Research Article

DEVELOPMENT OF ANDROID BASED HEALTHCARE APPLICATION FOR DIABETES PATIENTS

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ABSTRACT

Objective: The objective of the study was to create android based mobile phone application with multiple features for diabetics for the management of disease. Methods: A systematic review of all currently available diabetes apps for the android operating systems and identified the functionalities required in application and in order to check the usability of the mobile application a questionnaire was used. Results: A android app was developed after reviewing the previous literature and searching for medical android apps that are already available. The content of the mobile application was categorized into 13 main sections/functionalities, icons such as pill remainder, my diabetic record and SOS functionality to send SOS message to care givers/family members in hypoglycemic or hyperglycemia induced emergency conditions was included in the app. After the development of the application, the usability and satisfactory level of the mobile application was assessed and changed accordingly. Conclusion: The mobile application created was found useful among diabetes patient since it served as a self – learning medical app for the users for attaining knowledge and as a helping aid in controlling their disease.

Keywords: Application (app), Diabetes Mellitus (DM), Share my location (SOS), System usability scale (SUS).

INTRODUCTION

Diabetes Mellitus (DM) is a disease condition in which the body's ability to produce or respond to the hormone insulin is impaired, resulting in abnormal metabolism of carbohydrates and elevated levels of glucose in the blood.

Over the past three decades the prevalence of DM has been doubled of the estimated status and it still continues to increase due to the growth of an aging population and adverse lifestyle factors that raises the body mass index and age-specific incidence [1,2]. Diabetes was found to be a major contributor to global mortality by marking a scale of 1.3 million deaths annually [3]. In 2011, it was estimated that diabetes caused the death of 4.6 million in the adult population and the population of type 2 diabetes mellitus (T2DM) was increasing in every country [4]. By the year 2014, it was estimated that 422 million people worldwide had diabetes, out of which 85% of population was suffering from T2DM, 10% suffering from type 1 diabetes mellitus (T1DM), and the remaining from gestational diabetes mellitus (GDM) [2,5]. And today the International Diabetic Federation marks the population of diabetes patients worldwide, to reach more than 550 million by the year 2020[6]. These periodic statistics clearly mentions the increasing prevalence of diabetes population that may be caused due to genetic, environmental and behavioral risk factors[7].

Poor patient education has also been seen as a cause for such periodic increase in the statistics, thereby there is a need of patient education to improve the health status of the patient by encouraging the compliance with medical treatment regimens and promoting healthy lifestyles [8].

Reasons for development of diabetic mobile applications

Establishment and improvement of health care professionals - patient interaction system has been necessary for effective diabetic management. Time is an important element of high quality clinical care, and a necessary condition for the development of the patient-physician relationship with trust between both. Many physicians and health care leaders express concern about the amount of time available for clinical practice. Overworked physicians find it difficult to rarely find time for such conversations, especially when they are restricted to 20 to 30 minute appointments. When physicians spend an inadequate amount of time with their patients, the patients may not fully understand the importance of complying with all aspects of their recommended treatments, which eventually leads to deteriorating health and higher treatment costs.

Mobile health app plays an important role in fast and easy self-management of diabetes by providing effective information to the patients anytime and anywhere [9].

Borja Martinez P et al, in review study found out that there was more than 1,700 mobile applications for diabetes in all app stores combined which included Google play, Apple App Store, Blackberry, Windows and Ovi Store [10]. Though number of diabetes management apps are available in the market and in various studies it have been proven that currently available diabetic apps possess common functions at a time and they show limitations such as lack of personalized feedback and indeed failed to reach the patient's expectations [11]. Similarly the majority of apps offers the same functionalities and combine only one to two functions in one app [12]. Meanwhile the WHO also insists the

need of diabetes app that would provide information as per the expectation of the patient.

Choices of Operating System

Selection of operating system was a challenging process because there is a numerous operating system for mobile devices in the market out of which some of them are with marginal shares [13].

The Apple operating system is widely used among the public but the development policy of Apple is very restrictive, price of apple devices or anything related with it was comparatively expensive than android operating software [13,14]. Along with these disadvantages to keep the apps stick to the guidelines made by Apple, developers had to pay expensive annual fee for this application to be installed on iPhone, iPod, and iPad. While using from operating system Android, Symbian and RIM, Android offers a large choice of handset ranging from small to large and Comparatively the price of iOS (iPhone operating system) is affordable.

David Havreva et al, clearly discusses that the operating system android is more flexible and can be expanded without any limits compared to Windows Phone and iOS. But at the same time, they suggest that this operating system gets hanged up when multiple applications are working simultaneously [14].

Suggestion by the Patients Regarding Their Needs in a Diabetic Application

Javad J et al, they conduct a study in 9 participants who were Type 2 diabetic patients in order to explore the educational needs and design aspects for providing the diabetes education to the patients. The study resulted by highlighting the importance of patients receiving standardized general diabetes education with a specific focus on dietary interventions and the importance of physical activity which was found to have direct impact in clinical outcomes. The participants in the study suggested the need of a tool that would provide a standardized form of information regarding the diet that they can intake, they also showed keen interest in knowing the herbal medications and specific sugar content contained in each fruit that can be included in their diet. The participants showed interest in getting educational material which included information such as diet, stress and drug complications to read and learn about diabetes through a question and answer features [15].

Thus the aim of the study was to create an android based mobile phone application with multiple features for diabetes patients for the management of disease.

MATERIALS AND METHODS

Study Site: The study was conducted in Tertiary Health Care Hospital, Kerala

Study Design: The design of the study was of Prospective type.

Period of the Study: The study was performed for a period of six months, from May 2017 to October 2017

Inclusion Criteria: The mobile application is only applicable for diabetes patients, People who are using smartphones with android as the operating system can only access this mobile application, The age group and educational status of the people who access the mobile application was not considered.

Exclusion Criteria: The mobile application does not provide information for other disease, Smartphone users with another operating system (i.e. Windows, Apple, Blackberry, Symbian) was excluded from the study.

App Accessing Scale: The System Usability Scale (SUS), was a scale which was used to find out the usability of the mobile application among the healthcare professionals and the users, the scores were calculated from the questionnaire and based on the cores it was categorized as 'Not Acceptable', 'Acceptable' and 'Excellent'[16].

RESULTS AND DISCUSSION

The 'Diabetic World' android based mobile application was developed with multiple features through reviewing the various literature and currently available mobile applications and the suggestions of patient's need in those apps were considered during the development on icons.

Selection of icons for the mobile application was based on the information from various sources like book, journals and database like micromedex, lexicomp and UptoDate [17,18] which is insisted by professionals for providing health care data.

The learning contents included 10 main sections such as information about disease, complications, diagnosis, treatment, important tips that should be known about the medication, drug interactions, herbal interactions, lifestyle modifications and it included additional information to attract the user's attention such as pill remainder, my diabetic record and SOS functionality to send SOS message to caregivers / family members in hypoglycemic or hyperglycemic induced emergency conditions (Fig. 1). The details of each icon in the app is summarized in Table 1.

Icon 1: Know About My Disease

Gaining a good understanding of the disease, the signs and symptoms of the disease, what major factors which influence blood glucose levels, and when the patient should meet up with the healthcare professional should be well known by the patient so that he/she can keep them in mind while building their routine which was considered for the preparation of the icon 'Know about my disease'.

The same necessity was reported in a study conducted by Johnson SB[19], which showed the importance on the link how the knowledge about the disease can improve the life style of the patient.

Similarly, Marilyn C[20] et al, conducted a observational study in 170 patients with T2DM in order to assess the impact of diabetes education, the qualitative and quantitative analysis reported that the subjects were more aware and confident in delaying or preventing their disease.

Icon 2: Complications I Might Face

Yaa O [21] et al, conducted a descriptive study in a population of 630 patients at tertiary care hospital, Ghana. The main aim of the study was to determine the knowledge of diabetes complication among DM clients visiting the hospital, they reported that among 630 patients, 325 patients were affected with Diabetic foot, but on assessing their knowledge level on diabetes associated complications showed that 60 % of patients did not have knowledge on diabetes complication while only 13.1 % had adequate knowledge.

Similarly, Polonsky[22] et al, conducted a study highlighting that another very common and important reason for hospitalization is due to the complications associated with diabetes.

The above studies showed how important it is to inform the patients about the basic principles of prevention of diabetes complication, which was taken in consideration for the preparation of icon 'Complications I might face'.

Icon 3: How to Diagnose My Disease?

Assigning a type of diabetes to an individual often depends on the circumstances present at the time of diagnosis, and many diabetic individuals do not easily fit into a single class. For example, A study was conducted by American Diabetes Association in a person with gestational diabetes mellitus (GDM) who continued to be hyperglycemic after delivery and may be determined to have T2DM.
The above study showed the importance of correct diagnosis for the disease. Hence this icon is particularly patient oriented in accessing the knowledge of what all diagnosis tests the patient should undergo [23].

Icon 4: How My Medications Control My Blood Sugar Level?

The study conducted by Bartolomeo[24] et al, describes the importance of knowing the pathophysiological basis of the medication's mechanism of action, as a necessary step to individualize treatment of diabetic people, taking into proper consideration potential benefits and secondary effects of drugs, which was taken into concern for the icon 'How my medications control blood sugar level?'.

Icon 5: Major Interactions of My Medications That I Should Know

Icon 'Major interactions of my medications that I should know' is added because when patients are diagnosed with diabetes, a large number of medications become appropriate therapy. These include medications for dyslipidemia, hypertension, antiplatelet therapy, and glycemic control. So many medications can be overwhelming, and it is imperative that patients are thoroughly educated about their drug regimens.

A study supporting this was conducted by Hasniza Z [25] et al, who performed a cross sectional retrospective study in 200 T2DM patients with hypertension to study the drug related problems at a tertiary care hospital in Malaysia. Out of which 26% had insufficient knowledge on health and disease while 16% had insufficient knowledge on drug interactions, which thereby led to renal impairment, cardiovascular disease and increase duration of hospital stay, thus they insist early identification of drug related problems can enhance the prevention and management of drug related problems in T2DM patients with hypertension.

Icon 6: Interaction of My Medication with Herbal Products

Huda K [26] et al, conducted a survey-based study in 208 patients who surveyed at different areas of Karachi in order to find the possible potential herbal – drug interactions in elderly population of diabetes and the study resulted that 59 volunteers were at high risk of potential herbal drug interaction, among which 32.7% had dynamic interactions and 21.2% had kinetic interactions. This study suggested that healthcare professionals and consumers should be aware of potential herbal drug interactions and healthcare professionals should question and advise their patients who their use of herbal medicines.

Similarly, Ramesh C [27] et al, discusses the benefits as well as potential risks that can be caused while administrating the ant diabetic drugs with herbal medications. These interactions can lead to synergetic or antagonistic effects leading to undesired pharmacological effect, therefore safety consideration is a necessity.

Icon 7: Tips I Should Keep In Mind About My Drugs

Icon 'Tips I should keep in mind about my drugs' mainly contains detailed education and advices for the patients about their medication in a patient friendly manner which as a result improves the healthcare services by neglecting the non-adherence as insisted by Leslie RM[28] et al, they conducted a study over 2500 diabetes patients out of which, majority of them were un aware of the instructions that had to be followed while taking the medications and around 25% missed their schedule of appointment and language was also a barrier in understanding the information.

Icon 8: Which Food I Should Eat?

Counting carbohydrates is useful for people with insulin-requiring diabetes to administer appropriate prandial insulin doses to maintain euglycemia, icon 'which food I should eat?' helps patients to improve their nutritional choices and monitor their food and sugar intake.

Icon 9: How Much Exercise I Should Get?

Icon 'How much exercise I should get?, explains the importance of exercise for diabetes patients as exercise not only improves the glycaemic control, but it can also improve the insulin sensitivity and restore the diabetic associated complication such as cardiovascular damage, which is considered as one of the major complications of diabetes it also discusses the do's and don'ts of exercises for varies types of diabetes, such suggestion was insisted by the study conducted by Zar CT [29] et al.

Similarly, Rashid MA[30] et al, conducted a clinical study to examine the effect of physical activity and obesity on prevalence of T2DM in middle aged population and the study resulted that stair climbing, and cycling have reduced 95% risk of T2DM in high risk population.
The above study marked the importance of informing the patients the necessity of exercise in managing their disease.

Icon 10: Pill Remainders

Medication non-adherence is very common in people with diabetes resulting in poor glycaemic control, thereby as a tool to improve medication adherence the icon 'Pill remainders' was included in the mobile application as Viral NS [31] et al, also insisted the fact that short message service (SMS) results in better medication adherence and have opened avenues for apps development (Fig. 2A).

Icon 11: Nearest Hospital I Can Access

Icon ' Nearest hospital I can access', is a GPS-based location finding system that would help individuals at any point of time to find addresses and to locate the services such as hospitals, clinics and pharmacies using their mobile devices. Hassan LB [32] reports that mobile positioning is the most inexpensive and fasted method in understand locations.

Icon 12: My Diabetes Record

Testing blood sugar will let the patient know what his/her sugar level is at that time, but without keeping a log, they will not know any trends that may be occurring. One of the best ways of keeping track of blood sugars is by using a daily record, which is added in the icon 'My diabetes record'. Diabetes Dairy or Diabetes daily logs are the best way in selection of individualized pharmacotherapeutic regimen selection as reported by Osta EL[33] et al.

Icon 13: Share My Location

Out of many Medical applications available, only Magaed N [16] et al developed a app for patients with dementia, 'iWander', assists patients with daily living by providing audible prompts offering to direct the patient home, sending notifications and GPS coordinates to caretakers, or by calling local services. Thus the icon in the mobile application 'Share my location' gives an opportunity to the patients at any situations like hyperglycaemia or hypoglycaemia to notify their care givers when they seek help (Fig. 2B, 2C).

After modifications with feedback from experts, the app was finally developed and evaluated by patients with the help of System Usability Scale (SUS) [34].

The SUS is a simple, widely used 10-statement survey developed by John Brooke while at Digital Equipment Corporation in the 1980s as a "quick-and-dirty" subjective measure of system usability. The tool asks users to rate their level of agreement or disagreement to the 10 statements—half worded positively, half negatively—about the software under review and based on the System Usability Scoring, the respective category can be defined [16].

A total of 200 SUS evaluation forms where collected from participants, out of 200 participants 50 where physicians, 50 where other health care professionals and 100 where from diabetic patients who have accessed the mobile application (Table 2, Fig. 3).

Out of 50 participants of physicians who have accessed the mobile application, 42 physicians were found to range the SUS score between 85-100, which comes under excellent category, 8 physicians were found to range the SUS score between 65-84, which falls under acceptable category and non was found to range between 0-64, which respectively come under the category not accepted (Table 3, Fig. 4).

Out of 50 participants of other health care professionals who have accessed the mobile application, 49 other health care professionals were found to range the SUS score between 85-100, which comes under excellent category, and 1 other health care professional were found to range the SUS score between 65-84, which falls under acceptable category and non was found to range between 0-64, which respectively come under the category not accepted (Table 4, Fig. 5).

Out of 100 diabetes patients who have accessed the mobile application, 98 diabetes patients were found to range the SUS score between 85-100, which comes under excellent category, and 2 diabetes patients were found to range the SUS score between 65-84, which falls under acceptable category and non was found to range between 0-64, which respectively come under the category not accepted (Table 5, Fig. 6).

Other health care professionals rated high for the mobile application (94 %), followed by the diabetes patients (92.97 %), followed by the physicians (85.65 %) and respectively the mean category rated for the mobile application 'DIABETIC WORLD' was excellent. The app was finally reported useful for the physicians, other healthcare professionals and patients (Fig. 7).

Fig.1: Display of Icons in the mobile application

Fig. 1: Screenshot of the icons of the app
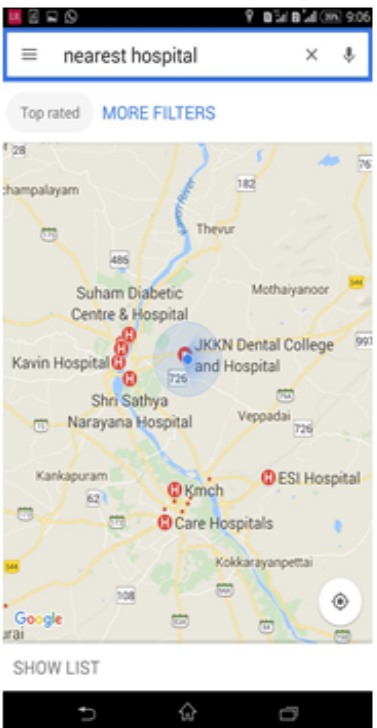
Table 1: The Content for the 13 Icons

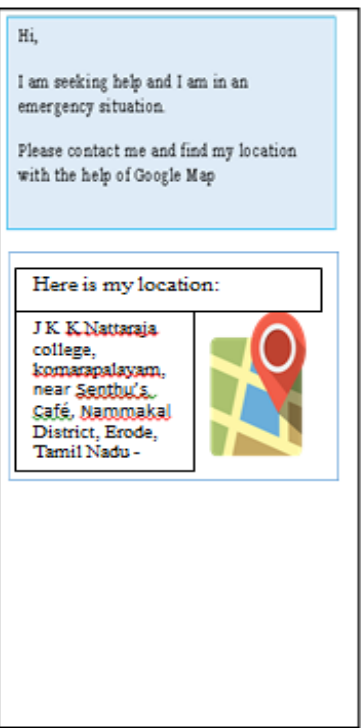| Sr.No	Icons of the App	Name of the Icon	Content of the Icon
1.		**Know about my disease**	It includes basic information on three main types of diabetes such as Type 1 Diabetes mellitus, Type 2 Diabetes Mellitus and Gestational Diabetes
2.		**Complications i might face**	This icon includes the information on Diabetic foot ulcer, Diabetic gastroparesis, Diabetic Hypoglycemia, Diabetic ketoacidosis, Diabetic Neuropathy, Diabetic Insipidus and Diabetic Retinopathy.
3.		**How to diagnose my disease?**	This icon includes the information on diagnostic tests for type 1, type 2 and gestational diabetes.
4.		**How my medications control my blood sugar level?**	This icon provides information on the classification of anti – diabetic drugs along with the mechanism of action of each class of medication.
5.		**Major interactions of my medications that i should know**	This icon includes complete drug interaction details on every anti-diabetic medication.
6.		**Interaction of my medication with herbal products**	This icon includes information on the interaction that can be caused when the patient takes his/her medication along with herbal medication.
7.		**Tips I should keep in mind about my drugs**	This icon includes basic information on how and when to administer the medication along with the major side effects.
8.		**Which foods i should eat?**	This icon provides details on diet for the patient.
9.		**How much exercise should i get?**	This icon discusses a planned physical activity chart for the patient
10.		**Pill remainders**	Here the patient is given a chance to neither type the details of the medication nor take a clear photo of the medication, and as the result the alarm will be set**.**

11.		**Nearest hospital i can access**	This icon provides the patient to get the details of the nearest hospitals with the help of GPS.
12.		**My diabetes record**	This icon helps the patient to maintain a record with the blood glucose readings of the patient
13.		**Share my location**	Here the patient can share his/her location in case of emergency, to his/her care takers by providing notifications This app gives a chance to create shortcut of this icon to the homepage of the mobile so that just one click of the patient can save his/her own life.

Fig.2 : A- Screenshot of icon "Pill Remainder", B- Screenshot of icon " Nearest hospitals I can access" and C- Message content of icon "Share my location"

Fig. 2: Screenshot of the content of the app

Table 2: Distribution Pattern of Participants of SUS (n=200)

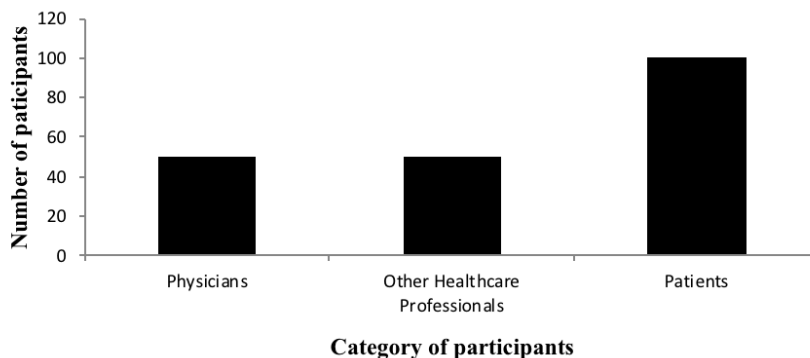| Sl No.	Category of Participants	Number of Participants (n= 200)
1	Physicians	50
2	Other Healthcare professionals (OHP)	50
3	Patients	100

Fig. 3: Distribution Pattern Of Total Participants Who Completed The SUS Scoring

Table 3: System Usability Scoring of Physicians

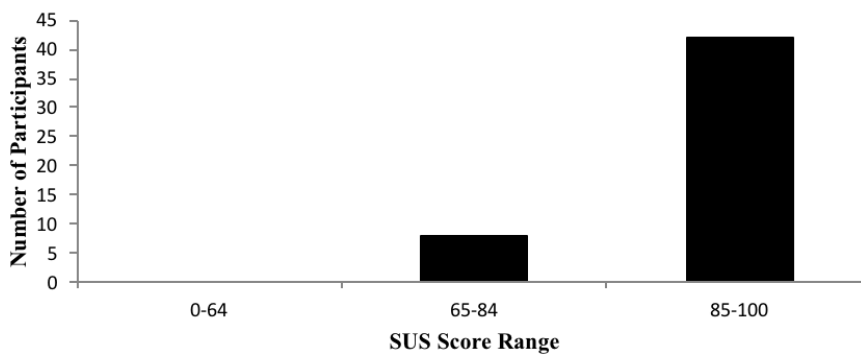| Sl No.	SUS score range	SUS Category	Number of participants (n=50)
1	0 – 64	Not Acceptable	0
2	65 – 84	Acceptable	8
3	85 – 100	Excellent	42

Fig. 4: SUS Scoring Scale of The Physicians

Table 4: System Usability Scoring of Other Health Care Professionals

Sl. No.	SUS score range	SUS category	Number of participants (n=50)
1	0 – 64	Not Acceptable	0
2	65 – 84	Acceptable	1
3	85 – 100	Excellent	49
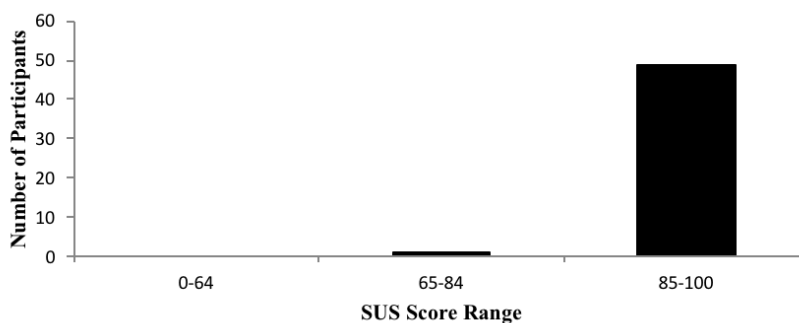
Fig 5: SUS Scoring Scale of Other Healthcare Professionals

Table 5: System Usability Scoring of Patients

Sl. No.	SUS score range	SUS category	Number of participants (n=100)
1	0 – 64	Not Acceptable	0
2	65 – 84	Acceptable	2
3	85 - 100	Excellent	98

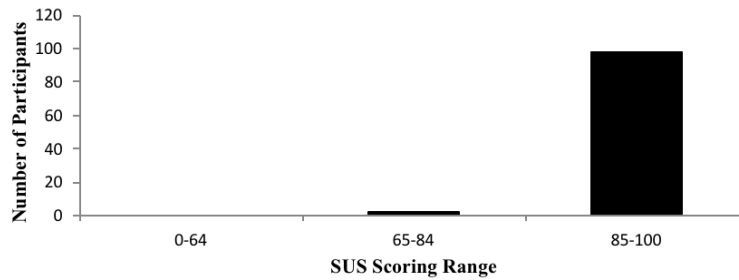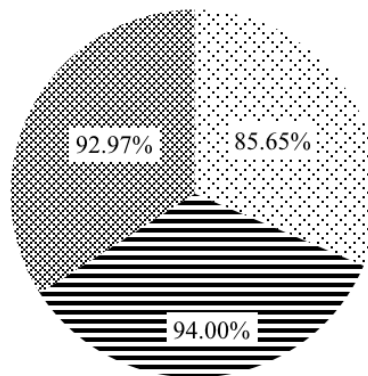**Fig 6: SUS scoring scale of patients**

Fig 7: Distribution of Excellent Category in SUS Scoring among the Participants

CONCLUSION

This study gives us a deep insight for the need of diabetes management as insist by the World Health Organization. Self-management is very important for patients with diabetes, and health care provided via mobile applications has a great advantage when applied to patients with diabetes; the adherence to activities for the management of diabetes, such as regular medication and insulin injection, self-monitoring of blood glucose, diet, and exercise, can be improved through mobile apps. Even though a number of mobile applications, Internet portal, and websites are available to help patients to improve their diabetes care. Studies are limited to show its effectiveness and cost-benefits in diabetes self-management. The present study has great significance, in that it tried to explore the roles of extended follow – up care to enhance the knowledge and self – care implementation of diabetes patients. Our study clearly marks beneficial to the users to understand their disease, know more about their medications, the do and don'ts regarding exercises and diet, help in tracking their blood glucose level, provide remainders and to assist help in case of emergency, thereby helped the patients to improve their quality of life.

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