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A Literature Review of Diabetes Application Comparative Analysis

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Abstract

Background: Some diabetic patients do not take enough care of their health and often do not control their blood sugar properly. One of many reasons could be the cause of this such as inadequate knowledge about the condition they have which could mean that they do not know the consequences that the disease could cause to their health. Another could be that they simply forgot about it temporarily since living with diabetes requires a drastic change in lifestyle and habits. Many aids have been developed to help diabetic patients adjust and live with their conditions. An example of this, which will be the focus of this paper is applications made for diabetic patients. The application often include features that help patients with their everyday life such as reminding the patient to take their medicine, let the patient log their blood sugar in the app which could then be displayed in a trend which could help the patient see if their lifestyle is suitable with their condition or not.

Objective: Investigate the effectiveness of said applications, see the strengths and weaknesses of those applications and suggest improvements that could be implemented.

Study Methods: A search was performed on google scholars and google chrome for papers pertaining to information about diabetes mellitus, the cause, and health consequences of said medical condition, papers reviewing the effectiveness of applications for diabetic patients. 4 applications for diabetic patients were selected based on which apps had the highest rating with the search term “diabetes app” and were tested for ease of use and features were tested to determine whether the application would be effective or not.

Result: The reason as to why some patients don’t take care of themselves properly stems from the lack of knowledge as in that they may not know the severity of their condition or they lack the motivation to change their lifestyle. The applications, while they did what they were supposed to do, does not work to help educate and motivate users, only sending occasional reminders which are easily ignored by the user.

Keywords:

Introduction

In general terms, diabetes is a disease in which the body has a hard time or in some cases, is unable to control the concentration of sugar, more specifically, glucose in the body [1]. As of now, there are no known cures for diabetes but the advances in medical technologies have allowed us to control the symptoms and prevent it from affecting patients too much. A patient with diabetes can live a relatively normal lifestyle with proper self-care and medications.

There are three main types of diabetes. The first is called “Type 1 diabetes”. With this type of diabetes, the body of a patient suffering from it is unable to produce insulin, a hormone that is crucial in maintaining blood glucose concentration [2]. The patient would need to constantly monitor their blood glucose concentration and administer insulin injections on a daily basis in order to stay alive. The second type is “Type 2 diabetes” With this type, the body still has the capability to produce insulin but its effectiveness has reduced significantly or the body is

unable to produce enough insulin [3]. The last type of diabetes is called "Gestational diabetes". It is diagnosed in pregnant women and usually goes away when pregnancy is finished [3].

Applications have been developed to assist patients in tracking their health data such as their blood glucose level, or exercise which could make managing diabetes an easier task as many of those applications make it easy for the patients to just log their blood glucose level on their phone which most people will already be carrying but the effectiveness of those applications may not be very good as many factors come into play and even with the help of applications, some patients may still not be taking good care of their health. This paper will study the features of some of the applications made for diabetic patients, compare those features to different apps and suggest improvements that could be made.

Dangers Of Diabetes

Having diabetes could be a health hazard to yourself if left untreated. It could damage many of the body's organs which include the heart, blood vessels, kidneys, eyes, nerves, and even the brain[2]. One way that diabetes could damage the heart is the buildup of cholesterol plaque in the bloodstream. If the plaque happens to form in the artery that supplies blood to the heart is ruptured, it could cause a heart attack. The same thing could happen in the brain which could lead to a stroke. Having a high blood sugar level will also damage the walls of small blood vessels over time which could affect many organs, including the nerves. This happens because as the arteries get damaged, less essential nutrients and oxygen gets delivered to the nerve cells which could damage and destroy the cells and lead to a condition called "neuropathy" also known as nerve damage This can then, in turn, lead to more health complications such as "peripheral neuropathy" [4]. This type of neuropathy usually affects parts of your limbs such as arms, hands, or feet. This is the most common type of neuropathy that people with diabetes have. The symptoms usually start at the feet which could be numbness, weakness, tingliness, sensitivity, or pain. Having numbness could be especially problematic if you are not careful because injuries could happen to the foot and the patient may not be aware of said injury. Injuries are usually not a problem if it gets treated properly but in this case, since the patient couldn't feel the injury due to the nerve damage, the injury could be left alone without treatment. This increases the risk of severe infection or inflammations which could create even more problems for the patient. Autonomic neuropathy could also happen in diabetic patients[4]. This type of neuropathy affects the nerves that control organs and glands. Examples of symptoms include irregular heartbeat, loss of bladder control, erectile dysfunction, etc. Nerves that control the motor functions could also be damaged. This is called "motor neuropathy" It is characterized by weakness in the limbs, and difficulty controlling muscle movements. Muscle twitches or cramps could also occur. With current medical technology, there are many options that help diabetic patients control their diabetes. One of the most common devices available would be the blood glucose sensor. These devices have been around for a long time and have been made increasingly more affordable. Since one of the main challenges in dealing with diabetes is the monitoring of the patient's blood glucose level, these devices have made it easy for patients to run the tests on themselves which are faster and cheaper than going to the hospital. Some sensors will continuously monitor the patient's blood glucose throughout the day without needing the patient to be reminded to do the test. These are called "continuous blood glucose monitors"[5]. They work by having a probe/needle be inserted into the patient's body around the belly area or the arm but these sensors will have to be replaced around once a week on average as the body will attack and clog up the sensor because the body recognizes it as a foreign object and will prevent it from working properly. But new types of glucose sensors are starting to emerge into the market, namely the"graphene-based sensors"[6] which are said to be better than traditional sensors due to the many properties of graphene that make it biologically compatible with the human body. Other than the traditional blood glucose sensors, there are also more ways that technology helps in dealing with diabetes. In some cases where diabetes has already damaged the organs such as the kidneys, monitoring technologies could be used to help keep track of the patient's well-being as some symptoms of kidney damage might not be noticeable and if left unattended could further damage the body.

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Diabetes Type 2

Type 2 diabetes, as mentioned before, the body is still able to produce insulin but its effectiveness has reduced significantly or the body is unable to produce enough insulin[3]. Patients with this type of diabetes would also need to monitor their blood glucose level to make sure that it doesn't go too high which could be dangerous. This type of diabetes could develop in people of all ages, including teenagers, children, and adults. There are many factors that could cause type 2 diabetes. One of many factors includes genetics. For example, if your family member has diabetes, the chances of you being diagnosed with diabetes in the future could be increased. Another factor could be lifestyle choices such as eating foods with high sugar content on a daily basis and not exercising[7]. This causes the pancreas, an organ that secretes insulin, to be overworked and could lead to damage which could cause type 2 diabetes. The body can also develop resistance to insulin because of this. Age/ethnicity could also be a risk factor as well. Although type 2 diabetes can be diagnosed in people of all ages, it is more likely to be diagnosed when a person is older than 40 years old and is of caucasian ethnicity or more than 25 years old if you are of African Caribbean, Black African, or South Asian ethnicity.

Challenges Patients Face In Managing Their Diabetes

Main problems with patients not taking proper care of their diabetes are the lack of knowledge on the disease and lack of motivation. This is because some patients may have not been properly informed about the disease by their physician or may lack access to proper education which is prevalent in rural areas[8]. This could cause them not to take their condition seriously enough and they may not consider the health consequences that the disease may have on their body. As mentioned before, they may also lack the motivation to take care of themselves. Many factors could be the cause of this such as shock in learning that they have diabetes or other mental disorders such as depression which stems from having diabetes[9].

Assistive Technology For Diabetes Patients

There are many tools that help patients manage their diabetes. Examples are wearing devices such as a smartwatch which could help track exercise and in turn, help with reducing blood glucose levels or it could help remind patients about things such as the time they need to take their medicine. Sensors which monitor the patient's blood glucose level throughout the day are also available. Many applications also have been developed to help patients manage their diabetes. Many of the tools available could be used in conjunction with applications that may improve the quality of life for the patients. Example of this is that a smartwatch or a sensor could be linked with an application that helps to log and keep track of different factors that affect blood glucose levels.

Mobile Application For Diabetes Patients

Many applications are available which could be installed on smartphones. These applications are designed to assist patients with various things such as logging their blood glucose, reminding the patients to take their medicines. Most applications are able to produce a log of blood glucose trends over a certain period of time if the patient logs their blood glucose into the app often. This feature could be very useful for patients to determine if their current lifestyle is suitable with their medical condition or not and it could help the patient adjust their habits over time. Although applications have some very useful features, it does not do a good job of making the user keep using the application. Most of the time, patients will try out an application for a few weeks and stop using them which goes against the purpose for these types of applications. The applications do not help the patients to learn about their condition and does not motivate the users to take care of themselves so it is all up to the patient themselves to do what they have to do.

Controlling Diabetes

Managing and controlling diabetes could be a difficult task without the assistance of a healthcare professional. One would need to know how different factors such as the types of food they consume, and their lifestyle behavior affects their blood sugar level. Fortunately, with our current technology, obtaining various information about diabetes has gotten significantly easier. One could easily search the internet for the things that they need to know about their condition. However, the information on the internet is not perfect and could sometimes be

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inaccurate, so it is advisable to be in contact with a qualified healthcare professional.

Managing your lifestyle and keeping track of your diet is also a crucial thing that needs to be done if you are diagnosed with diabetes. While the task may sound simple, it is easy to forget or lose track of what needs to be done. To solve this problem, many applications have been developed over the years for diabetic patients to utilize. These applications assist patients throughout the day with what they need to do such as reminding them to log what food they consumed throughout the day, helping them calculate their approximate blood sugar level, or even connecting them to their healthcare provider which makes it very convenient for patients. However, these applications are not perfect and may have flaws that may be problematic for users. In this part, the study will discuss the applications and their flaws, then solutions to those problems will be discussed.

Lack of updates. Lots of applications reviewed in [10], lacked updates. Some of the apps were last updated in 2012. The lack of updates means that no new information is being added and the app could be running on outdated information, thus, could make the app inaccurate and potentially dangerous. While it is easy to see which app has been updated recently, not everyone will know where to look, meaning they won't know which app is more reliable. This can then lead to patients needing to switch apps if they had chosen the app that has not been updated for a long time which then requires them to transfer their information, if they had already used the app, to the new app which is time consuming and inconvenient.

Usability Of The Application

According to [10], only three out of thirteen applications had “acceptable” usability scores. This could mean that some computer illiterate users may have difficulties operating the application itself. Usability is extremely important for this kind of application as users need to

be able to input information as efficiently as possible as to not disrupt their everyday life. Users would be more willing to use the app properly if the app has minimal effects on their schedule. If this is not the case then users may neglect to log their activities as they could think it’s a bother and too much of an inconvenience, especially if the user think its a small thing that would not affect their overall blood sugar level but can still add up in the long run.

Personal information may be important to some people. With this in mind, the privacy policy of some apps reviewed shows some concerning things. Developers of some apps stated that the user’s information can be shared or sold to a third party. Although the higher rated apps stated that the developers have no access to users’ personal information. (2) App effectiveness, According to the study,[10] , the authors stated that there were some improvements to the blood glucose level of patients who used diabetes applications but this does not apply to all apps and the methods that they used is debatable whether is it truly from the use of the app itself or not because patients were still in contact with their healthcare provider meaning that the healthcare provider could be the main cause of the reduction in blood glucose level. Although the study stated that there were improvements to the patient's blood glucose level, they also stated there were no improvements in the quality of life of the patients, meaning that whether the patient is using the app or not, they still act the same with any other diabetic patient. (3)Link to medical sensors, few apps mentioned in the study had a function that allowed the app to link to a blood glucose sensor and automatically log the glucose level in the patient's blood. This is a great feature that allows patients to keep track of their blood glucose levels more easily without having to take out the sensor to look at the readings. Taking out a smartphone for that purpose would be more convenient and discrete. Although, the sensors that apps can link to are very limited because not all sensors have the function to connect to a smartphone. (4) Accessibility, most of the apps in the study can be downloaded via the App Store and Play Store for devices running iOS and Android respectively. Some apps require a prescription from a doctor to create an account to be able to sue the app or just to activate the app itself. Few of the apps were region locked, meaning that the app can only be downloaded in the designated region. Some apps required the user to pay to be able to download the app or had a monthly subscription plan in which the user had to pay a monthly fee to be able to keep using the app. But most apps were able to be downloaded and used with no limitations. (5) Patient retention, because of the relatively short period of time apps

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were tested (6-12 months) it is difficult to determine if the patient would keep using diabetes applications in the long run as it is very possible that patients do not want to have to log everything they do in the app for the rest of their lives and would stop at some point. Because of this, apps would need some way to prevent the patient from getting fed up with using the app every day.

Diabetes Applications In 2022

With the flaws of some applications in mind, 4 different apps for managing diabetes on the App Store were downloaded and tested. For each app, its crucial function for managing blood sugar levels and other features within the app will be tested.

Mynetdiary

The first time starting the app, the user sees a simple interface that prompts the user to pick their diabetes type, age, gender, height, body weight, and units of measurement (metric/ imperial), and then the user gets shown a page that offers an upgrade to a "premium" version of the app for a fee. It is a subscription-type service that could either be paid annually or monthly and new users get a 44% discount if they choose to pay annually. Users could skip this page without paying for the subscription. After this, the user gets taken to the main page of the app, the dashboard, which contains essential information. The app contains features of a diabetes management app such as a blood glucose level tracker, insulin tracker, meal tracker, and exercise tracker. The app contains a food database where the user can choose which type they consumed and the app will automatically add the calories to the tracker. This app does not contain a blood glucose calculator, just a place where the user can log the reading from an external sensor. The app does not seem to be able to connect to any kind of blood glucose tracker. The interface is clean and simple to use with normal, easy-to-understand words used to describe each function of the app.

Onedrop

When the user first uses the app, it prompts the user to create an account, after that, the user needs to select their diabetes type and their age and then the user gets taken to the dashboard. The app seems to have been designed to fit the phone screen as when downloaded on an iPad, the size does not fill the screen but only uses a portion of it. The app allows the user to log their health data(Blood glucose level, weight, diet, exercise, etc.) The app also has its own blood glucose sensor that users could purchase and connect to the app. The user interface is clean and easy to navigate. The user does not have to press a lot of buttons to get to the desired function of the app.

Mysugr

When first starting the app, the user is prompted to give an email, after that, a verification code will be sent to the given email which then the user needs to put into the app in order to continue. The user then will need to create a password for presumably the account that the user will be using. Then the page where the user gets to select their diabetes type, medication type, and unit of measurement. After that, the user gets taken to a dashboard. The dashboard is very simple and contains a glucose logger. The user has the ability to generate a report of their glucose levels after several logs have been made over a period of several months. After 21 logs, the app's feature that allows the user to estimate their glucose level unlocks. The accuracy of this could not be tested at the moment due to time constraints. The app has the ability to connect to accu-check sensors. The app seems to be made for a phone screen only as when downloaded on an iPad, the app does not fill up the screen.

Contour

When first starting the app, the user is prompted to select their language, but the choice is very limited and then their region. After that, the user needs to make an account then the user needs to click a link that will be sent to the given email. When that is done, the user gets taken to the dashboard. Here the user has the ability to manually log their blood glucose readings. Other than this, the features of this app is limited compared to others and the user interface may be confusing for some at first as some user could easily get lost in the app.

Problem With Thai Populace

Language Barrier

According to the English proficiency index, Thailand ranks among one of the lowest in the English proficiency test carried out by EF Education First. It is ranked 100 out of 112 countries included in the list.

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The result suggests that most Thais will have difficulty interpreting English words and therefore will have difficulty using most diabetes management applications as they are in English. This means that the choices of applications are limited.

Some applications that are written in the Thai language are also rather obscure and often require specific search terms for them to come up in the App Store/Play Store. Because of this, some people might decide on not to use any applications at all because they couldn't find applications that would suit their needs[11].

IT Literacy

Many Thais living in rural areas lack access to technologies such as smartphones mainly due to financial constraints. This means that they are unable to utilize the applications available.

Recommendations For Improvement Of Diabetes Management Applications

Most of the apps for managing diabetes work as a simple blood sugar level log with some extra features, but most of the apps function in the same way. A way to improve upon the application would be to be able to automatically log the blood glucose level via an external sensor, while some app has this functionality, the sensors that they connect to are rather limited, so a wider range of sensor support would be beneficial for the users as there are many blood sugar sensors on the market. The developer could collaborate with the manufacturer of a sensor to bring the connectivity of their sensor to the app. Another way to improve the apps would be to make them as simple and efficient for new users as possible. Many apps in the study and the app that I tested required the user to use their email to create an account before the app can be used which may be a deciding factor in whether the user decides to use the app or not. Some users may not have an email and in that case, would prevent that particular user from using the app unless they create an email. Removing the email requirement and making it optional would be beneficial. Apps in the study and the apps I tested had the function to remind the user to log their glucose level, and diet as some users could be forgetful. This might seem like a good feature but it may get annoying and obnoxious over time and although the user has the ability to turn this function off, it could make the user forget to log their health information. With that in mind, a new method of reminding the user could be devised. A method in mind would be to make the app game-like. By implementing features of a game, like in-game currencies, in-game character/products, it could make users more invested in the usage of the app. A reward system could be set up so that when the user completes a certain task, such as logging their blood glucose level or taking their medications, a virtual reward could be given to the user in the form of in-game currency then the user could save up the currency to spend it on other features of the app.

List of recommended features for diabetes management applications (1) Easy to use UI (no need to go through lots of tabs to get to the intended feature.) An intuitive user interface should be the most important feature of an application related to healthcare. This is because not all users have the same level of IT literacy and some may have difficulties using the app if the user interface isn't clear enough. A good user interface should be easy to navigate, meaning that the features included in the app are easy to get to without needing to go through a lot of steps. The simplest way to achieve this is to have a default page where the user is taken to first when they launch the app. On the default page, there should be buttons for all features listed, preferably arranged in a way that makes it easy to find such as in alphabetical order or separated into their own categories[12]. (2) Blood glucose logger, preferably automatic where the patient can connect their sensors with. (3) Blood glucose logger, a system that records the patient's blood glucose level periodically is an essential feature of diabetes management application. It should be as easy to use as possible because it should not take a significant amount of time for the user to record their blood glucose level. It should also not feel like a chore for the user as this could cause the user to not use this feature. A way to do this, as mentioned earlier, is to gamify the system or making logging the glucose level seem like a game[13]. (4) AI-based food recognition system (Patient takes a photo of their food before consuming and the app will automatically record nutritional information about the meal.) Patients might be too lazy to manually log their diet. Make it easy to use. There are already many food recognition software available on the market which would make the implementation

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of this feature more affordable. This feature allows the patient to take a photo of the food they are consuming which the software could then recognize and calculate the amount of glucose that the user has taken in and automatically make a log of it. This will shorten the time needed to make a blood glucose log[14]. (5) Some kind of blood glucose predictor/calculator based on previous readings and the food consumed[15]. (6) A way to connect directly to a physician/ healthcare provider.

This feature, as the name suggests, allows the user to quickly make contact with a qualified physician in case of an emergency. The developer of the application could work with hospitals or the government to create the system. (7) A feature to generate a report of overall health, blood glucose level. This feature allows the user to see the overall trend of their blood glucose level which could let the user know about the quality of their current lifestyle and could let the user know if any adjustments are needed to improve their blood glucose level. (8) Have a secure privacy policy (Stating that the patient's personal information won't be sold to a third party), Some people are very serious about the security of their personal information. The application should have a secure way of storing the user's information such as storing them in blockchains where there are no centralized server which makes it harder to for information to be leaked[16]. (9) Be updated regularly, especially the food database[17]. (10) Bug-free, Glitches or bugs can cause wrong values to be displayed or apps to malfunction. In some cases, the app might display a blood glucose value that is lower than the actual value which can cause the user to assume that it is safe to consume more food which may increase their blood glucose to a dangerous level[18]. (11) Easily accessible, easy to find on AppStore, play store, etc., and available in many languages[19]. (12) Exercise tracker, preferably being able to connect to fitness devices such as apple watch, and track movements, heart rate, calories burned, etc. This feature can be useful for users that exercise regularly. The app with record how often and how long the patient exercises which It should also be able to automatically track the user's exercise which could help with the calculation of blood glucose levels[20]. (13) Error detector which detects if the patients made input mistake. Some users may make an error when logging their blood glucose level manually such as putting an extra zero at the end of a number. This feature should look at the previous figures that the user has put in and detect any anomaly that may be caused by user error[21]. (14) Video tutorial, Some patients may not be able to use the applications right away as the user may not understand what each function does so a video that explains it to the user will be very beneficial to the user. (15) Educational videos and articles, Applications can contain information about diabetes which the patients could view which will help them learn about their disease. The information could be given to them in small chunks to avoid boredom or loss of attention such as 2-3 minute videos that the patients could watch daily or often which will not take much of their time.

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