuses on the ease of use and effectiveness of the application, it does not require one to be in perfect health physically and only requires that the individual is able to interact and cognitively accept the application. While the participants may not have understood the requirement for diabetic patients, they were able to provide feedback with regard to the ease of use of the application. Finally, as 46% of the participants had a family member who had diabetes, they are at an increased risk of diabetes and therefore may need to monitor their health, in order to continue to remain a low risk candidate for diabetes. The insight that they provide regarding the ease of use and effectiveness of the application is therefore valuable. These participants may be able to critically evaluate health benefits of such application for future use.

Device and Comfort

The initial questionnaire also asked participants their comfort level with technology. Knowing the comfort level of participants is necessary in order to eliminate the external influences on the research. If participants are not comfortable with using technology, they would be more likely to have difficulty using the Glucose Buddy application on an electronic device. The users who are comfortable with technology are also more likely to identify if the application is easy to use and navigate based on their own comfort level. There was no participant who was less than comfortable with technology and this eliminated the risk of having participants who do not feel comfortable with technology using a new application. The results of the study showed that 60% of participants were very comfortable, while 18% were somewhat comfortable and 22% of participants were comfortable. Participants are therefore more likely to state that if they did not like certain aspects of the technology, as it was not because of their lack of comfort but was due to the application itself.

The researcher provided an iPod device for use during the study for those who did not want to download it or use their own personal Apple device. When answering the question about the device that participant had, they may have assumed that this was the
device they were using in the research study, and therefore results showed in increase in
the number of iPod devices. While the study question asked their type of comfort level
with the device, it did not specifically explain the types of device that they were
comfortable with. Each type of device works differently, and users may feel more
comfortable utilizing particular devices. Also, depending on what the user is doing they
may use a particular device for different functions. For example, if they want to write a
letter they may find it more useful to use a laptop with a full keyboard while one might
use an iPad or tablet for browsing on the internet. Finally, users might want to use an
iPod or iPhone for listening to music. When using the Glucose Buddy application, as it
requires daily entering of data at various times of the day, users may want to have this
done on their mobile device such as an iPhone, which they carry around with them. When
viewing the graphs on the application, they may want to do this on a bigger device so that
they can see the full data, instead of a smaller device. Therefore, participants may have
also found the application effective as it was available on their mobile device instead of
on a laptop. One participant stated that the graphs were unclear; this may have been
related to viewing it on an iPod instead of a bigger device.

Personal Privacy and Security

Finally, the study looked at the various types of privacy and security features that
users had on their own personal device. Security features on devices ranged for each user
as shown in Figure 11. A total of 78% of participants have one or more types of security
features on their device, while 22% did not have any type of security feature on their
device. The password was the most frequently used type of security on the device by 24%
of participants closely followed by PINs and Patterns each at 22% of the participants.
Only 10% had more than one type of security feature which could have been any
combination between PIN, Passwords, or Patterns.
The second questionnaire asked questions with regard to how beneficial, effective and user friendly the application is for the public. The questionnaire focused on how the application functioned for users. This part of the study required that participants perform a variety of functions on the device and answer the questions based on their results and its effectiveness.

The first question asked was if the user had used the application prior to the study. Participants who used or viewed the Glucose Buddy application prior to the study may have had a biased view point. They may have had a better understanding of how the application works and know its functionality. Participants may have also interpreted this question to include viewing the application with a family member or a friend instead of using the application for themselves. One participant stated that they had heard of the application as a family member had diabetes. The extent to which the individual had used the application prior to the study was limited as they did not use it on a daily basis and therefore did not have an impact on the results of the study. Only 3 participants had used the application prior to the study. There was no indication of why any of the participants had used the application previously and for what purpose, whether it was for browsing or
helping a family member. Previous use of the application was not a limitation to the study therefore these results were included. There was no difference in the results of the study from the general population for those who had used the application previously. These participants took the same amount of time as any of the other participants who had not used the application previously and also asked questions about the applications use during the research. Participants who used the application prior to the study spent approximately the same amount of time as any of the other users on completing the questionnaires.

In terms of finding the application on the personal device including downloading it, 82% of participants stated that it was easy to download on their device. Only one participant chose to download the application on their device who also stated it was easy to find. For all other participants, the application was pre-loaded onto the provided device, and therefore could have contributed to why participants stated that it was easy to find and download on the device. Users were given verbal instructions that the application was called Glucose Buddy or GB on the device. They were also reminded that the application was to be used without any training or assistance from the researcher and that they could enter in anywhere on the application they see fit, in order to help them answer the research questions. They were also reminded that there was no time limit for the research study and they could take as long as they required. Participants were also given the opportunity at the end of the questionnaire to identify any additional comments with regard to the application in the space provided. There were approximately 5 participants who had asked questions about the application during the study such as, where it was on the device provided, and where the graphs were, thus indicating that while they may not have downloaded it, 18% of participants did have difficulty locating the application without assistance.

As this study focused on users learning on their own and navigating through various screens without any tutorial or assistance, it was fairly easy in terms of navigation, utilization and entering in information for almost all participants as indicated in Figure 12 below. A total of 96% stated that the application was easy to navigate without any issues; 86% of the participants stated that they were able to learn the application without any tutorial or assistance and 92% of participants stated that
information was easy to enter onto the application. The lack of support or tutorial was the biggest issue in terms of ease of use with 14% wanting some sort of guidance or assistance. The study did not provide options for what type of tutorials participants wanted nor how much additional information they would require for them to learn about the application.

![Usability Chart]

*Figure 12. Usability of the application*

Participants were also asked to identify if the cost of the application impacted their decision making. As indicated in Figure 13, the lack of cost associated with the application had a positive effect for users. While 80% of users felt that the free application was effective, only 64% felt that such a free application would be reliable to guide health. While the application is free to use, there was an opinion that there was low reliability on it to guide their health. Participants are more likely to use the application as a guide to manage their health, but do not feel that it is an application that could be used in isolation or be used as a source of truth for health management. Participants did not indicate why they did not feel that such applications were reliable for health management, and where they would go in order to obtain health management information. While participants are likely to use free applications for diabetic management, it is not a source
of reliable information, but could be deemed beneficial for health management. Further research is needed to identify if applications with costs are more reliable to use and share with health care providers.

**Figure 13.** The benefits versus the reliability of a free application in health care

Out of the 38% of participants who had used applications to manage their health previously, 58% indicated that the Glucose Buddy application could be used in the health care system, and 79% would recommend this program to others. Although only 58% stated that it could be used in the health care system, 16% of participants stated they did not know if it could be applicable or not, which may be related to the knowledge gap, or a lack of understanding of health care and diabetes. In addition, only one user who personally used a health application to manage their health stated, they would not recommend this program to others. From the 62% of participants who did not use applications to manage their health, 81% stated that Glucose Buddy could be applied to our health care system and 77% would recommend it to others. It was also significant to note that for those participants who do not use health applications to manage their personal health, they indicated that the Glucose Buddy application could be used in health care and would recommend it to others.
Finally, Figure 14 indicates if users felt the application would benefit diabetics after using the application themselves, as well as if they would recommend the application to others. As noted earlier, none of the participants directly had diabetes themselves and therefore, 28% did not know if it could be beneficial for diabetic patients. Participants who did not know if the application could benefit diabetics had also more often indicated that the application was effective or less then effective in one of the three areas of monitoring, blood glucose, meals or exercise as noted in Table 3.

Figure 14. Comparison of the benefits of the application to diabetics and recommendation of the application.

Table 3. Comparison of the unknown benefits to diabetics and effectiveness of the application

<table>
<thead>
<tr>
<th></th>
<th>Very Effective</th>
<th>Mostly Effective</th>
<th>Effective</th>
<th>Somewhat effective</th>
<th>Not Effective</th>
<th>No Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Glucose</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Exercise</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Meals</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
The effectiveness of the application in capturing blood glucose levels, meals and exercise did not have a strong relationship with those who identified the application to be beneficial to diabetics as noted in from a total of 70% of participants Table 4. An average of 58% of the participants identified the application to be effective, more than effective or very effective in capturing the data as well as being beneficial to diabetic patients.

None of the participants made an indication with regard to being able to find and enter the body metrics and how to use the reminders in the application and so, this would need further analysis.

| Table 4. Comparison of the benefits to diabetics and effectiveness of the application |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                | Very Effective | Mostly Effective | Effective | Somewhat effective | Not Effective | No Answer |
| Blood Glucose                  | 6              | 11              | 13          | 2                | 0              | 3              |
| Exercise                       | 7              | 12              | 9           | 3                | 1              | 3              |
| Meals                          | 10             | 9               | 11          | 1                | 1              | 3              |
| Average                        | 23             | 32              | 33          | 6                | 2              | 9              |

A total of 78% of participants would recommend the program while 16% did not know and 8% would not recommend this to other users. This may also be due to various reasons, such as privacy and security, lack of understanding of the application and its functions, or not liking the application itself. When comparing the benefits and recommendations of the application, an average of 74% of participants both would recommend this application to others and feel that it could benefit diabetics.

The second questionnaire also identified the effectiveness of the application for the specific areas of diabetic monitoring needed as indicated in Table 5. It identifies how effective the particular device is for management of diabetes in the different areas. While none of the participants had diabetics it was useful to identify how they felt the application worked for the function it was supposed to provide. Even though participants did not have diabetes, effectiveness in the various areas included being able to find where
the data was to easily enter it in and be able to quickly review it once it has been entered. On average, for all areas of diabetic monitoring, it appeared to be effective. For blood glucose monitoring 14% stated that it was very effective, 26% stated that it was mostly effective, 36% stated that it was effective, and 22% in total stated that it was less than effective or did not answer. For exercise, 74% felt that it was effective or more, 18% stated it was less than effective and 8% did not answer. For meal intake 12% stated that it was less than effective, while 48% said it was very effective and 20% stated it was mostly effective. Overall, the participants felt that the application was only effective in the various areas, but not great, indicating that there could be improvements made to this. Finally, for sharing with health care providers, 28% indicated that it was less than effective or did not answer.

<table>
<thead>
<tr>
<th>Table 5. Effectiveness of the Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Blood Glucose Levels</strong></td>
</tr>
<tr>
<td>Very Effective</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td><strong>Exercise</strong></td>
</tr>
<tr>
<td>Very Effective</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td><strong>Meals</strong></td>
</tr>
<tr>
<td>Very Effective</td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td><strong>Sharing with health care providers</strong></td>
</tr>
<tr>
<td>Very Effective</td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td><strong>Average Rating</strong></td>
</tr>
<tr>
<td>Very Effective</td>
</tr>
<tr>
<td>19.5</td>
</tr>
</tbody>
</table>

*Note: Percentage of participant results related to effectiveness of the application in capturing blood glucose levels, length of exercise and daily meal intakes.*

Finally users identified, as noted in Figure 15, how comfortable they felt sharing the information with the health care provider, how it impacted their privacy and how comfortable they were with providing the health care provider with electronic access to their information. While 80% felt comfortable sharing with information with the health care provider, only 22% were comfortable with providing electronic access to them. The
levels of access for the application were basic and either provided the user with all access or no access. Participants did not state why they did not want to provide access or for what areas they wanted to limit the health care provider’s access to. This would indicate that participants may want to share the information with the health care provider, but wants to have control over their own personal health information and want the ability to access this data anytime.

Figure 15. Sharing of the application with Health care providers and level of comfort with providing them access.

Privacy and Security

The next part of the questionnaire focused on privacy and security of the program, the implications of the application in health care and overall recommendations. Since this application captures personal health information of users on a regular basis it was interesting to find if users would be comfortable with sharing such personal health information. When capturing health information, there needs to be security measures put in place to ensure confidentiality of patient information. Figure 16 identifies if the application could be used in our health care system and how users felt about sharing this
information with health care providers. While 72% of participants stated that the program could possibly be used in health care, 12% stated that it was not beneficial to be used in health care. In addition, 80% of these participants stated that they would share the health information entered with health care providers and 10% did not want to share this with health care providers. It was unclear why some participants did not want to share this information as it was not indicated on the study. This could have been due to a variety of reasons including lack of security with sharing information electronically, not wanting to provide daily personal data to the clinician or not seeing value in sharing this information with the provider. In terms of using the application in health care, it was also unclear as to how it could be used, if participants wanted health care providers to provide training and benefits of the application.

Survey opinions on the security of the application are illustrated in Figure 17. Only 8% of participants found the application to be very secure compared to the 30% who found it to be unsecure. If users felt that the application was unsecure, the probability of them using the application to manage their diabetes would decline (Myers, Frieden, Bherwani, & Henning, 2009). As noted in the literature review, the privacy and
security of health data for users is important, and the lack of security in any device or application increases the risk of privacy breaches occurring. The perception of lack of security could impact how often participants use the application to manage their blood sugar levels. Since the application contains personal information, these users would therefore like to see their information more secured.

![Security of the Application](image)

*Figure 17. Security of the Glucose Buddy Application as indicated by participants.*

Participants were also asked to identify, if they did not like the type of security on the application, what they would recommend for this application. As noted in Figure 18, 86% of participants stated that a minimum, one type of security feature should be required and only 2% did not want any security feature on the application. Password was the most recommended type of security feature by 54% of users 32% stated that a PIN would be sufficient. As noted in the literature review, passwords and PINS are the two most frequent types of security measures for applications and devices.
Figure 18. Recommended security feature on the Glucose Buddy application as indicated by the participants.

As noted from the initial questionnaire, 22% of participants had an unsecure personal device while 78% had one or more than one type of security feature. It is therefore evident that the security feature that was recommended was based on entering in personal health data. The one participant who stated that there did not need to be any security feature on the application had a password type security feature on their device. The user may have felt that because their device is already secure, they may not want to have an additional security feature to enter into an application. The participant also identified that they felt that the application was secure and would feel comfortable sharing this information with the health care provider. While most participants do not lock their own personal device, it is evident that in general, they would like to have a security feature on the application, in order to keep their health information secure.

From the initial survey, it was evident that all participants were comfortable or more than comfortable with technology, but only 28% of participants were less confident with the security feature of the application. Therefore, participants would like to see a
security feature on the device and would feel more confident with an application that had at least one level of security.

![Confidence Level](image)

*Figure 19. Confidence level with security of personal information on the Glucose Buddy application.*

**Online Review**

An online review was also conducted to identify if the reviews provided online were consistent with views provided by the participants. A total of 100 comments were reviewed from different sites, such as the iTunes webpage, the Google play webpage and the Glucose Buddy Facebook page. The online reviews included those who used the Apple devices as well as those who used Android devices, as it did not clearly indicate the type of device used by the reviewer. Reviews from the iTunes page, the Google play page and the Facebook page were by users of the Glucose Buddy application. Reviews were categorized based on its ease of use and ability to enter and navigate information, review of the graphs by users online and common issues of the application. A total of 55% of users had positive feedback about the application, 35% of users had both positive and negative reviews for the application and 10% of users only had negative feedback of
the application. All reviews were provided within the past six months, from Jan 2013-June 2013.

In the review done by the Academic Nutrition and Dietician (2013) and iMedical Apps (2013) both indicated that the application was easy to use, enter in information and review the graphs. Users on the iTunes webpage also indicated that this was easy and simple to use and navigate without any issues. Both Academic Nutrition and Dietician (2013) and iMedical Apps (2013) indicated that the notifications and reminders were easy and straightforward to understand. Only one user indicated that the reminders were not useful and required that the user be on their phone at all times or constantly checking the application. No other reviewers provided feedback with regard to the notification and reminders part of the application. Finally, iMedical Apps (2013) as well as two reviewers from the iTunes webpage, indicated another benefit of the application was that it allowed for the syncing of data from the Apple device to the online version. This was beneficial as the user was able to upload data over a period of time and store it on a device with larger data capabilities. Table 6 below summarizes the remainder of the findings by the reviewers. 91% of research participants from the study indicated that the application was easy to use and could potentially be beneficial to support self-management and a total of 90% of online reviews indicated that it was easy to use, liked the application and have seen an improvement in their diabetic management overall.

<table>
<thead>
<tr>
<th>Table 6. Online Reviews</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use, navigate, enter information, find information,</td>
<td>35 %</td>
</tr>
<tr>
<td>Excellent/nice/good/great</td>
<td>23 %</td>
</tr>
<tr>
<td>Support self-management outcomes, sharing with provider</td>
<td>32 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90%</strong></td>
</tr>
</tbody>
</table>

*Note: Reviews by users of the application from the iTunes webpage (2013), the Google play webpage (2013) and the Glucose Buddy Facebook page (2013).*
A variety of cons were indicated by each of the different users. A total of 45% of users provided this negative feedback. The first was the limited functionality in the application. Academic nutrition and dietician (2013), as well as 26% of public reviewers from the iTunes webpage (2013), Google Play webpage (2013) and the Glucose Buddy Facebook page (2013) indicated that the application had limited functionality in terms of what it was capable of doing. Figure 20 below identifies the areas of functionality requested by the reviewers in terms of functionality.

![Functionality](image)

*Figure 20. Functionality options requested by online reviews. From the iTunes webpage (2013), Google Play webpage (2013) and the Glucose Buddy Facebook page (2013).*

If one wanted to track their calories they would be required to use a separate application outside of Glucose Buddy. iMedical Apps (2013) and one user from the Glucose Buddy Facebook page (2013) indicated that once data is entered into the application, it cannot be edited. It would require the process of deleting and re-entering in the data which can be tedious and time consuming. It also indicated that the graphs were not user friendly in that it averaged the blood glucose results for the day and comparing it over a number of days. It did not allow the user to graph the blood glucose results for the
day indicating if they were on track over the day or not. Online reviews by diabetic users indicated more concerns with the applications functionality instead of the overall application. While this was not indicated by participants of the study, the online reviews by the diabetic population focused more on the applications functionality and health performance. Finally, both the Academic nutrition and dietician (2013) and iMedical Apps (2013) indicated that the application had numerous ads on the sides and bottom, limiting the screen view that could be distracting and overall ‘annoying’. This was not indicated by any of the users of the application in any of the other reviews. Overall, all of the reviews provided online summarized that while the application does have its flaws and issues, the general consensus is that it is overall a good application for all types of diabetic’s self-management.
DISCUSSION

Ease of use

Users want to have technology that is easy to use and useful to carry out tasks in their daily lives (Chaisson, Forget, Biddle, & Van Oorschot, 2009). Some technology that was quickly accepted and adapted include email, web browsing, and social media sites, such as Facebook and Twitter. Just as these technology changes are accepted, any health care application developed also needs to be accepted and adapted by users. If users feel that the Glucose Buddy application is not easy to use or useful, it will not be accepted. With this study, although there were no diabetic participants, it was beneficial to see how the general population felt regarding the ease of use of the application and its potential usefulness for diabetic management. Ease of use includes how easy the application is to find, download and use without any tutorial provided. It also includes the costs associated with the application and the type of devices it is ideal for. In this case, Glucose Buddy was a free application available for any type of technological device. The results of the study show that the Glucose Buddy application was easy to use and navigate without a tutorial; it is perceived to be beneficial for diabetic management and the low cost was an appealing feature of the application. Both the perceived ease of use and perceived usefulness of the application were present in users and therefore participants appeared to have accepted the technology with a positive attitude. As a result, they are more likely to use the application in the future.

While this application is available to all individuals, participants have identified that the application does not come with instructions on how to use the application, how it works and where to find information. Prior to downloading the application there is little information with regard to the purpose of the application and how it can help individuals. Once the application is downloaded, users are taken directly to the home page so that they can start using the application. The ease of use included the ability to use the application without any tutorial provided by the researcher. During the research study, many participants asked numerous questions on how the application worked, not knowing how to find certain information or data. There were a total of 8 participants who asked questions during the study with regard to the application, such as navigation and entering information, where to find data and how to share and print the results. Two
participants stated in the comment section of the survey that the application was not easy to use without a tutorial or visually pleasing. There is no help tab or help icon on the page for users to click on, and therefore the user is required to learn how to use the application on their own. If users have a question, there is no area on the application for the user to provide feedback or ask questions. When looking at the web version of the application, there was no information about the history of the application, how it worked nor did it provide online help for the use of the application. The application does not provide any instructions regarding its use, and the individual is therefore required to learn on their own how to enter information and use the application. Hence, users are required to download the application first before identifying if it is going to be useful to help them in managing their health. For participants and users who did not have this help feature or tutorial, they may not have accepted the technology as it was not easy to use without this help feature.

The one user that identified that the application was difficult to navigate could have been due to the lack of clarity in the terminology used in the log. For example, there was an icon that was labeled logs, but did not explain that this included all types of logs for blood glucose, medication and meals. For users to know that all the different types of logs were captured under here, they would be required to go into the page identified and search for the information on their own. Once a user went into the icon of the logs they may have then had difficulty navigating through the tabs at the top of the screen as seen in Figure 21. Due to the limited time for the study, it was difficult to identify if the user had navigation issues from the home screen page, or from the various tabs inside the application. The assumption was made during the study that participants who did not voice any complains or concerns with navigation or ease of use, were comfortable with the application and found it simple and straightforward. Participants were asked on the questionnaire to identify how comfortable they were using the application. Only those participants who felt that the ease of use and navigation was hindering their ability to complete the study were the ones who had voiced concerns. Therefore, while the ease of use was not positive for all participants, there were no major challenges identified. The lack of online help and the offering of online help was a main concern for participants. Having help or navigation available could improve the ease of use for all participants.
Effectiveness of the Application

While the research study did not have any diabetic participants, the review in terms of the effectiveness of diabetic self-management was similar to the reviews online. The results for the effectiveness of the application were based on participants who stated that they had used other health applications to manage their health. The effectiveness of the application identifies the perceived usefulness to the participant and if they felt that it would benefit them. For one to effectively manage their diabetes there needs to be a balance between blood glucose levels, exercise, and meals. Participants of the research study identified that data entry onto the application was easy to do and information entered was also easy to find. This application is specific to diabetics and blood glucose monitoring is one of the key tools to manage this illness, it seemed to be the easiest area for data entry. It allowed for minimal information to be captured but the capability to improve functionality is present. Information is very general and can be customized for different users.
Another issue noted in the application as indicated by the participants in the study was the lack of specific detail for data entry. One participant indicated that the application was not detailed enough, but they did not indicate what information was missing. It seems to capture data with regard to diabetes well but is not effective to one’s overall health. For example, one user explained they wanted to be able to capture, calories with their meals, or calories burned with the exercise and provide data for overall weight management. The user also related this to another application called “My Fitness Pal” which captured more detailed information that the Glucose Buddy did not. This would indicate that users who used the application would want an overall holistic view of their health information captured in one place, including their diabetes. The application cannot be used as a ‘one stop shop’ for managing health, and requires that users use a number of different applications in combination with this one. Some may find this beneficial as they can manage the different aspects of their health separately, while others may want to have this all in one place. The benefits of having the various applications is that different application may excel in different areas, providing more in-depth information and resources than a single application that manages many different areas. For example, an application that manages medication may have a full list of various medications and track this information in a more effective manner, than Glucose Buddy. For others, this may not be a benefit as they then have to manage multiple applications in order to get an overall health view. They may want to see the overall health status instead of the specifics to each area of health concern to be addressed, as they feel a more overall holistic approach to their well-being. While there are numerous health care applications available for users, they are not coordinated with each other and the user is required to capture information in various different places. When trying to share this information with health care providers or have a personal electronic health record, this could increase the risk of errors or lack of full data required by an electronic health record.

Positive feedback that was received was that it is perceived by the study participants that it would be easy for those with diabetes and other health challenges to access this application on any of the various devices that they have to monitor their diabetes. Overall, majority of participants in the study, as well as online, indicated that
the application was easy to utilize, navigate and user friendly. The application performs minimal basic features quite well without any voiced issues by participants.

User Interface Design

The user interface design identifies the layout of the application and provides a connection between the user and the technology. A good user interface design also enhances the application to allow for ease of use and navigation for the user. If the user interface design appeals to the user, the user would be more likely to enjoy using the application. The three main types of user interface designs, touch, zoom and intelligent were in the application to varying extents. Touch or TUI was evident throughout the application in all the various tabs. TUI is most intuitive with regards to use in smart phones due to the evolvement of technology (Lei & Wong, 2009). The TUI in the application therefore may have been a familiar type of user interface design that participants are accustomed to. It allows for numerous functions to be performed from the screen increasing the ease of use for the user (Lei, & Wong, 2009). By clicking directly on what they want to do, it allows for easy navigation and entering of data without navigating through various screens. The second type of user interface design was zoom or ZUI. ZUI was noted to be in the application but limited to the graphing feature only. While the application features were simple to read, for those participants who had a difficult time reading there was no feature to allow them to increase the font size or zoom in on the other areas of the application. Having this feature in the graph seemed to be realistic as you could zoom in and pinpoint on various areas of the graph. During the research there was not enough data entered into the application so that it could be graphed. Only one user identified that this was an issue and that the little information entered into the application was difficult to read on the graph as it was too small and unclear. Finally, IUI was also minimally used in the application limited only to graphing, weight and blood pressure it was able to display the information in a logical sequence, as noted in Figure 22. When entering in the weight, it was sorted by date and time entered followed by the weight entered for that time period. As each subsequent entry was made, it was added into a new line. Blood pressure was entered separately from the weight allowing the user to identify changes to the blood pressure separately then from the
weight. As noted in Figure 23, the blood pressure, medication, activity and food are all listed in the same table and therefore difficult to read and view at a quick glance.

While the application does have very specific areas to document data, it does not show if the user is doing good or bad in terms of their overall diabetic management treatment. Users cannot make comparisons to know if they are on track or if they need to make modifications to some of their lifestyles. Users would need to fully understand what a good range for blood glucose levels are and what critical levels are. They need to also be able to interpret the graphs and data they enter into the application, in order for the IUI to be useful for them. The user interface designs in the application are very basic and limited to certain areas of the application. It can be beneficial in numerous ways and not overwhelming by having too many different user interface designs available. Overall, results indicate a majority of participants viewed that the user interface design supported the ease of use and effectiveness of the application.

Figure 22. Viewing the history of the weight entered in by users. Allows users to sort by different time periods. Also allows the user to export the data to an email.
Another concern with the study was that only one user identified in the comment section of the survey about the method of manual entry of data into the application versus an automatic approach. When taking blood glucose monitoring levels, manual entry into the application increases risk of error with transcription. A user may accidentally enter in the wrong digit, which may lead to the user taking the wrong amount of insulin. Automatic upload from a blood glucose monitoring device directly onto the application decreases the risk of error when transcribing from one source to another. One user stated that data input for the logs were too manual and time consuming. Some users preferred an automatic entry instead of capturing the information and then manually having to enter it in. There are different types of technology available that captures the blood glucose readings and uploads the results onto devices (University of Florida, 2013). These include Glooko, and iBG Star (University of Florida, 2013). These devices have the capability to capture the data and send it to different applications without having the user translate the
information. This saves time so that the user is not duplicating effort in transferring the data from one device to another. There are decreased risks of error with an automatic upload instead of a manual entry and by connecting devices directly to your Apple device, this encourages participation for those on the go (University of Florida, 2013). These benefits can be quite appealing to diabetics in that they can continue to live their life with diabetes without significant intrusion on their time for recording data. With devices that provide automatic upload of blood glucose results, diabetic patients’ are able to ensure that they do not miss a reading, and can spend less time using the application and transferring data into it.

Another feedback provided by one participant was that exercise was difficult to see how it was managed. When entering in exercise information users are required to identify what the activity is first before it can be entered into the application. The user then enters in the number of minutes they spent on the activity. The participant did not specify why it was difficult to see this information; one of the issues I identified when using the application was trying to identify how many calories were burned when I entered in walking for 15min. In order to gather this information, I would be required to use a different application or find out on my own, as this was not in the application.

Reminders in the Application

There was one user that identified through the comment section with regards to setting reminders in the application. The participant identified that there should be a reminder set so that users can remember to open and enter in data into the application. As noted, the application did indeed have reminders but this section was unclear. The reminder tool is important in that it helps diabetic patients remember to take their blood glucose levels and enter in medication and activities. As noted in the literature review, for self-monitoring to be effective, users need to constantly be keeping track of their blood glucose, ensuring that they are exercising and eating a balanced diet. Three users from the online reviews identified issues with the reminder in the application. The users clearly identified that they were unable to set the reminders and get the alarms to work. The users also indicated that it was unclear on how to get the reminders to trigger with an alarm.
The research participant identified that there was no way to send a notice to themselves and that this could be an area for improvement. Testing the reminders on the application may require a longer term research study, therefore research participants may not have utilized this feature to fully understand how it worked. The reminder section of the application was not as effective but is an important part of glucose monitoring. For users, setting reminders could improve the utilization of the application as they remember to enter in information.

Reminders in the application required multiple selections, first the type of reminder, dates and time of the reminder and the type of alarm. The reminder features in the application may need to be more simplified and user friendly. Automatic features such as being repeated daily and at the times selected by the user. When utilizing the reminder application, reminders could not be edited but required deleting and re-entry of the information. There was also no volume associated with the reminder so it was unclear if they could be muted. Allowing edits to the reminder would make using reminders more ideal, and having the ability to mute reminders would allow for easier use of this feature in the application.

**Privacy and Security**

The privacy and security of personal health information is an essential component for most individuals. A breach of privacy information can cause an individual to not want to provide critical health data to the organization. The plans to create an interconnected electronic health records have raised great concerns with regard to privacy and confidentiality of patient data even more (Myers, Frieden, Berwanie, & Henning, 2009). Not only does sharing of health information with health care providers increase ones overall health, but it also assists with the health of the community and providing data and statistics regarding health changes in the community (Weitzman, Adida, Kelemen & Mandi, 2011). It is therefore beneficial for users to be able to share information with health care providers in a timely effective manner. Health data helps authorities monitor the incidence patterns, and trends of injury and disease in populations (Hodge, 2003). With the health data that providers collect, they can help identify, manage and control the spread of communicable disease such as SARS, TB, or other infections.
With the data that health care providers collect, they provide statistics regarding the health of the population and identify ways to improve it. Although this data is presented as a collection from all individuals, users may still feel uncomfortable sharing this information, as it is their personal data. For diabetic users, they may not want to share that they are diabetic or how they have been managing their illness overtime with health care providers or the community.

The lack of privacy was also brought up by all of the participants except one. Two users indicated that the information entered into this application was sensitive health data and needed greater security measures. The participant felt that if their phone was stolen, this information would easily be available to other individuals. In 2006, a survey was conducted and 80% reported being very concerned about identify theft or fraud (McGraw, Dempsey, Harris, & Goldman, 2009). The results from the study showed that research participants wanted more privacy and security on the application, in order to protect their health information. The most effective method to enhance the privacy and security of the application was the use of a password or a PIN. As noted in the literature review, password options are more secure than PIN options (Furnell, Papadopoulos, & Dowland, 2004; Mckenzie, Patel & Swaminathan, 2010). Having security measures in place is beneficial but the research participants indicated that it does not require that the application require complex multiple levels of security. The application has sensitive information which therefore needs to be protected, but also needs to balance with patients ease of use and quick access to the application. Only 2% of study participants stated that they would not want to have any type of security feature on their device. This could be related to the inability to remember passwords and pins as easily. In the study conducted by Furnell, Papadopoulos, & Dowland, (2004), users are more likely to forget their PIN or password, and often relate it to them in some way, such as using the birthdate for a PIN, or sharing the password with a family member. This increases the risk of security and privacy information issues for the individual. People with chronic illnesses report even higher levels of concern about the privacy of their medical records and are more likely than average to withhold information for fear of it being improperly used (McGraw, Dempsey, Harris, & Goldman, 2009). Therefore, for application such as Glucose Buddy, there needs to be a clear policy and steps showing the user that their
information will remain protected or what measures the application will take to ensure the security of the data for users. A breach of personal health information can be a cause for concern for individuals. Misuse or wrongful disclosures of sensitive health data can lead to discrimination and stigmatization against individuals (Hodge, 2003). For example, if the blood glucose levels of a family member were sent by accident to another family member, there could be issues relating to stigmatization of the individual within the family as well as a risk of sharing information with extended family without the individuals consent. This could cause the individual to no longer want to use such applications as they did not want to share their blood glucose readings with extended family. It is therefore critical that such applications have security measures put into place to prevent and decrease the risk of harm to the individual.

Users also indicated that they would like to see passwords to protect this sensitive information. Not only can the information be stolen from the user’s device, but there is a risk of breach to the Glucose Buddy application or website or the server. A single breach to any application or device can expose tens of thousands of health records (McGraw, Dempsey, Harris, & Goldman, 2009). For individuals who use the Glucose Buddy application, their information is stored onto the Glucose Buddy server. If one were to access and get onto this server, they could potentially have access to numerous logs and information entered in by all the different individuals. With a shift from paper to electronic health records, come its benefits and its challenges. Only 10% of participants stated that they were very confident with entering in their health information onto the application. This indicates that while using the application, users found that they were not comfortable with entering in their personal data and it makes them uncomfortable. There were no clear indications as to how to mitigate this concern.

Review of the Application

After the study, I reviewed the application to identify if there were any other areas missed on the study. There is no place to share the diabetic log detailed information with others. While this was available, it was limited to sharing one set of information at a time, it can only be done via the web application and via printouts. There is no electronic way to share the logs that were entered into the system. Sharing of this data, with the health
care provider can be most effective for managing health data and decreasing risk of associated complications for the users, if it was done electronically. When participants enter in this data, it should automatically upload to the physician or health care database so that they can provide ongoing monitoring. When patients go in to see their health care provider, the provider is aware at how well they have been monitoring their diabetes, and what the results are of their glucose monitoring. There is less time spent on having the patient bring in the data and for the patient to review it with the health care provider.

Sharing was only limited to the weight, and blood pressure results. In order to share information with providers it would require that they export the information using a .CVS file (excel) which then sends the information to another. When sending the file, it does not state the user name or highlight any of the critically low areas and the time does not show if it is the morning or afternoon (does not state AM or PM or use a 24 hour clock. In addition, there were numerous acronyms used in the application, which may not have been understood by all participants. For new diabetic patients, this would be an issue as they would need to monitor their diabetes more assiduously, and with acronyms that they do not understand, this could discourage users from using the application. Additionally, it was unclear as to how the application recognized when meal times were. For example, meal time could vary for each user, so setting a reminder for a meal time, such as before breakfast, it may be at the wrong time, thus discouraging users from using the reminders appropriately.

In addition, users could link it to iPhones but not to any of the android phones. This was one of the flaws of the application as not all diabetic users will use Apple products. While this application can be used on different devices, it is most compatible with Apple devices, which thus also limited its population of interest. Sharing this device from application to the web services is easier for those with an Apple device. Graphing data is useful to compare from week to week over a long period of time how well they are managed their blood glucose levels, and if it is always within the acceptable range. Users can then identify to see if there is a pattern to their glucose levels when it is graphed. For example, they may identify that every afternoon, their blood glucose levels increase due to the increased sugar intake after lunch and before dinner.
While this study provided valuable information in regards to the application and areas for further research, there were many limitations associated with the study including the sampling method and design. The sample size of the study was small with only 50 participants that were not representative of the target population, the study used a convenience sample method with none of the participants having diabetes, and the study was conducted at UOIT only with a short time frame. The sample size is important in allowing it to be representative of the population and limiting external influences that could impact the study.

With a larger sample size, the results of the study can be generalized to the target population and individual differences can be eliminated. A convenience sampling method was also not representative of the population, because it involved participants who were readily available and with no specific inclusion criteria. There was no randomization involved in the sample size increasing the risk of missing a large population of interest. Finally, the study did not have any participants who had diabetes of any kind. While it is valuable to know how effective free applications are to the general public, they may not have an understanding of how diabetic applications can benefit diabetic patients. This study was conducted over a 3 month period due to the time restrictions. For diabetic patients, this is a life-long condition and not something that can be managed within a short time frame. While it is beneficial to understand, in a short time frame, if a user finds an application helpful and beneficial, the study was not able to identify if it improved overall health or if users would continue to use the application over a period of time. The study was also limited to only Apple devices. While this eliminated variables of the different operating systems, not everyone uses an Apple device. The application is available for any type of smartphone and it would be valuable to identify if the device impacts the use of the application and how it can be decision and outcomes.

Another limitation that existed was the research design and how the study was conducted. The research study was done on paper at UOIT. While participants did not have a time limit to how long they could utilize the application and learn its functionality and complete the survey, on average, participants took approximately 10 min. Providing the participants with an electronic copy of the survey and allowing them to conduct the
study on their own time may impact the amount of time they spent on the survey and learn how it works. With an electronic copy of the survey, it would also remove observer effect and increase self-learning. They would not be able to ask the researcher questions about the application and it would be one in a realistic setting. In addition, the Glucose Buddy can be utilized online, and this study only focused on the application and utilization of Glucose Buddy on a mobile device and not online.

Finally, the study survey questions were developed as a Likert scale and did not provide an opportunity for participants to explain their answers until the end of the surveys. For example, sharing the results with health care providers was identified as something most participants would not do, but there was no explanation as to why. This may be related to comfort level, lack of privacy and security or a knowledge gap on how to do so. In a future study this could be addressed by having a follow up session where participants identify why they would not share this information. Additionally, each participant could have had different levels of understanding of diabetes and how the application could be effective for self-management since none of them had diabetes themselves. While some participants knew a family member or had a family history of diabetes, it was difficult to gauge just how much they knew about their diabetes. Furthermore, the questions asked in the study may have been interpreted differently for each user thus producing varying results. For example, the management of health is a very broad term and could be interpreted differently by all participants. Many participants who stated that they would use technology to manage their health did not state what type of technology, why and what areas of health they would use it in, and since this was not clearly defined for participants this could have impacted how each participant understood this question and answered it. Knowing what application participants used previously to manage their health may allow the researcher to compare to the Glucose Buddy application to other health applications that exist.

One of the benefits of the study was that it looked at students who were all within the same age group. This age group has been exposed to technology for quite some time and for the most part, knows how to use it with comfort. This is also a school of technology so all users have a laptop. Unfortunately, this cannot be applied to the older population and those who have not grown up with technology. Looking at the older
population and how they would accept and use the application also needs to be considered. Participants of the study were given the option to download the application on their device or use one provided by the researcher. All but one participant used the exact same device to navigate through the application. This eliminated different variables that could have been present by users using their own device. A benefit of this study was that it used one application that was free and available to all users. As the application is compatible with all different types of devices, it would be ideal to see how different users would view the application on various devices.
RECOMMENDATIONS

Based on the results of this research study, there are several recommendations to the Glucose Buddy application to improve its ease of use, usefulness and benefits to the users. Several recommendations were made towards the Glucose Buddy development team that could enhance the ease of use and effectiveness of the application to support diabetic health management. Recommendations were also made for diabetics to allow the patient more autonomy over their health and their health data, increase communication between the patient and the health care team and overall improve the quality of life for the individual. Finally, recommendations were made towards the health care provider for technology acceptance and integration in the health care system.

Application Improvement

The first recommendation for the Glucose Buddy application would be to have a help icon available, or link to a help feature online, for users who need the extra support for navigation or have questions about the use of the application, such as how to enter in data or find data. The help feature should be easily visible and accessible on any type of device. It should contain information that explains to users what the application is and how it to use it, such as how to enter in data, how to read the results, how to share with the health care provider, and how to delete information. This feature may also benefit with the use of video instructions to show users the basics of how to enter, view and share data with others. This may appeal to users who prefer visual learning instead of written instructions. Although a help feature may not be used by everyone, its mere presence may also allow users to be more comfortable with the application knowing that they have a resource to go to. As noted in the article by Bay & Ziefle (2005), different age groups have different learning needs. Users in the younger generation may not need as much support or assistance with technology but would like the ability to access additional help if required. Those from the older generation, who have not grown up in the digital age, may require more assistance and would highly benefit from this additional help feature. Making a help feature available for users could also support the ease of use and effectiveness of the application, as the user will be able to identify if they have used the
application correctly and know that the results that they enter in are within the range of maximum high and minimum low before they are required to seek medical attention. They may then be able to identify what range their blood glucose levels fall in and compare it to the norm. As this is a free application and is not supported by any organization, the help feature should not contain information with regards to the interpretation of results. The application should not be used as a source of health teaching, in order to prevent misleading or inaccurate information to the user. The help feature online can possibly provide a link to a health resource that may be more ideal for health education related to diabetes. For example, linking to the Canadian Diabetes Association that provides detailed information about diabetes and management, how to interpret blood glucose results and how one’s health can be improved by the user. While this could be useful, the help feature may be able to link health resources for the user to get additional information. Interpreting the data entered in the application should not be provided without a health professional to ensure that standards for health are met and that accurate data is provided for users.

The second recommendation would be to increase the functionality of the application. Many users identified concerns with the limited functionality of the application, which could be addressed by improving on the intelligent user interface design. The first area for functionality improvement would be in the graph. As identified by online users, graphing of blood glucose results is an average for the day and not for each individual entry. By expanding on the intelligent user interface design, the user should have the ability to select the format of the graphs, such as viewing an average of each day’s results or each individual result, as well as the timeframe that they want to graph to display for. For example, one user may want to see one week of blood glucose results at a time, whereas another user may want to see three days’ worth of data only. This would provide better data output in a visual diagram that the user could modify as they felt best applied to their health situation.

The next area for functionality improvement would be related to meal entry. Units of measurement for meal entry in the application are only available in grams. Users want the ability to select different measurements such as ounces, milliliters or the number of the meal consumed, for example, number of eggs. Not all users use the same levels of
measurement, so users should be able to change the levels of measurements based on their own preference how they may measure their meals. In addition, meal entry in the application is a manual process, having to translate from the glucometer to the Glucose Buddy application, and does not provide a list of the different most common type of meals that are available. The application should provide a basic list of common meal items, such as eggs, milk, cereal, salads, with the amount based on an average recommended portion size as indicated by the Canadian Diabetes Association. This could encourage and guide the user on average portion sizes but the application should still have the ability to modify these average portion sizes, as each user may differ. In addition, allowing a free text option may still be necessary in the application as users may come from different backgrounds and eat different types of meals.

The third area for application improvement in functionality would be in the reminders section of the application. Currently, reminders in the application are based on “simple time reminder” or an “event reminder”, such as before breakfast or after breakfast. While the “simple time reminder” is beneficial, this type of reminder does not allow for details to be entered, such as the reason for wanting this reminder, such as being related to taking a blood glucose morning reading or entering in medication. The second type of reminder is based on an event type such as before breakfast or after breakfast. With this type of reminder, the application does not indicate what time ‘before breakfast’ is, for example 0700 or 0900. The reminder also occurs after the event only, so this would only trigger after the event has occurred, instead of identifying to the user prior to the event. Finally, any type of reminder in the application does not allow for editing, snoozing of the reminder to reoccur and muting the reminder, to trigger or vibrate but not ring.

The final recommendation for the application software is to improve the privacy and the security of the application. The application contains personal health data of patients and the risk of breach could potentially cause harm to the individual. By developing a security feature on the application, the user is restricted from viewing the data on the application and sending it out via email, or any other electronic method, without proper electronic signature or authentication. Implementing a security feature onto the application such as a PIN or a password in order to log onto the application and
view the data may be sufficient for users. Since the health information such as blood glucose results is easily accessible and viewable on devices, if a device were lost or stolen, the individual is at risk for losing their personal health data. Protecting health data also complies with the legal PHIPDA act of Canada in order to protect the privacy of individuals. With a security feature, patients are more likely to feel comfortable sending their personal health data via secure measures.

Additionally, as more and more individuals are taking an active role in their health and becoming more autonomous by using personal health applications, this information should also be linked to their personal integrated electronic health record. While the personal health record may be managed by health care providers, there should be a patient portal that allows the individual to view and enter in personal data as well. The patient portal for example, could include diabetic glucose results and medications taken. It could also include areas that allow the patient to ask questions to the health care team and gets feedback about their health, without having to go in for an appointment. For health care practitioners, they can enter in clinical documentation with regard to the patients overall health that the patient can view. They can interpret the data that is entered by the patient, such as glucose levels, interpret them into knowledge and make clinical recommendations for the patient to encourage healthy living.

The application should also remain free for all users to download and continue to be easy to use and effective. Having an application with no costs associated to it will increase the probability that patients would utilize the application. For diabetic patients, this is a lifelong condition and having to pay for a health application may not be ideal, especially for those from lower income families. Having an application that is easy to use and effective can also be beneficial as there will be little training required and the patient is able to quickly learn the application without any assistance. Finally, having this Glucose Buddy application endorsed by a health care organization, such as the Canadian Diabetes Association could potentially improve the likelihood of the application being accepted by both clinicians and users as well as being more reliable. In order for the application to be endorsed, the application should first address concerns around the privacy and security of the application, modify the application to improve its functionality and meet the needs of users and finally ensure that it is integrated with the
electronic health record. Once this is done, it can potentially be endorsed by an organization, thus increasing the likelihood of application use and acceptance.

**Diabetic Patients**

The Glucose Buddy application is free to all users and can be used on any type of electronic device. There are several recommendations to the diabetic patient when using the application. The first recommendation is to use the application on a daily basis for accurate data and best possible decision making and outcomes. Although diabetes is chronic illness, it can be managed at home and the patient can continue living a healthy lifestyle. Diabetic patients can do so by using the reminders in the application to support the daily monitoring and managing. The reminder should be used to remind support the daily checking of blood glucose levels and entering the resulting information into the application. Reminders work as alarm clocks and should be used as a “health management’ alarm clock at different times during the day. While users may get caught up in life events and issues, they may sometimes forget to monitor their glucose or take their dose of insulin. As a result, they can use the reminder feature to prevent this from occurring and making certain that the reminders keep them monitoring their health throughout the day. By using an electronic application to track their data, it will increase the chances of compliance due to the reminders functionality. The reminders can be useful to prevent users from relying on their memory as to when they need to take medication or when they need to take a blood glucose reading.

Another recommendation would be to enter data onto the application on a regular basis and be shared regularly with the health care provider. Sharing of health data between the health care provider and the diabetic patient supports the use of open and ongoing communication process. By sharing this data electronically, the user is able to get feedback in a timely fashion and could identify early on if health concerns arise and not wait until the next clinical visit to discuss the issue. Sharing of the data electronically can be beneficial and if with encryption, this also maintains the privacy and security of the electronic data.
Health Care provider

The final set of recommendations should be towards health care providers. The technology acceptance model does not only apply to diabetic patients but also to health care providers. For this application to contribute to the health care system on a larger scale, it needs to also be accepted by clinicians as a tool that is beneficial to recommend to diabetic patients.

The Glucose Buddy application captures basic information for diabetics and allows them to monitor changes over time. For users who have been diagnosed within the past 5 years, they may need greater support for self-management. Therefore, the next recommendation for health care providers would be that the application should be geared towards newly diagnosed diabetics, particularly those who have Type 2 diabetes. Patients with Type 1 diabetes often occur at a younger age, often under the age of 13, when they are still developing habits of self-management. While it is being seen in the older population, this is still infrequent. For patients with Type 1 diabetes, this is also linked to non-modifiable risk factors, such as genetics, race and ethnicity and family history. In addition, those with Type 1 diabetes also are immediately given an external source of insulin, as there is none being produced by the body. As a result, these patients are required to make immediate lifestyle changes to monitor their health instead of a gradual change. While the Glucose Buddy application may be beneficial for this group of users, the diagnosis requires immediate intervention and modifications in order for one to have a quality of life outside of the hospital. For patients diagnosed with gestational diabetes, this is often a temporary diagnosis during the second and third trimester of pregnancy due to hormonal changes in the body. For women with gestational diabetes, they would require temporary changes monitoring of their blood glucose levels and may not need to make long term lifestyle changes.

For those who are newly diagnosed with Type 2 diabetes, this is often due to modifiable risk factors such as obesity, sedentary lifestyle and unhealthy eating patterns. As a result, these users would need to make lifestyle changes to maintain their health. Therefore, an application for newly diagnosed Type 2 diabetic patients can help a user identify how well they are self-managing and provide them with data to help them develop a routine.
CONCLUSION

Health care is an essential aspect to our society, in order to maintain a balanced quality of life. In Canada, having a publically funded health care system ensures that each and every individual receives the same basic health care services as required. Costs to health care organizations are limited, and as more individuals use health care services, providers are trying to find new ways to keep costs to a minimum. One of the major costs to a health care organization is by those who have chronic conditions. Chronic conditions can be any long term condition requiring ongoing interventions and health changes. For those who have chronic conditions, they have frequent visits and require multiple services, in order to maintain a good quality of life. While some of these services are essential, health care organizations need to find ways to manage these chronic conditions outside of the health care system to decrease costs to the health care organization. This research study focused on the chronic condition of diabetes, and the ease of use, navigation and user interface design of the application. In addition, it compared the results of reviewers online to the research study to identify if the application could potentially benefit the diabetic patients with self-management techniques.

User Interface Design

The user interface design of any application contributes to how one utilizes and accepts technology. The Glucose Buddy uses three types of user interface designs, touch, zoom and intelligent, which all contribute to ease of use and effectiveness of the application. For the Glucose Buddy application to be used, data needs to be entered in. The easier this is for participants to do, the more likely they would use the application. Research participants did not identify issues with being able to enter data, where to enter this data and how to enter it in. Therefore, as the Glucose Buddy allowed easy entry of information, by using touch interface design, it was deemed to be effective and contributed to its ease of use. The second user interface design in the study was zoom interface design. This was limited to the graph feature in the application. As the research participants did not enter enough data to graph, the zoom interface design on the application would need further research.
Finally, intelligent user interface design was evident in the application, which was used to show the results of the data entered. The research participants could not identify if this could be used for daily monitoring and would support health management on a long term basis. It was noted by online reviews that this type of design would need further enhancements. Online reviewers indicated that they would like to see more graphing options for the chart, would like to see a calorie counter linked to the meal entries and would also like to have more functionality with the Android version of the application as compared to the Apple version. Therefore, this type of user interface design would need further research. It would involve using the Glucose Buddy application on both the Apple and the Android version in addition to adding enhancements to various areas of the application using the intelligent user interface design to be more effective.

**Technology**

Technology in health care is focused on improving workflow process and providing better outcomes. TAM is an important criterion for this to occur. Participants of the research study were not given any education or training about the application prior to the study. The results still show that the Glucose Buddy application was easy to use and navigate for many users. Once the application was available on the device, the users had quick easy access to it at any time. Many participants during the study spent less than 15 min using the application, indicating that it did not require extensive time on the application to learn and answer the research questions. The ease of use was also enhanced by the different types of user interface design that was evident in the application. As the application was perceived as easy to use, this contributed to the attitude that it would be perceived useful and more likely to be used by diabetic patients.

**Privacy and Security**

Privacy and security of health information is crucial in any type of technology or application. Applications that are holding such confidential information should have clear outlines about what the policy and procedures are and responsibilities of both the application and the user to maintain the confidential and privacy of the information stored
in, and entered into the application. The results of the study show that the application Glucose Buddy is effective and user-friendly for the average user today. The free application provides the ability for users to interact and input basic health data into the application and view the trends over time. The application could be improved by allowing ease for sharing the information and viewing the information in different ways. In terms of self-management, the study was unable to identify if self-management could be improved for diabetic patient’s, but there is a strong correlation that it could be effective in diabetic management and for personal use. It may or may not impact the cost to health care organizations but can help the individual learn about how important it is to monitor glucose levels. While participants know how to use the application, find that it is useful and beneficial and effective, they are not comfortable with the level of privacy and security on the device and therefore, are less likely to use it as a result.

*Canada Health Infoway*

The Canada Health Infoway project works to support an integrated electronic health record for all patients. Electronic management of health is becoming more apparent for both public and private use. For patients currently living with chronic conditions, such as diabetes, it is therefore essential to link health data gathered between self-monitoring and the health care provider. Using the Glucose Buddy application can be used to support this link and contribute to the patient’s electronic health record. Patients can use the Glucose Buddy application, where they enter in their daily health data creating a database of their diabetic health history. This could then be shared with health care providers and other clinicians as required by the user. Sharing this electronically with the provider can also allow for the information to be stored into a central electronic health record database for the user. In addition, the application may be able to support diabetic education for patients and potentially increase self-management through education.

From the research study, there were still several areas for improvement for the Glucose Buddy application to make this more reliable and effective. By making enhancements to areas of the Glucose Buddy application, such as increased privacy and security of the application, and more sophisticated functionality and intelligent user interface design, it could be used more in health care to support patient outcomes and
overall health. Such changes to the application may increase costs, and it would be beneficial to identify if free applications versus paid applications have an effect on how an individual uses the application to make health decisions.

By using an application, data is organized into a manner that can be analyzed easily and can be viewed overtime, and shared electronically. The template for data entry is already set up and the design captures multiple types of information in one area. There is minimal effort required of the patient when using the application. The Glucose Buddy application was identified as being easy to use and navigate without tutorial. Therefore, any diabetic patient could potentially use the application without any training or education. Based on the results of the study, the application Glucose Buddy has the potential to improve and to contribute to the improvement of self-management but further research is required. It would be necessary to measure the effectiveness of the application for changing habits and improving self-management.
FUTURE RESEARCH CONDITIONS

Future research for applications related to diabetic management, in particular related to Glucose Buddy, should include the use of a larger sample size focused on the diabetic population. Sampling size should be based on participants from different diabetic clinics or those currently in an acute care organization. It would use a random sampling method such as stratified sampling method. The sampling participants should further be categorized into length of time since diagnosis. This would ensure that there is a representative sample of the population and that the results could be generalized. It would be limited to patients who did indeed have diabetes, and in particular, Type 2 diabetes to limit the number of variables. As this application is specific for diabetes, using diabetic participants would provide a more specific result on the diabetes part of this application. Newly diagnosed diabetics are at a higher risk of obtaining associated complications due to not fully understanding the condition and its management requirements.

Future research should also include participants from different age groups to understand how the technology is accepted and used by both the younger generation that has grown up using technology on a daily basis, and the older generation who have been given the technology. This would allow the study to use participants who are comfortable with technology, as they have grown up with it as well as understand how the older generation has accepted technology and adapted to it.

In addition, a second stream of the research should be focused on clinicians and clinician acceptance. The purpose of this would be to identify if they would encourage the use of the Glucose Buddy application as well as the applications of TAM to the technology and application from a clinician perspective. The inclusion of clinicians would also enable future research to study the interaction and sharing of health data from the diabetic to the clinician to be evaluation in terms of its effectiveness with technology.

The research should be a longitudinal study over the course of a year to identify if use of this application decreased hospital readmissions and diabetic related issues, compared to those who did not use the application or used another application. It would allow users to use any type of device that they owned to utilize the application and not
just limiting it to Apple devices. This would include finding and downloading the application on their personal device of choice. Additionally, the future research should provide an electronic copy of the survey to allow them to carry out tasks on their own time in a comfortable area. The same application may be used to identify areas for improvement as opposed to using different applications and comparing them to one another.
REFERENCES


support improved care for chronic illness. *Journal of general international medicine*. 22(3). Pg. 425.
APPENDIX A

Questionnaire-Demographic Data

1. What is your age group:
   - 19-29
   - 30-39
   - 40-49
   - 50+

2. What is your gender?
   - Male
   - Female
   - Undisclosed

3. What program are you in?
   - Business and IT
   - Education
   - Engineering and Applied Science
   - Science
   - Energy System & Nuclear Science
   - Health science
   - Social science
   - & Humanities

4. What type of technology do you have?
   - iPad
   - iPod
   - iPhone

5. Have you ever used technology to manage your health?
   - Yes
   - No

6. How comfortable are you using technology?
   - Very comfortable
   - Somewhat comfortable
   - Comfortable
   - Somewhat uncomfortable
   - Not comfortable at all

7. What type of security do you have on your device?
   - Unsecure
   - PIN
   - Pattern
   - Password
   - Other: ___________

8. Do you have a family history of diabetes:
   - Yes
   - No
   - Do not know
9. Do you have diabetes?

Yes  No

a. If you answered yes to the above question identify what type:

Type 1  Type 2  Don’t know what type

10. If you answered yes to the above question, how long have you had diabetes for?

1-5 years  6-10 years  11-15 years  15+ years

11. How do you currently manage your diabetes?

Do not track  Track it on paper  Track on a word/excel sheet  Use an electronic program  Other

---

**Questionnaire 2: The Application**

1. Have you used the application prior to the study?

Yes  No  Do not know

2. Is this program easy to register for on your device?

Yes  No  Do not know

3. Was the program easy to use without a tutorial?

Yes  No  Do not know

4. Was the program easy to navigate?

Yes  No  Do not know

5. Was the program easy to allow for information to be entered?

Yes  No  Do not know

6. Do you think this program could benefit those with diabetes?
Diabetic Management

7. Would this program be practical/ideal for daily use/monitoring of glucose level, exercise and nutritional intake?

   Yes    No    Do not know

8. Would free applications such as glucose buddy encourage you to be proactive in managing your health?

   Yes    No    Do not know

9. Would you be willing to rely on free programs such as glucose buddy to guide your health?

   Yes    No    Do not know

Please answer the following questions regarding the effectiveness and usability of the program:

10. How effective was the program in capturing blood glucose levels

    Very Effective    Mostly Effective    Effective    Somewhat effective    Not

11. How effective was the program in capturing exercise

    Very Effective    Mostly Effective    Effective    Somewhat effective    Not

12. How effective was the program in capturing meals

    Very Effective    Mostly Effective    Effective    Somewhat effective    Not

13. How effective do you think this program is to sharing with health care professionals?

    Very Effective    Mostly Effective    Effective    Somewhat effective    Not
**Questionnaire 3-Security and Privacy**

1. Do you think this program can be used in our health system?
   - **Yes**
   - **No**
   - **Do not know**

2. Would you recommend this program to others?
   - **Yes**
   - **No**
   - **Do not know**

3. Would you use the information from this device to share with your healthcare provider?
   - **Yes**
   - **No**
   - **Do not know**

4. Do you feel comfortable with the level of security on this program?
   - **Yes**
   - **No**
   - **Do not know**

5. Do you think your privacy is protected on this program?
   - **Yes**
   - **No**
   - **Do not know**

6. Are you comfortable putting your personal health information into the program?
   - **Yes**
   - **No**
   - **Do not know**

7. Would allowing such programs to be available to all healthcare providers breach the confidentiality of your health information?
   - **Yes**
   - **No**
   - **Do not know**

8. Would you feel comfortable allowing all healthcare providers to have access to your health programs you use electronically, such as glucose buddy?
   - **Yes**
   - **No**
   - **Do not know**

9. Rate the security of the application
   - **Very secure**
   - **Somewhat secure**
   - **Secure**
   - **Somewhat unsecure**
   - **Unsecure**

10. What kind of security feature would you recommend for this application?
    - **No security**
    - **PIN**
    - **Password**
    - **Other:** ___________________________
11. Do you feel confident that your personal information will remain secure on the program?

*Very confident*  *Somewhat confident*  *Confident*  *Somewhat unconfident*  *Not confident*

12. Do you have any other comments or observations regarding this program?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________