Diabetes Management Self-Helper Mobile Application for Malaysian Type 2 Diabetes Patients

by

Muhammad Nur Arif bin Samin

Interim report submitted in partial fulfillment of

the requirements for the

Bachelor of Technology (Hons)

(Information and Communication Technology)

SEPTEMBER 2013

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Diabetes Management Self-Helper Mobile Application for Malaysian Type 2 Diabetes Patients

by

Muhammad Nur Arif bin Samin

A project dissertation submitted to the
Information and Communication Technology Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Technology (Hons)
(Information And Communication Technology)

Approved by,

_____

(Dr Helmi Bin Md Rais)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

SEPTEMBER 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

_____

MUHAMMAD NUR ARIF BIN SAMIN

ACKNOWLEDGEMENT

First and foremost, gratitude must be shown towards our beloved God, Allah of whom without His blessing, I would not be able to successfully complete the study. I would also love to express my thanks towards my family that is always providing full support no matter how hard thing is. A special thanks for Dr Helmi, my supervisor that provides me with guidance and constructive criticism to ensure that my project is accomplished successfully and in timely manner. Last but not least, a special thanks for towards my friends that are always behind my back.

ABSTRACT

Background

Diabetes is worldwide epidemic that is included projected to be 7th highest death cause by 2030. WHO updated in March 2013 that 347 million people around the world are affected by diabetes. To improvise diabetics' self-management, self-help mobile health applications are introduced for smartphones users around the world to help them in managing the disease effectively and efficiently. However, studies show that these applications are lacking in many areas and specifically in Malaysia, the existence of applications that are made for local type 2 diabetes patients is negligible as most of them are made overseas, hence do not really take specific lifestyle patterns of Malaysians into account.

Objective

This research aims to develop a mobile application on Android OS platform to assist individuals of type 2 diabetes backgrounds with self-management practices and to increase awareness among local type 2 diabetics of self-management and its benefits.

Methods

A preliminary design of the prototype was constructed to give a better overview of the real prototype that will be developed in the future. A pilot study was also made to identify current percentage of diabetes management application users among type 2 diabetics and their perception towards usefulness of diabetes management application whether they have experience in using it or not.

Conclusion

Diabetes is a serious global issue that needs to be managed efficiently in order to produce a healthy and productive community. This application will help in delivering accurate information and enhance diabetics' self-management to produce better health outcomes and avoid or prevent harmful complications that could threaten the life of a diabetes patient from occurring.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background of study

Diabetes mellitus is a chronic disease that is commonly linked with overweight people. In fact, one of the risk factors for the development of diabetes is having an excessive weight. Diabetes is also included among major chronic diseases that receive spotlights each year. It occurs when the amount of blood in sugar become too high as the result of insufficient insulin produced by the pancreas, the body unable to utilize insulin accordingly and effectively or due to less often case where the body destroy beta cells of the pancreas, causing it to be unable to produce insulin at all. Insulin is a hormone that helps to move sugars into body cells to convert it into a source of energy. Unmanaged diabetes will lead to serious complications over time such as dehydration, weight loss, damaging body, developing diabetic ketoacidosis (DKA) and diabetic coma.

According to WHO (World Health Organization) Diabetes Fact Sheet, updated in March 2013, 347 million people around the world are affected by diabetes and the organization also projected that the diseases will be the 7^{th} leading cause of mortality by 2030. International Diabetes Federation (IDF) also reported in 2012 that almost half of these diabetics were not even aware of their health condition and estimated that 4.8 million will die due to complications developed from it (Castillo, 2012).

Two major types of diabetes are; 1) type 1 diabetes, and; 2) type 2 diabetes. However this research will focus on type 2 diabetes area as 90% of local diabetics according to latest statistical analysis, are affected by it.

1.1.1 Type 2 diabetes facts

The most common type of diabetes that affects the majority of diabetics in the world is type 2 diabetes. According to WHO, 90 percent diabetics in the world are affected by type 2 diabetes, largely due to being overweight and laidback lifestyle.

Type 2 diabetes can develop due to insulin resistance; that is the body either producing insufficient insulin or it could not utilize the insulin produced effectively. This condition will cause glucose buildup in the blood, unable to be moved into body cells. Hence these

cells could not function well. Complications that can develop from type 2 diabetes vary in terms of severity, including severe weight loss due to dehydration, inability to heal open wounds, and five-fold chances of suffering from heart stroke.

There are several ways used to treat type 2 diabetes. Included methods are weight loss surgery, using natural remedies, utilizing non-insulin diabetes injectable, consuming oral diabetes medications and getting supervision from diabetes care team.

To control diabetes, one must always monitor the blood glucose level and maintain it at a healthy level as agreed with health care providers. This method is called glycemic control. Common methods involved are HbA1c test, done by doctors at least twice a year on diabetes patients and also self-monitoring of blood glucose (SMBG), done by outpatients at home using specific devices to get immediate readings of blood glucose level after certain activities that might heighten up or reduce glucose in blood.

1.1.2 Self-management for type 2 diabetes

Maintaining blood glucose at an optimal level and controlling diet as well as performing regular exercises are part of self-management module for a person with type 2 diabetes. Self-management routine is very important for every diabetes patients as it helps to reduce or even prevent complications from occurring.

Self-management is an individual actively taking part in taking care of himself in terms of health outcome. The concept of self-management is very popular across the world with a large percentage of individuals with type 2 diabetes in Europe and United States of America already practicing self-management by performing various methods suggested by their respective health care providers.

The prediction of a huge increase in diabetes cases by 2030 according to WHO caused panic around the world as many countries started to give more attention to prevent it from affecting them at a large scale. Governments have started to provide more funds for health care areas and stress on providing self-management education for individuals already affected with the disease. Education for self-management is very important as the number of diabetics that are not able to take care of themselves due to lack of information and training is still large.

1.1.3 Mobile health (mHealth) application for type 2 diabetes

Mobile health (mHealth) is a term used for medicinal area supported by the use of mobile devices technology. mHealth has been an exploding field since the emergence of iPhone in the mobile phone market. Based on a report by PricewaterhouseCooper made for GSMA, it is predicted that revenue of USD 22.5 billion awaits app developers in 2017, and it is made possible by mHealth. This area covers up many types of illnesses and diseases from many aspects including educational information as well as management, and it does not exclude diabetes. Mobile applications for diabetes are among apps that can easily be found in the iPhone App Store and Google Android Play Store.

Mobile apps for diabetes come in many forms. Some of them merely act as alternative social networks to connect people with diabetes backgrounds so that they are able to share personal experiences and advices with fellow diabetics. Some apps offer educational information such as approximate amount of calories and carbohydrates in foods based. Many of these apps also offer blood glucose logbook function, which serves as a platform to assist self-monitoring of blood glucose (SMBG) practice which is recommended for self-management of diabetes for outpatients.

1.2 Problem statements

1.2.1 Lack of awareness towards proper self-management among diabetics in Malaysia

Diabetic patients' self-management is still major concern around the globe. Majority of them did not managed to plan their routines well due to lack of information and awareness towards the condition. Tasks that patients need to undergo in order to self-manage are daunting and sometimes difficult to maintain (Heisler et al, 2002), especially if there is no assistance in monitoring their activities.

According to Obesity Prevention Council President, Jong Koi Chong, an estimated number of 3.6 million adults in Malaysia are affected by diabetes, which has placed the country as a nation with the most diabetics in the region (The Star, 2013). He also mentioned the statistical comparison in which Malaysia had 8.6 percent adults affected by diabetes in 2006, which has rose into 15.2 percent in 2011, showing 6.6 percent increment within five years. However, most of these patients have little knowledge about the disease and some of them choose to remain unknowledgeable about it, even if they are already affected. Malaysians are also well-known with their laidback lifestyles, signifying lack of exercise and unhealthy eating patterns. For diabetics, continuing with this lifestyles will lead to serious complications and might eventually be lethal.

In glycemic control, one must perform both HbA1c test and SMBG to achieve optimal monitoring. However in Malaysia, percentage of diabetics that perform SMBG is very low, approximately within the range of 7-21% according to a study made in 1998. Many among those that performed SMBG take it for granted and did it without proper schedule or plan.

1.2.2 Lack of mobile diabetes application that is created specifically for diabetics in Malaysia on Android devices

Emergence of mobile technology in recent years introduces a groundbreaking platform in almost any area including medical field. In recent years, there are many applications introduced to enable diabetics to monitor their condition using a smartphone. However,

many of these applications were created oversea, and are their functions are not scaled properly for diabetics in Malaysia.

For example, most food directories of existing diabetes apps contain foods listing that Malaysians even never heard of. This deficiency makes meal planning a difficult task especially for those who are travelling around the country often.

As of now, most diabetes apps also still lacking educational function that can guide users for self-management. Most diabetics in Malaysia are scared of performing self-management technique such as SMBG due to lack of information and guidance, thus reducing the quality of their lifestyle as the results of no well-planned management of the illness.

In addition, a large number of diabetes applications are created for iPhone. This fact is quite bizarre as the entry barrier cost to develop apps for iPhone is very high, contradicting with of Google Android which only needs developer to pay a small amount of fee to enable publishing on the Google Play Store. Number of users for respective platform also differs in a large amount as recently Apple iPhone global market share was reported to fall to only 13.1% while Samsung alone, one of the biggest smartphone suppliers in the world, which is using Android operating system for all of its smartphone devices, held 30.4% of global market share.

1.3 Objectives

Listed are the objectives that this research is trying to achieve:

1.3.1 To develop a mobile application for Android platform that can assist individuals of type 2 diabetes backgrounds with their self-management

This study aims to develop a prototype of mobile application for type 2 diabetes specifically in Malaysia. Android operating system is chosen as the platform to develop the application as it provides a low entry barrier cost for startup developer and the learning curve to develop a first mobile application for Android OS is very short especially for programmers with Java programming language experience. Statistics also shows that globally, there are more Android device users compared to other platform, especially in Asia.

Prototype of the mobile app that will be created for this research will include essential functions that can assist outpatients of type 2 diabetes with self-management. One of the functions that will be provided is blood glucose tracker which is very important for every self-management diabetes application. The tracker will enable users to log in blood glucose level into the logbook and it will generate a graph to show progress of monitoring. It will also be enhanced with Google Cloud Messaging and Google App Engine backend to enable seamless data transmission between devices so that users are able to share the results with their respective health care providers. The application will also include a foods directory that contains local foods listing for users' reference. This will ease meal planning and calorie counting of daily food intake so that users are able to perform an optimal glycemic control for themselves.

1.3.2 To increase awareness among local individuals with type 2 diabetes of self-management practices

This research also aims to increase awareness of self-management practices for type 2 diabetes patients in Malaysia. Statistics showed that the increase in number of individuals affected by type 2 diabetes was very huge but glycemic control among patients was worsening while the number of unidentified diabetics remained large. Most

of local diabetics were only able to detect the condition once complication has developed.

As the concern for diabetics in Malaysia rises, government and health care bodies stress out that it is important for diabetics to start educating themselves of the essential information needed to manage the condition in order to delay or avoid complications which could cause severe aftereffect as well as morbidity. To support the act, this research also aims to increase awareness of Malaysians especially among identified diabetes of the importance of well-planned self-management and its practices to empower better health outcomes in the future and create a healthier nation.

1.4 Scope of study

1.4.1 Self-management practices for type 2 diabetes

To understand diabetics' self-management, a thorough research on diabetes management must be studied in order to produce an application that can accommodate the needs of diabetes outpatients. Information provisions and treatments recommendations from physicians' point of view must also be taken into account as this study aims to educate users of proper self-management practices hence guidance from medical practitioners is needed.

1.4.2 Development of Android application

This research will also need learning in terms developing Android application. Development flow for an Android application must first be studied in order to produce a working mobile application for type 2 diabetes. Algorithms needed to support blood glucose tracker also need to be identified before development can be made. As the application will include local foods directory for carb and calories referencing, the best way to let users access and display the directory must be identified before it can be implemented into the application.

CHAPTER 2

LITERATURE REVIEW

Diabetes is a global phenomenon present in almost any country in the world. However, due to lack of early stage signs, many diabetics are unaware of the illness that is developing in their body due to oversights. Difficulty in having a face-to-face time with physicians and doctors or an office visits to the clinics or hospitals is also believed to be one of the risk factors that can lead to greater consequences, resulting in lethal aftermaths. WHO (World Health Organization) prediction is by 2025, the number of people with diabetes worldwide will skyrocket to 300 million (Cockram, 2000), exerting a heavy pressure on the health care system along with other major chronic diseases.

2.1 Self-management in diabetes

According to American Diabetes Association (ADA), diabetes self-management is "the ongoing process of facilitating the knowledge, skill, and ability necessary for diabetes self-care. Self-management should incorporate the needs, goals, and life experiences of the person with diabetes and should be guided by evidence-based standards. The overall objectives of DSME (diabetes self-management education) are to support informed decision making, self-care behaviors, problem solving, and active collaboration with the health care team and improve clinical outcomes, health status, and quality of life."

2.1.1 Is self-management noteworthy?

Susan et al. in 2000 made a systematic review of the effectiveness of self-management training in type 2 diabetes by analyzing research papers published between 1980 and 1999, acquired from MEDLINE, Educational Resources Information Center (ERIC) and Nursing and Allied Health databases. They managed to gather 72 studies to be compiled into amusing collection of data regarding self-management among patients with type 2 diabetes backgrounds.

Most importantly, proofs collected showed positive impacts of self-management education especially in immediate term as participants became more willing to practice self-management approaches such as self-monitoring of blood glucose (SMBG).

Increase of positive attitudes towards self-management, by all means had also caused participants to improve their diet and physical activity levels to produce better health outcomes for themselves. Glycemic control had also shown improvements over the course along with behavioral outcomes. These evidences signify the importance of self-management among type 2 diabetes patients as the results had largely shown positive impacts especially with the interventions of health care providers or trainers to guide them with the right methods and techniques.

2.1.2 Importance of physicians understanding in patients self-management

Diabetes introduces a great challenge for patients in adapting with it in terms of behavior and self-management to acquire an optimal lifestyle in spite of living with the disease (Heisler et al, 2002). As expressed earlier, even though the complications might be horrifying, diabetes is still a manageable illness.

In a research that studied relative importance of physician communication in diabetes self-management, it is stated that ninety-five percent (95%) of diabetic patients carry out treatments either by themselves or with the help of family members. However, these patients are provided with different information and recommendations by their respective physicians. More interestingly, up to three-fourths of these patients did not follow those provided recommendations in their self-management routines.

Enhanced communication and shared decision making between patient-provider can help in achieving higher patient satisfaction, obedience to treatment plans and better health outcomes (Di Matteo, 1994). According to experts, patient-provider relations need a ‘paradigm shift’ in terms of collaboration, involving combined definition of problems, treatment goals and management plans (Anderson & Funnell, 2000). Previous studies show that almost fifty percent (50%) of patients left an office visit without knowing the next step in order to proceed with self-management, which is true among elders. Other age groups however portrayed higher desire to participate in decision making with their physicians.

2.2 Local type 2 diabetes scenarios

2.2.1 Malaysians point of view towards diabetes

Diabetes mellitus, or commonly known as diabetes, is a global problem, affecting millions of people around the world. The disease is manageable, yet a large percentage of diabetics are not able to manage it well, and this includes a major portion of Malaysians that are suffering from diabetes, with lack of diabetic control encompassed within the major health concerns discussed among health care professionals in the country. A study made by Ministry of Health in 2011 shows that one out of five people that belong to the above-thirty age category suffers from diabetes, resulting in up to 2.6 million of Malaysians with the disease (New Straits Times, 2012). An estimate of half of the number given went unrecognized and undiagnosed. If this pattern continues, it will eventually develop increase in complications and treatment cost once the number of people suffering from diabetes rose to a high volume (Salmiah & Kamaruzaman, 2009).

One of the major causes for blunders in managing diabetes among Malaysians is the lack of knowledge and awareness towards the disease. According to a study made in 2009, it has been found out that many patients, specifically in Malaysia, took this issue for granted and did not bother to consult with their physicians or doctors about the diseases or intricacies that might develop from it accordingly (Salmiah & Kamaruzaman, 2009). Many health care professionals believe that patients with diabetes need to be well-informed about the disease that they have to live a healthy life and maintain balanced lifestyles.

Many patients retrieved information about diabetes on their own, mostly either using the internet or through family members. Yet, majority of these patients insisted that that it would be more helpful if their physicians or doctors can communicate more details (Salmiah & Kamaruzaman, 2009), which can be done during office visits. However, the same study also shows that some health care professionals deemed their patients to be in dissent when it comes to face-to-face discussion as most of them displayed know-it-all attitude which is contributing in building the barrier in producing better health care management.

2.2.2 Prevalence of SMBG among type 2 diabetes patients in Malaysia

Glycemic control is often done by performing both self-monitoring of blood glucose (SMBG) and glycated hemoglobin (HbA1c) test. HbA1c test is usually performed by health care providers on their diabetes patients at least twice per year to determine average blood glucose level in previous months. Targeted blood glucose level in the results are normally set in an agreement between patients and health care providers accordingly, based on many factors including patients' activities and diet. Different from HbA1c, SMBG is performed to acquire real-time reading of blood glucose level. SMBG is done according to patients' needs for it, and how critical the results will be for them. The significant advantage of SMBG is imperative results will enable diabetics to instantly adjust their self-management plan or consult with doctors immediately if concerns arise.

SMBG according to Martin et al. and Karter et al. quoted by Mastura et al. in their research article was performed by 75.0% and 52.6% in Germany and Northern California respectively. Compared to a study made in 1998 for Diabcare-Malaysia by Mustafa B. et al. however, only 7-21% of diabetics in Malaysia practiced SMBG.

Hence, in 2007, Mastura et al. conducted a study to determine the popularity of SMBG among patients that attended government health clinics and factors that could influence the practice of it. 569 participants with type 2 diabetes background took part in the study and it received 99.5% response rate, consisting of 566 participants. Out of this number, only 85 participants or 15.3% of them practiced SMBG. In addition, these SMBG practitioners had different scenarios and attitudes with the method. Among them, only 14 (16.4%) participants monitor their blood glucose level at least once per day. Interestingly, 52 (61.2%) participants recorded SMBG results but only 28 (32.9%) of them shared those results with health care providers.

They also managed to find out several factors that influence the practices of SMBG among the participants. According to Mastura et al., people with better education, higher income, had longer period of time experiencing diabetes and include insulin injection as part of their treatment were more likely to perform SMBG. Low rate of SMBG among

local type 2 diabetics were contributed by factors such as lack of confidence in managing the condition by themselves due to poor education. Most of participants were not aware of the details for SMBG and ultimately ignored the method as potential technique that could further improve their health.

2.3 Mobile application for diabetes self-management

2.3.1 Features of mobile diabetes applications versus evidence-based guidelines

Lyles and co-workers made a research in 2011 to compare major features available in diabetes applications that existed in the market to evidence-based guidelines provided by clinical researches. Search was made in online vendor markets comprising of online stores for Apple iPhone, Google Android, BlackBerry and Nokia Symbian.

Listed down in the research paper is the clinical guideline recommending the following features to be included in diabetes application for patients' self-management:

1. Education and personalized feedback
2. Diet management
3. Weight management
4. Physical activity
5. Communication and patient monitoring by primary care providers
6. Insulin and medication management
7. Other therapeutics (foot, eye care)
8. Psychosocial care
9. Immunization
10. Complication management

Based on the results gathered, even though a wide range of choices available for diabetes applications, most of them only partially adhered to the guideline, and education remained a function that was not given the priority. In addition, no diabetes application has an integrated social media function as the area remained unexplored. Legislative and organizational barriers were also determined as the obstacle related in disseminating

patient data, hence stopping potential innovators such as Google Health from prevailing in the market.

2.3.2 Few Touch application

In 2010, Årsand and his colleagues made a study on the feasibility of mobile application in changing lifestyle among people with type 2 diabetes for a 6-month period. They developed an application entitled as Few Touch which includes function such as off-the-shelf blood glucose meter, step counter and food habits recording. Figure 1 below shows some of the interfaces included in the application.

Figure 1: Few Touch interfaces

This application was developed based on three key functions; 1) healthy diet; 2) blood glucose management, and; 3) physical activity. Based on further research, they found out that the system managed to acquire high score in terms of usability assessment which was done through SUS questionnaire (84 out of 100). However, this application only presented a concept that supports self-management as they claimed that producing an application that helps patients to interact with health care professionals would be resource-intensive. This application is based on Windows Mobile operating system and designed using HTC Touch Dual, a device produced by HTC Corporation, Taiwan.

2.3.3 Ideas and enhancement for mobile applications that support diabetes

A research was made on behavioral patterns of youths with type 1 diabetes towards their usage of web and mobile technology and its impact on health-related quality of life (HRQOL). Conducted by Pulman et al., this study had also resulted in the development of a prototype that suited the needs of diabetics in youth category along with suggestions of improvements for diabetes mobile application that will be made in the future.

Even though the study was made for type 1 diabetes, it is taken into consideration for reference of this paper as the patterns of mobile application created for diabetes patients are of the same baseline.

From the mentioned research, Pulman et al. managed to compile some recommendations to enhance a mobile application for diabetics in their results. Among them is the inclusion of blood sugar recorder functionalities to be used for self-monitoring of blood glucose (SMBG) that is integrated with cloud system that could store data entered and accessible anywhere. The tendency of people to stick with their mobile phones all the time makes this function very attractive yet not many existing diabetes application includes it.

Another interesting idea is making the food directories locally centralized and accessible in the phone without having to get connected to the internet. To be frank, in Malaysia, developers are currently still lacking the initiatives to compile foods information into one single directory for diabetics' references. This situation also occurs probably due to lack of usage rate for this kind of application among Malaysians.

Health appointment tracker is also mentioned in the enhancement ideas to be included in future application. It will enable users to keep track of appointment dates and times in mobile phone, reducing the probability of forgetting about it due to inability to record it immediately. In additional, participants also suggested including medication tracker function that will help them to memorize what has been done and what has not. Medication tracker will greatly reduce the chance of patients taking medications twice at the same time, as well as enhanced with alarm that will remind users to take them on time if they still have not done it.

CHAPTER 3

METHODOLOGY

3.1 Requirement analysis and specification

3.1.1 Targeted users

This research aims to develop a mobile application that can assist type 2 diabetes outpatients with their self-management. Targeted users are local individuals with type 2 diabetes background that currently own a smartphone with Android operating system of version 4.0 and above.

3.1.2 Application development environment

The application will be based on Android operating system, in which the development is based on JDK (Java Development Kit) and ADT (Android Development Tools). Two open source IDE (Integrated Development Environment) are available for the development; 1) Android Studio which is built on IntelliJ IDEA platform, and; 2) ADT that is based on Eclipse IDE platform. Both of these tools are optimized directly by Android system developers from Google Inc. In additional, to build a cloud-integrated application to be used for blood glucose tracker function, Google App Engine backend and Google Cloud Messaging platform have been identified as tools needed to provide seamless data transfer between devices for Android application.

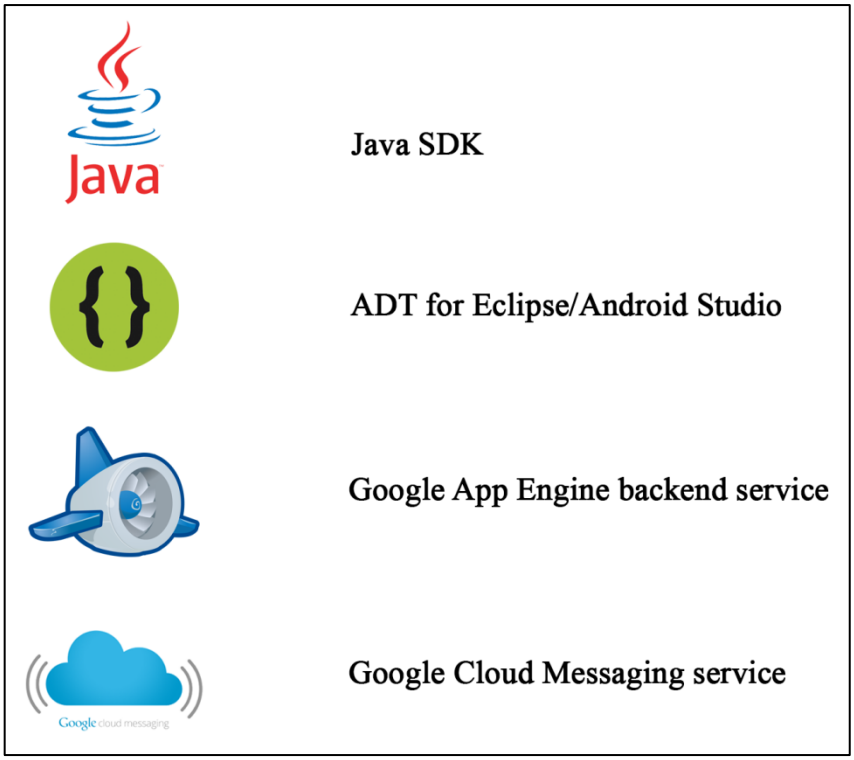


Figure 2: Tools that will be used for app development

3.2 System architecture

The prototype will first be included with the following four functions. Any additional functions will be taken into consideration in later stage of research.

Key functions:

1. Blood glucose tracker
2. Foods directory
3. Self-management education and guidelines
4. Appointment tracker

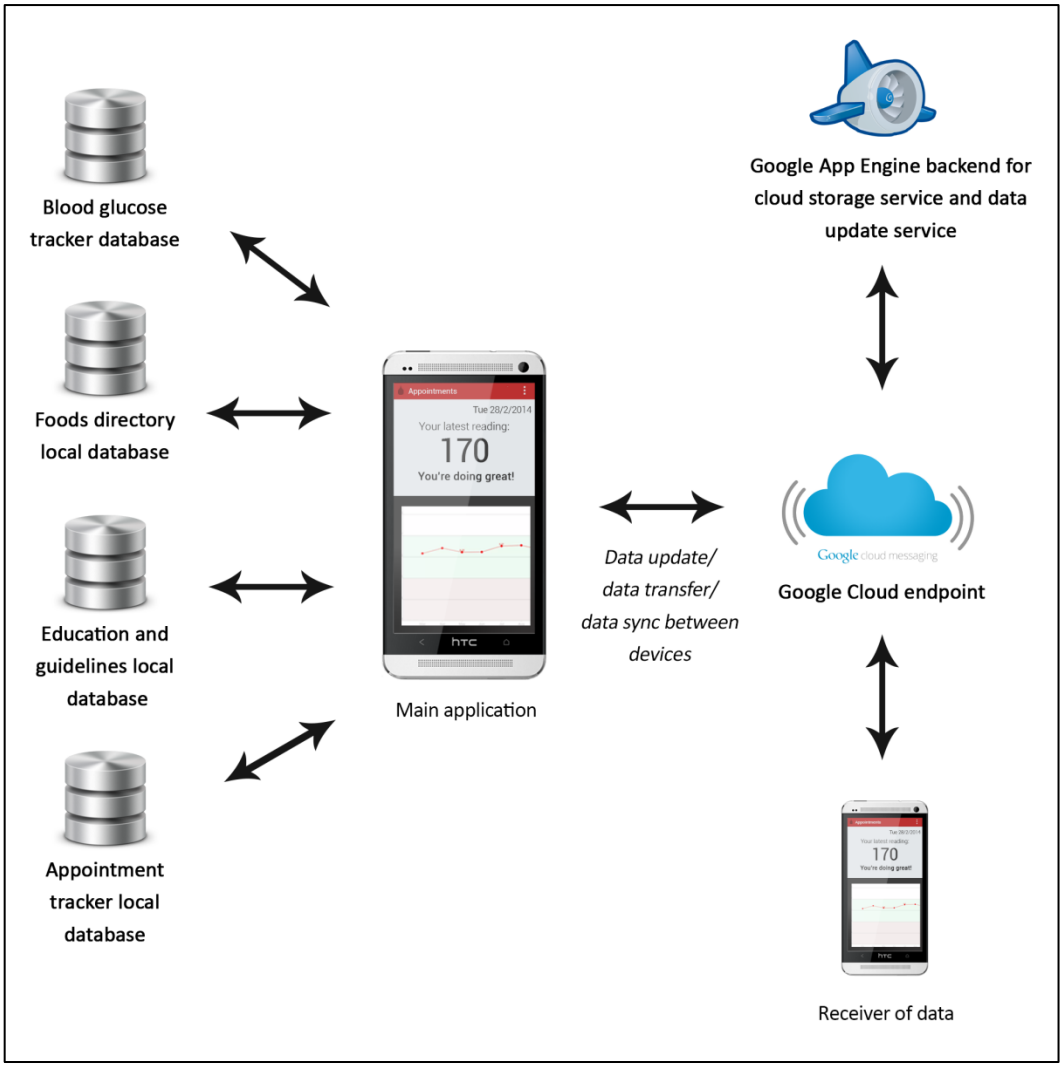


Figure 3: System architecture of the prototype

3.3 Key milestones

Key milestones in this study are listed in Table 1. Timeline or Gantt chart for these milestones can be referred in Appendix 1. Take note that each activity prior to each milestone must be achieved before the study can proceed with the proceeding milestones.

Key milestones	Target week
Submission of Progress Report	7
Pre-SEDEX	10
Submission of Draft Report	11
Submission of Dissertation (Soft bound)	12
Submission of Technical Paper	12
Oral presentation	13
Submission of Project Dissertation	14

Table 1: Key milestones

3.4 Methodology

For this research, a methodology entitled as Lean Startup, developed by Eric Ries in 2011 for businesses and products development is employed.

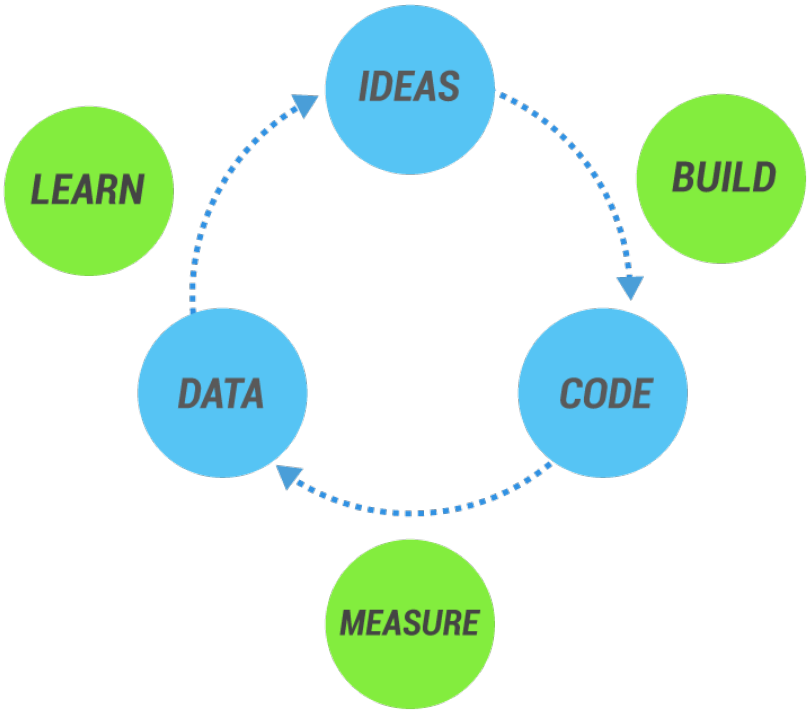


Figure 4: Lean Startup Methodology

This methodology aims to minimize time within each cycle by pacing up development and releasing them into production right away for user testing. The product from this cycle, which is produced as a minimum-viable-product, contains minimal and sufficient functionalities accordingly, based on the specification set for the end product. End users can immediately test the product and suggest improvements for it. Eventually the end product will become an article that is required by the targeted market. Each cycle will start with the ideas phase, followed up by code and data phases, with build, learn and measure phases in between each two of those main phases. The concept is built around the main question, “Should we do it?” instead of “How should we do it?” Using this methodology, more progress can be made and learning process can be validated by measuring data collected followed by corrective actions to improve the initial idea.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Preliminary prototype

In user interface designing and prototyping stage, the application was constructed based on the key functions listed in the previous chapter:

- Blood glucose tracker
- Foods directory
- Self-management education and guidelines
- Appointment tracker

Each of these functions was analyzed based on common daily life scenarios experienced by type 2 diabetes outpatients. These cases were analyzed on how each specific function laid out for this application will help its users in curbing with problem faced in real life situations. These scenarios are explained in the form of diagrams in the next section.

4.1.1 Usage case study for each function

Blood glucose tracker

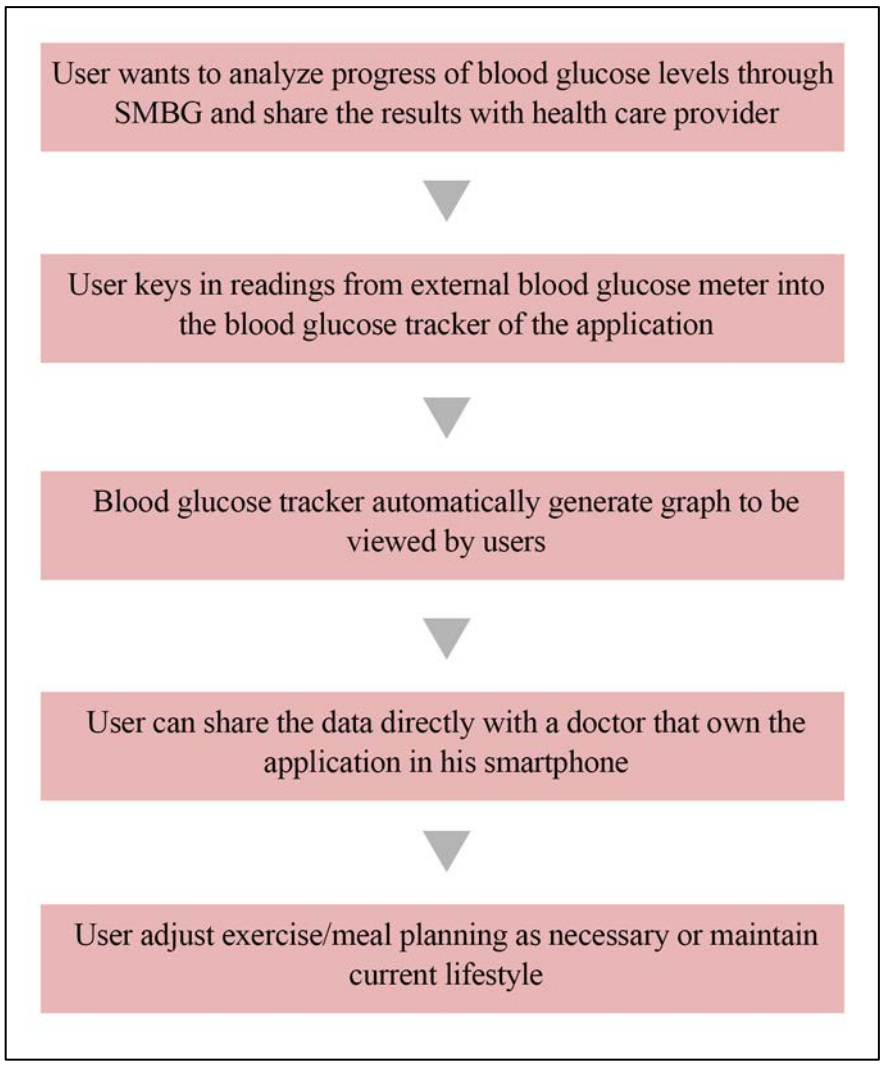


Figure 4: Usage case study for blood glucose tracker function

Foods directory

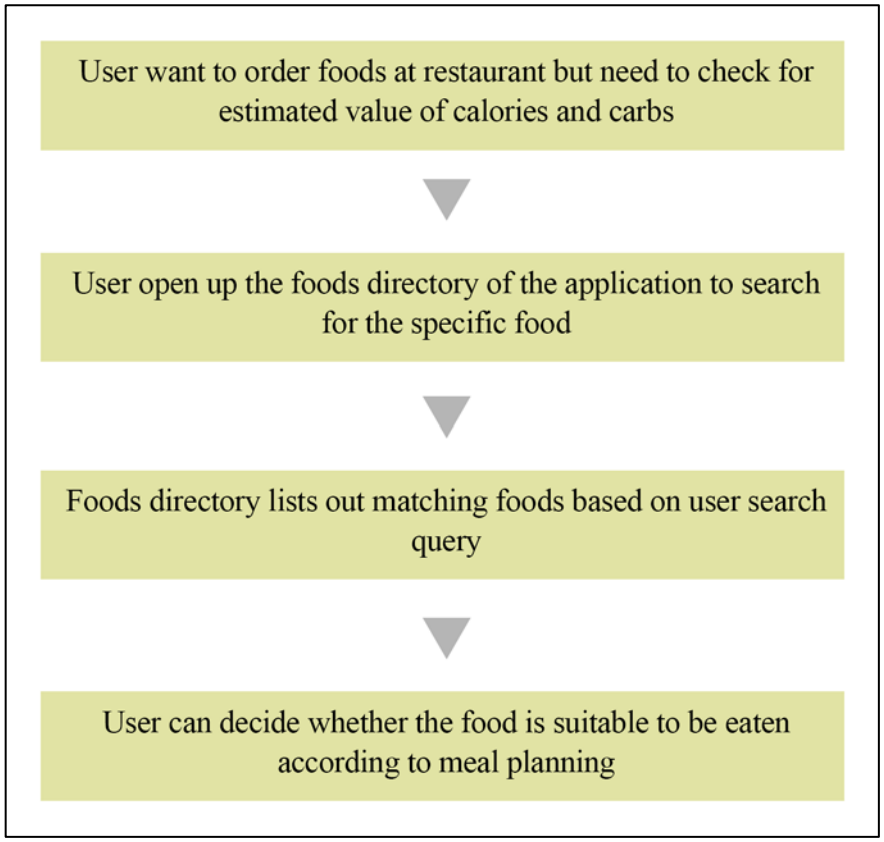


Figure 5: Usage case study for foods directory function

Self-management education and guidelines

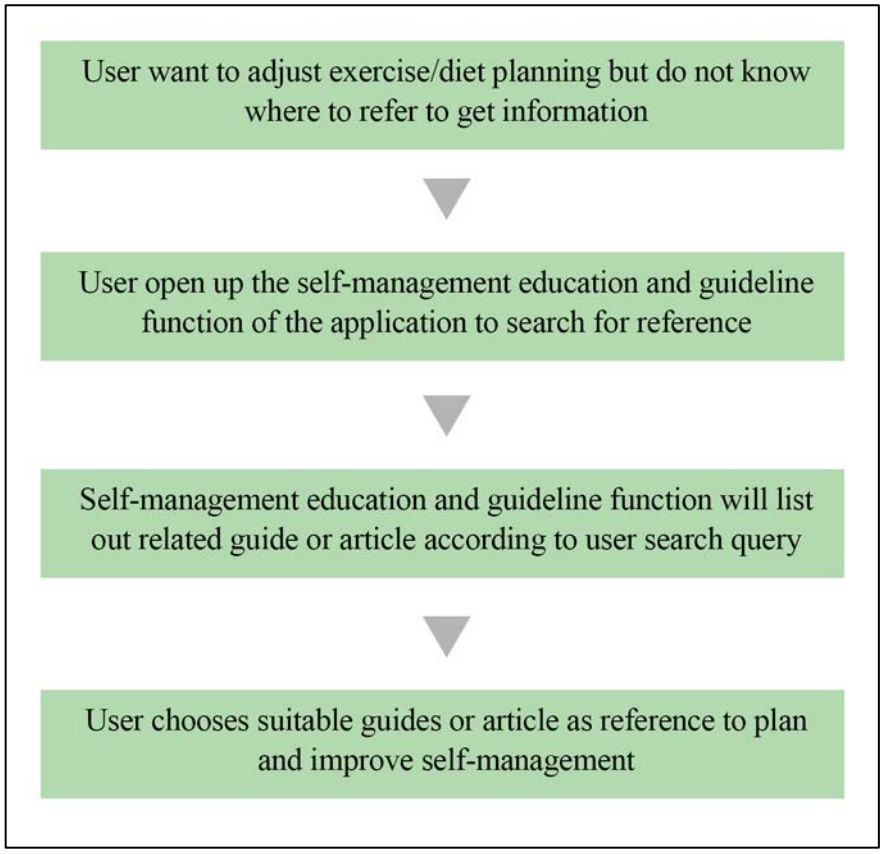


Figure 6: Usage case study for self-management education and guideline function

Appointment tracker

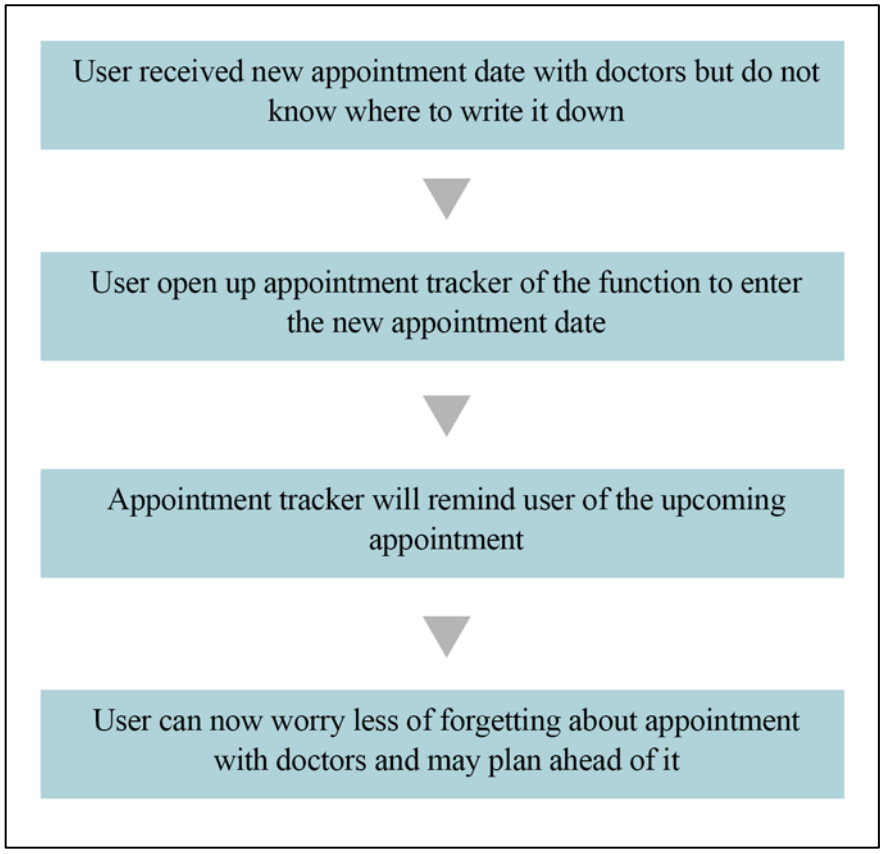


Figure 7: Usage case study for appointment tracker function

4.1.2 User interface design

To get a better overview of the application that will be developed, a mockup of user interface (UI) for the application has designed. Included in this section are UI designs for every usage case analysis as described in the previous section.

Blood glucose tracker

Figure 8: UI design for blood glucose tracker function

Foods directory

Figure 9: UI design for foods directory function

Self-management education and guideline

Figure 10: UI design for self-management education and guideline function

Appointment tracker

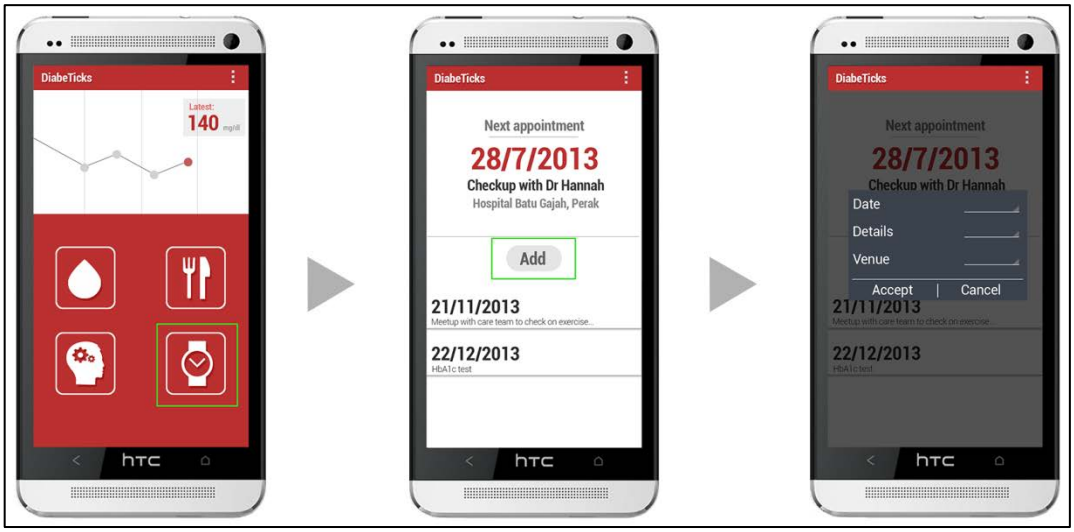


Figure 11: UI design for appointment tracker function

4.2 Pilot study

A pilot study was made to identify current percentage of diabetes management application users among type 2 diabetics and their perception towards usefulness of diabetes management application whether they have experience in using it or not. It was also made to identify the rate of awareness towards self-management practices of type 2 diabetes. A questionnaire was prepared and distributed using social network among local diabetes community. 20 volunteers with type 2 diabetes background offered to participate in answering the questionnaire. Results of each question are analyzed one by one in this section.

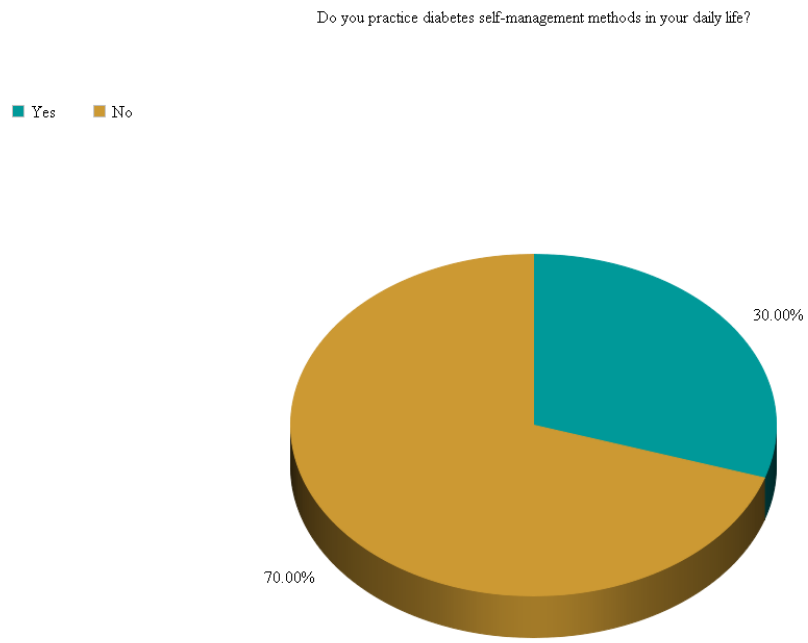


Figure 12: Question 1 for pilot study

Question: Do you practice diabetes self-management methods in your daily life?

This question is included to assess the percentage of diabetics that perform self-management as their routines with results of previous studies made as the baseline. Past researches show that only 7-21% of diabetics in Malaysia perform self-management in their daily life. In this pilot study, statistic shows that only 6 (30%) out of 20 participants

perform diabetes self-management at home. As the number of the sample is small, it is safe to say that it is comparable to the baseline results produced by past researches and it remains around a similar range for the past years despite the nation showing a huge increase in number of diabetics across the country. According to past studies, local diabetics hesitated to perform self-management due to lack of information and guidance. Hence the following question;

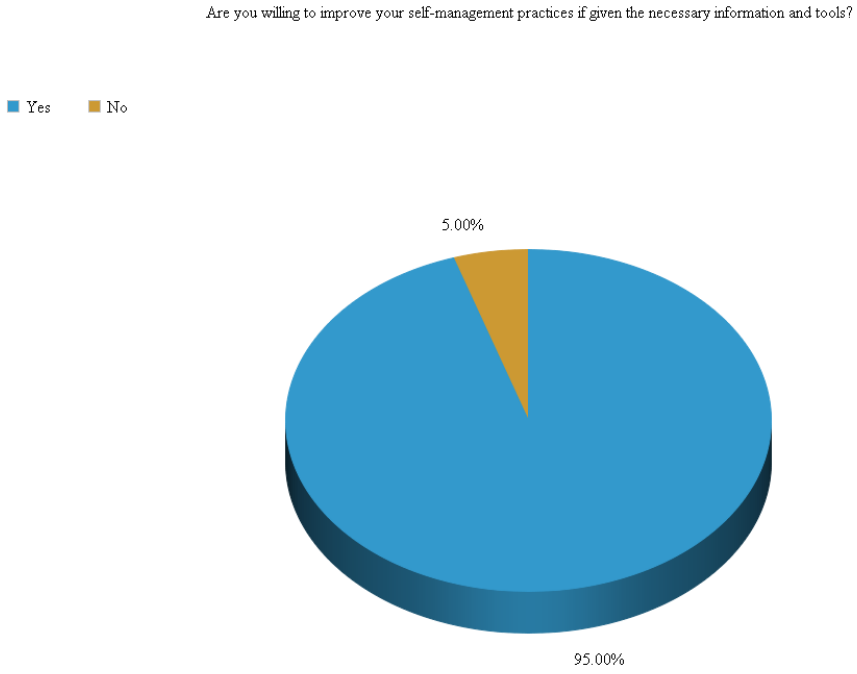


Figure 13: Question 2 for pilot study

Question: Are you willing to improve your self-management practices if given the necessary information and tools?

As mentioned earlier, many type 2 diabetes patients are not confident of performing self-management practices such as SMBG due to lack of training and education. As the percentage of participants that perform self-management as their routines are low, it can be safely assumed that most of them are facing the same situations. A positive response was received when participants were asked whether they will improve their self-management if they are given the right education and tools as 19 (95%) out of 20

answered yes, portraying the positive attitude towards searching for better health outcomes if given the chance to do so.

The next three questions are related to each other; participants will have to answer all questions if they answer 'yes' the first question, while others can safely ignore the following two questions if the answer is 'no'.

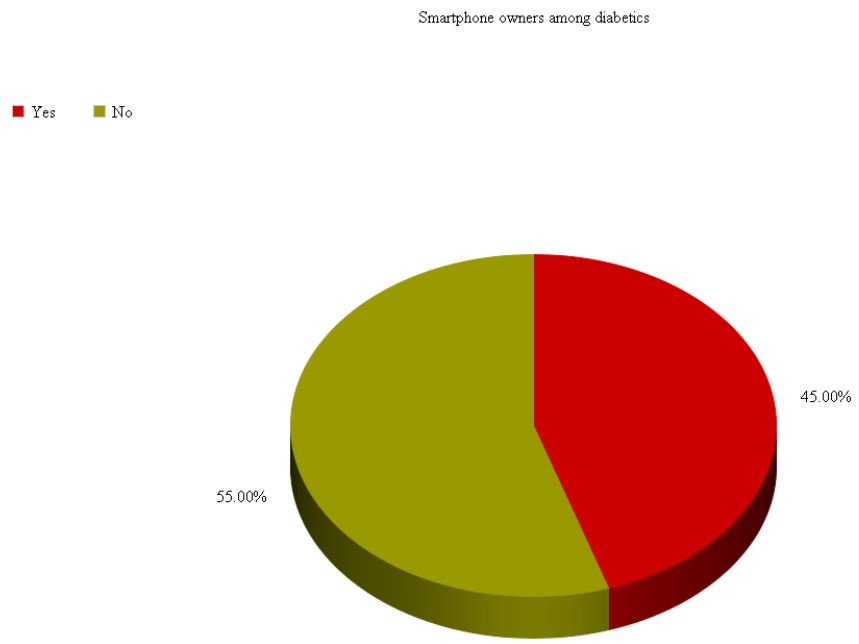


Figure 14: Question 3 for pilot study

Question: Do you own a smartphone?

This question was asked to assess the percentage of smartphone owners among diabetics to identify the relevancy of doing this research specifically for local users in Malaysia. As of now, smartphone suppliers managed to penetrate 27% of the whole Malaysia market in this particular field, and this value will be used as the baseline.

In this study, it has been found out that 9 (45%) out of 20 own a smartphone. The percentage is far higher than the baseline value described earlier. This shows that the application will have a large potential number of customer bases. The baseline number is also projected to increase two-fold in the next few years, providing a greater possibility

of getting more audience for the application. However due to the small number of sampling in this pilot study, a further assessment with more participants must be made to achieve higher accuracy.

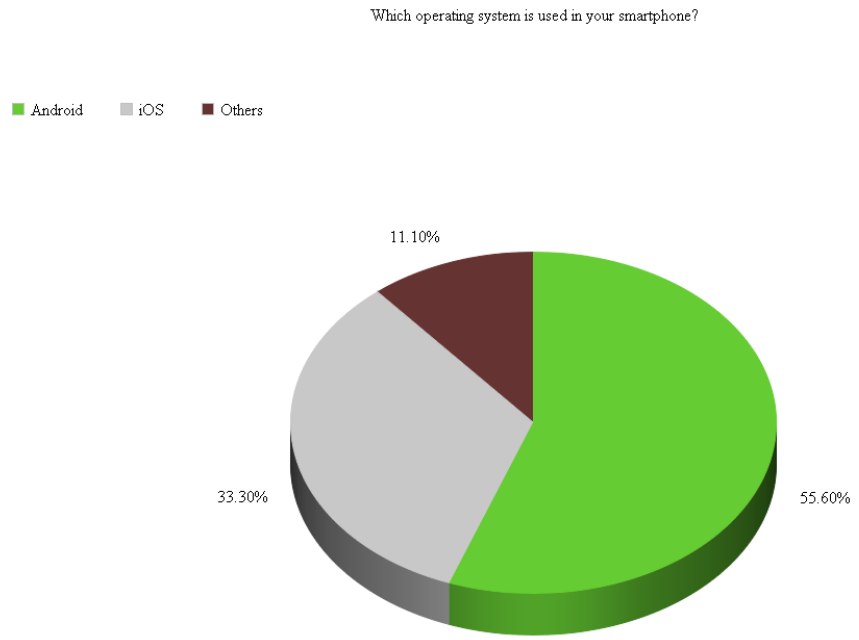


Figure 15: Question 4 for pilot study

Question: Which operating system is used in your smartphone?

This follow up question is trying to assess on the number of Android OS users among those that own smartphones. According to answers given, majority (55.6%) of participants that own smartphones own a device with Android OS running on it while the remaining use iOS or other operating systems not mentioned in the question as it was deemed as unnecessary. This statistic further strengthens the resolve of creating the self-management application on Android OS platform as it has the largest user base among diabetics with smartphones.

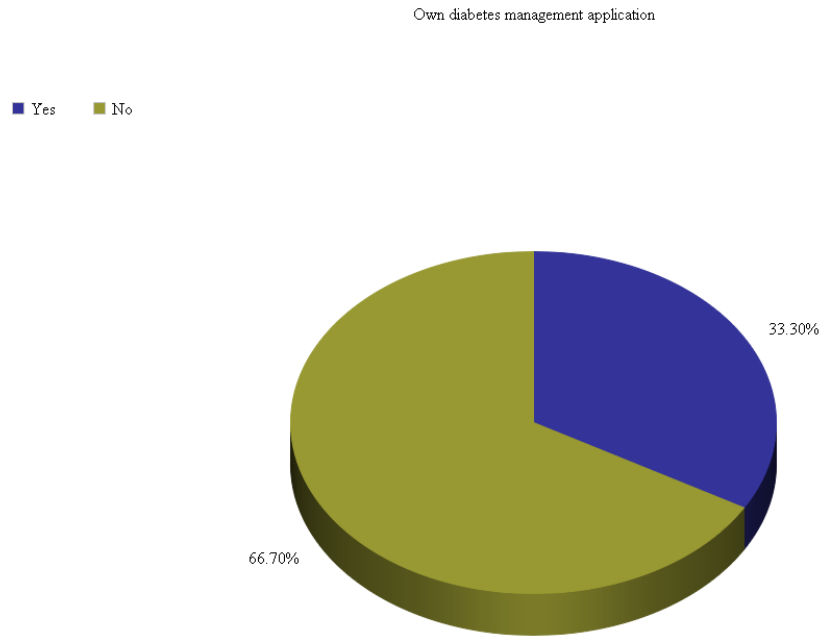


Figure 16: Question 5 for pilot study

Question: Have you ever own a diabetes management application?

Another follow up question for participants with smartphone is used to assess the percentage of diabetics that take initiative to download a diabetes management app into their phone regardless of OS used. 3 (33.3%) participants admitted that they had previously downloaded a diabetes management application. The number is half of those that perform self-management in their daily life as mentioned in the previous question. It can be assumed that the remaining of whom that has never own a diabetes management application either do not own a smartphone or unaware of the existence of such application in the market.

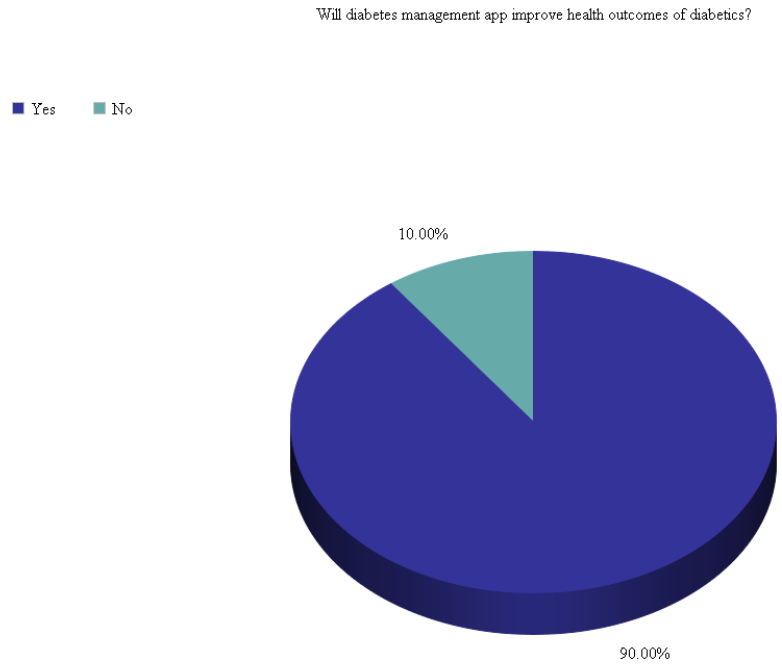


Figure 17: Question 6 for pilot study

Question: Will diabetes management app improve health outcomes of diabetics?

The last question is used to assess the perception of participants towards usefulness of a diabetes management application regardless of their experience with any of the existing application. Most participants (90%) agreed that a diabetes management application will help them to lead a better life as a diabetics, thus showing that majority of them are actually anticipating a tool that could help them in performing better in real life situations according to a diabetic's perspective. Therefore it can be concluded that the application that will be developed is going to receive a positive welcome from the local diabetics' community if they receive information about it through the right channel.

4.3 Application development

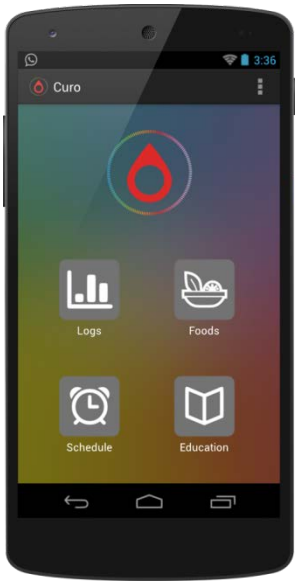


Figure 18: Homescreen for Curo

The real product is developed based on the specification made in the design phase. The end product for this research is entitled as Curo. As seen in the home screen shown in Figure 18, the application contains four main functions; 1) Logs, 2) Foods, 3) Schedule, and 4) Education. The logo for Curo is made exclusively for the application, resembling a colorful life even for diabetics.

The first main function, Logs, is used to record and display readings of blood glucose level entered by user, which can be acquire using external blood glucose level measurement device. This function is the most important of all functions included as it serves the purpose of including self-blood glucose monitoring activity in a diabetes function, as recommended by the guideline. Displays for the function are shown in Figure 19. As portrayed in the figure, the main screen for Logs displays two major readings; current or latest reading along with the previous reading entered by user using a bar graph. On top of the screen, the current reading will be displayed along with note input included with when the reading was entered into the logs, along with an indicator that signify whether it is high (Hi), regular (Re), or low (Lo) which is based on the standard of blood glucose level laid down professional health bodies.

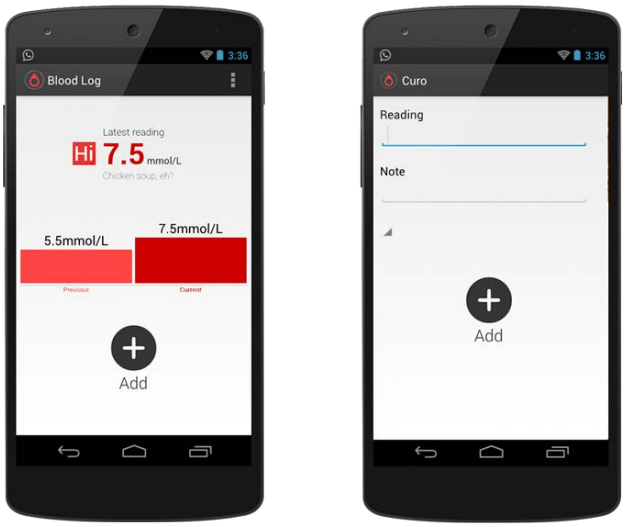


Figure 19: Logs function

Next function is Foods, which lists down a library of foods with along nutritional facts which can be used by diabetics as reference to plan their daily meal. Displays for Foods function are as shown in Figure 20. For this minimum-viable-product version, the function enables users to click on a food from the list to see its details and add it to their favorite list.

Another function included in Curo is Schedule, which allows users to keep their diabetes-related appointments with doctors in check and not cluttered with other scheduling by using built-in calendar or other scheduling application. Like other alarm manager function, Schedule will alert users when the scheduled appointment is approaching. Displays for Schedule function are as shown in Figure 21.

The last function included in Curo is Education, which simply provides extra readings for diabetics so that they can learn more tips and tricks in managing their condition. Articles in Education will be curated by diabetes professionals so that diabetics could acquire real extra knowledge about diabetes, hence serving the purpose of reducing the number of diabetics that are lacking the knowledge about their condition in Malaysia.

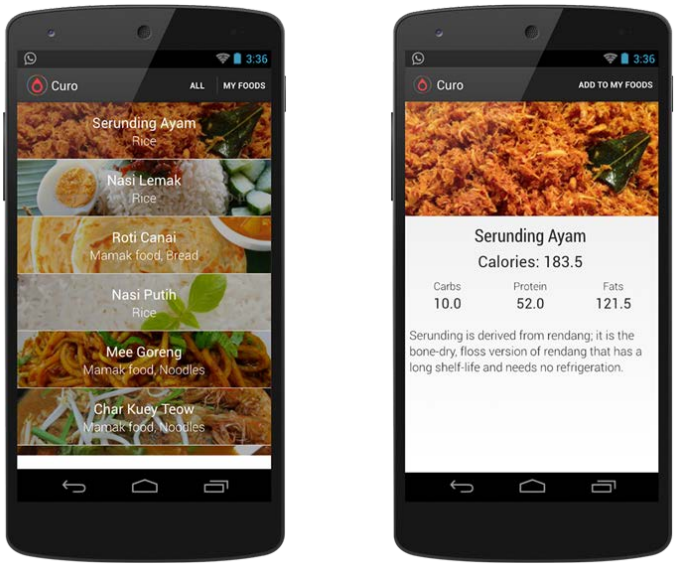


Figure 20: Foods function

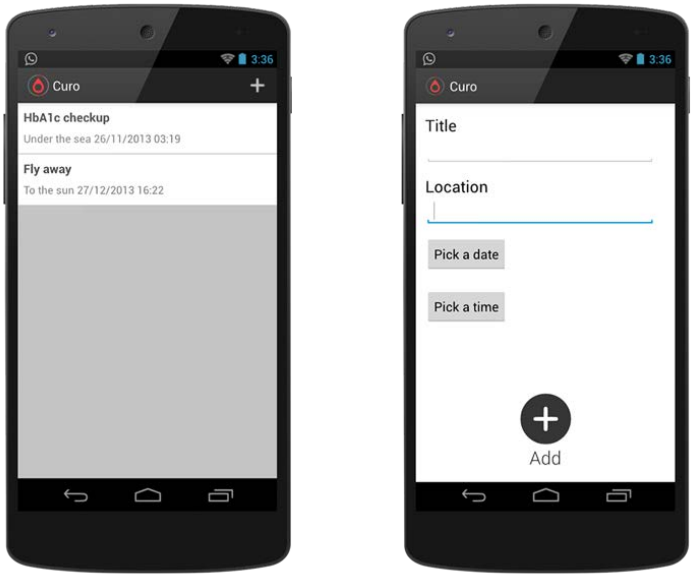


Figure 21: Schedule function

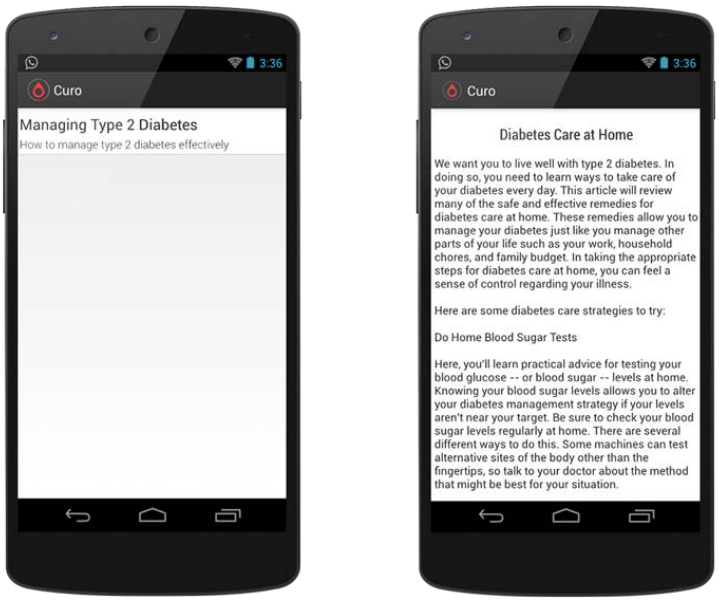


Figure 22: Education function

4.4 Recommendation

This application does not represent a finished article and hence need to through the development cycle again in the future to improve its functionalities. Logs function, for instance, can be enhanced further by providing a synchronizing utility to enable health care professionals to access their specific patients' data in order to review the blood glucose levels from time to time.

The Education function must also be enhanced further to produce a significant meaning out of it for users. For example, article can be classified into 'Public' or 'Professionals' to indicate who the publisher is. Future app developer can also utilize the improving technology of mobile phone to create a better responsive application for diabetics to make it easier to use such as manipulating the motion chip processor.

CHAPTER 5

CONCLUSION

Diabetes is a worldwide epidemic that occurs due to cultural and social changes in accordance to vast development. Change of lifestyles has led to this horrifying situation and it is estimated that the number will keep growing as years goes by. Diabetics need as much information as they can acquire to prevent and manage this issue to reduce death cases that are growing due to unmonitored complications. In Malaysia, due to the nature of being conservative that still exist especially among elders, many diabetics went undiagnosed and uninformed about the disease. Many of them bowed to the consequences of diabetes as they assumed it is a normal issue for anyone that is aging. Thus, it is important for this study to actually produce a diabetes self-management application that will help the growing number of diabetics in achieving a better life. The prototype that will be developed will focus on assisting diabetics in terms of self-management practices such as self-monitoring of blood glucose (SMBG), meal planning as well as providing them with a platform that could help in terms of supplying information and guidance.

Do note that this application is preliminary and based on a concept model, hence might not be able to include all possible functions available in most diabetes applications existing in current market. This study will focus on integrating several key functions such as blood glucose tracker, health appointment tracker, foods directory and self-management education. The application is also planned to be developed mainly using English language to explore the potential of worldwide usage among diabetes patients. Further research based on this study will have to include all missing functions in order to produce a complete diabetes application in the future.

REFERENCES

(2007). *Diabetes self-management: Guidelines for providing services to people newly diagnosed with Type 2 diabetes.* Melbourne: Victorian Government Department.

American Diabetes Association. (2004). Standards of Medical Care in Diabetes. *Diabetes Care*, S15-S35.

Årsand, E., Tatara, N., Østengen, G., & Hartvigsen, G. (2010). Mobile Phone-Based Self-Management Tools for Type 2 Diabetes: The Few Touch Application. *Journal of Diabetes Science and Technology*, 328-336.

Castillo, M. (2012, November 14). *371 million people have diabetes globally, about half undiagnosed*. Retrieved June 21, 2013, from CBS News: http://www.cbsnews.com/8301-204_162-57549731/371-million-people-have-diabetes-globally-about-half-undiagnosed/

Funnell, M. M., Brown, T. L., Childs, B. P., Haas, L. B., Hosey, G. M., Jensen, B., et al. (2008). National Standards for Diabetes Self-Management Education. *Diabetes Care*, S97-S104.

Ginsberg, B. H. (2007). Blood Glucose Monitoring: Necessary and Sufficient? *Journal of Diabetes Science and Technology*, 612-613.

Huri, H. Z., Wen, O. C., & Pendek, R. (2008). Self-monitoring of blood glucose among type-2 diabetes patients in Malaysia. *Asian Biomedicine*, 335-340.

Lyles, C., Hartvigsen, G., Chomutare, T., & Fernandez-Luque, L. (2011). Features of Mobile Diabetes Applications: Review of the Literature and Analysis of Current Applications Compared Against Evidence-Based Guidelines. *Journal of Medical Internet Research*, e65.

Mastura, I., Mimi, O., Piterman, L., Teng, C., & Wijesinha, S. (2007). Self-Monitoring of Blood Glucose Among Diabetes Patients Attending Government Health Clinics. *Med J Malaysia*, 147-151.

Mendoza, M., & Rosenberg, T. (2013). Self-management of type 2 diabetes: A good idea-or not? *The Journal of Family Practice*, 244-248.

Michele Heisler, MD, MPA, Reynard R. Bouknight, MD, PhD, Rodney A. Hayward, MD, Dylan M. Smith, PhD, Eve A. Kerr, MD, MPH. (2002). The Relative Importance of Physician Communication, Participatory Decision Making, and Patient Understanding in Diabetes Self-Management. *Journal of General Internal Medicine*, 243-252.

New Straits Times. (2012, November 12). *'We've highest diabetes rate in the region'*. Retrieved June 20, 2013, from New Straits Times: http://www.nst.com.my/2013budget/we-ve-highest-diabetes-rate-in-the-region-1.170268

Norris, S. L., Engelgau, M. M., & Narayan, K. V. (2001). Effectiveness of Self-Management Training in Type 2 Diabetes. *Diabetes Care*, 561-587.

Pulman, A. J., Taylor, J., Galvin, K., & Masding, M. G. (2012). *Designing Mobile Applications to support type 1 diabetes education.*

Pulman, A., Taylor, J., Galvin, K., & Masding, M. (2013). *Ideas and Enhancements Related to Mobile Applications to Support Type 1 Diabetes.* Retrieved July 20, 2013, from JMIR Mhealth Uhealth: http://mhealth.jmir.org/2013/2/e12/

Ratini, M. (2012, May 7). *Type 1 Diabetes*. Retrieved June 20, 2013, from WebMD: http://diabetes.webmd.com/guide/type-1-diabetes

Ratini, M. (2012, May 16). *Type 2 Diabetes*. Retrieved June 20, 2013, from WebMD: http://diabetes.webmd.com/guide/type-2-diabetes

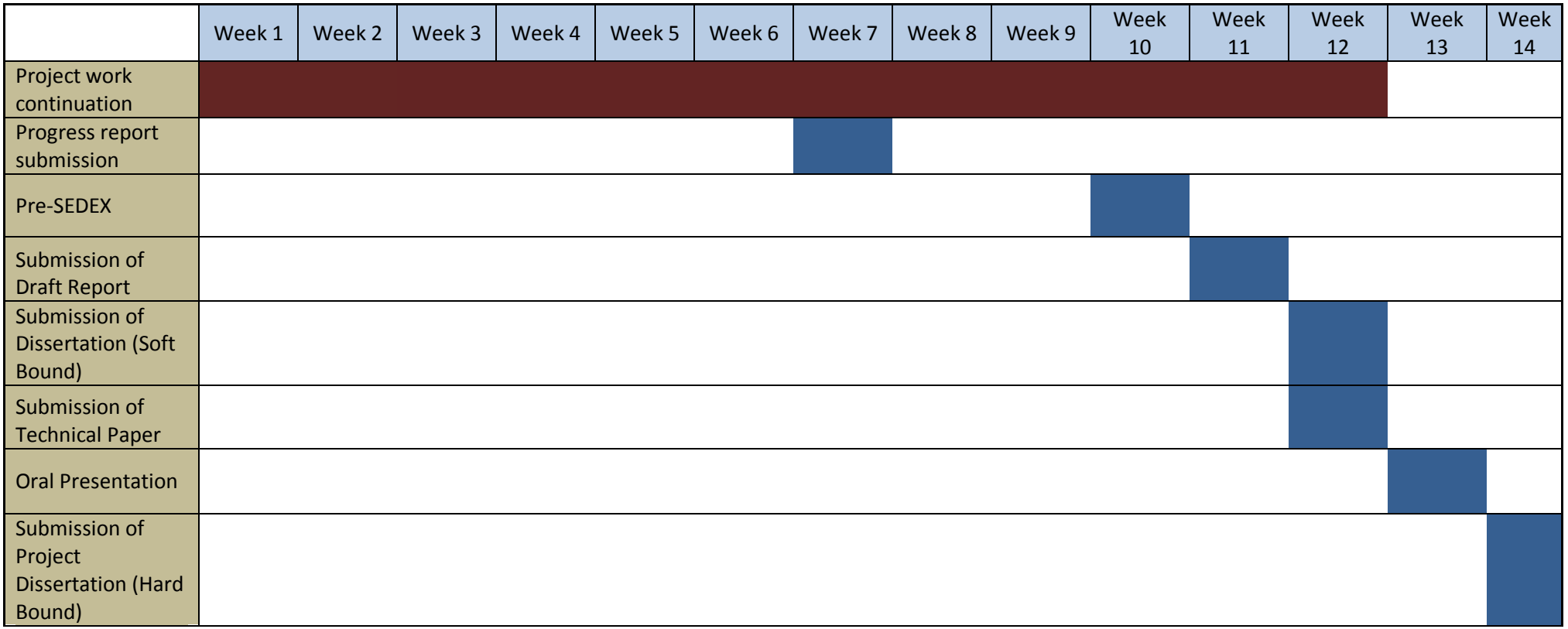
Salmiah, M. A., & Kamaruzaman, J. (2009). Barriers to Optimal Control of Type 2 Diabetes in Malaysian Malay Patients. *Global Journal of Health Science*.

The Star. (2013, June 14). *Number of diabetics in Malaysia alarming*. Retrieved June 20, 2013, from The Star Online:

http://thestar.com.my/news/story.asp?file=/2013/6/14/nation/20130614132745&sec=nation

World Health Organization. (2013, March). *Diabetes Fact Sheets*. Retrieved June 21, 2013, from World Health Organization: http://www.who.int/mediacentre/factsheets/fs312/en/index.html

APPENDICES



Appendix 1: Gantt chart for the research