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REVIEW ARTICLE

A Review of Mobile Applications for Diabetes: Could it replace the Role of Professional Health Care?

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Abstract

Background: The prevalence of diabetes is increasing year to year, despite various attempts to reduce prevalence have been made. The role of professional health teams (PHTs) is critical to manage diabetes progression. Advances in technology such as Mobile Applications (MA) have provided new opportunities to support the success of diabetes treatment. This article aims to provide a critical analysis of the challenges that are not fully fulfilled and highlights directives for future research that can enhance the implementation of MA in diabetes management. Methods: A systematic review has been conducted. A number of articles related to mobile applications and diabetes mellitus published between 2011-2020 have been taken from Google Scholar, PubMed, and Medical Pro Quest, and 15 articles were selected based on criteria set. Results: Each study appears to have different features in design MA, affecting the results varied in the 15 studies reviewed. Mobile technology-based applications demonstrated their role in improving communication, being accessible, facilitating self-management processes, improving compliance with treatment, and ultimately improving blood sugar control. Conclusion: The role of PHTs is important for the successful implementation of the fast-developing sensor and transfer app in the medical sector. It is the role of PHTs to select adequate devices, apply them, and earnestly analyse their effectiveness and economic feasibility.

Keywords: *Mobile application, Diabetes, Professional health teams.*

Introduction

Diabetes Mellitus (DM) is one of degenerative diseases characterized by metabolic disorders caused by one of the functions of the body organ that cannot produce enough insulin or cannot use the insulin produced effectively, so that there is an increase in blood sugar levels or also known as hyperglycemia [1].

The prevalence of Diabetes is increasing from year to year, although various attempts have been made. According to the previous study, there was an estimated increase in diabetic patients by 50.7% from 2011 to 2030 [2].Non-compliance with treatment and lifestyle therapy is a factor that inhibits the control of blood sugar, requiring interventions [3].The data obtained shows that only 35% of type 2 DM patients achieve glycemic control (HbA_{1c} <7) If this is not treated it will cause complications from the DM itself [4].

To solve this problem, counseling to patients as one of the behavioral support programs has been applied. But unfortunately, time constraints, making counseling focuses solely on general information, and instructions on drug use. In daily practice, counseling delivered is not followed by patients and produces suboptimal outcome [5]. One of the reasons why the patients do not implement counseling advices is that some information obtained by the patients is forgotten or misinterpreted.

In addition, at the beginning of counseling, the patient's needs are not discussed, so that the information provided is not related to the patient's needs, and sometimes the patients are uncomfortable talking about certain problems face to face [6]. Some previous studies have mentioned that to achieve

optimal therapeutic outcomes, counseling and lifestyle education are required to be done continuously. Structured education can improve the glycemic profile (HbA_{1c}) compared to regular information [7]. One of the most structured educational interventions that can be applied to DM patients is the Diabetes Self-Management Educations (DSMEs).

DSME is an ongoing process that facilitates the knowledge, skills, and abilities of DM patients in conducting self-care [8]. With technology advancement today, the DSMEs program can be easily delivered to patients so patients can perform diabetes treatment independently under the supervision of doctors, pharmacists and nurses (Professional Health Teams/PHTs).

One of the most commonly used technology is the popular mobile app (MA), providing a range of communication methods and fairly inexpensive. MA has great potential to provide self-care education and inspire patients to uphold healthy habits, thus helping them control chronic diseases. However, some research studies have shown that mobile apps may not be effective for all patients to achieve their targeted goals [9].

Another study showed that the design of Diabetes MA feature was still focused on reporting and setting reminders rather than providing personalized education or therapeutic support [10]. Overall, we found the MA device holding a great promise to improve diabetes management and behavioral results.

However, it is important to ensure that the MA for the management of the patient has the standards of diabetes treatment according to guidelines. Many diabetes applications does not have a clear description of the process and design development, as well as an educational component that enhances patient's knowledge for behavioral change [11, 12].

Furthermore, the involvement of PHTs in the development of diabetes mobile app is important to ensure the quality of health information and support provided by the application [13]. This PHTs involvement will foster avoidance of legal implications surrounding noncompliance to regulatory and medical standards that relate to digital health services especially those which empower people to track, manage and make decisions about their health [14].This article aims to provide a comprehensive review of existing references concerning the MA intervention for diabetes patients by evaluating functional and non-functional requirements together with related issues necessary for large-scale adoption of such interventions.

Specifically, we review and try to answer the question: Is there a patient and PHTs (user) intervention in the preparation of the feature? What type of intervention? Does PHTs interact actively with patients with MA help? What are the educational features given based on the Diabetes Self-Management concept?

How is the intervention? In general, we want to explore whether MA can meet the IDF recommendation, a diabetic care management program involving patients and caregivers, doctors, pharmacists, and nurses so that the therapeutic goals can be achieved.

Material and Methods

Researchers were conducted a systematical process to identify articles related to diabetes management with mobile applications in English published between 2011-2020 on the following electronic databases: Google Scholar, PubMed, and Medical ProQuest. The following keywords are applied in the searching: “Diabetes Mellitus” and “Mobile Application” or” Smartphone” and “Diabetes Management.”

We were also manually searching for the reference list of related articles to identify additional studies. Titles and abstracts were screened and evaluated to select articles that evaluate the use of mobile applications in a diabetic intervention, generated 210 publications.

The article was then retargeted with the following inclusion criteria: intervention studies using mobile applications, and studies on diabetes management. Only articles with full text available were selected. Study quality assessment was conducted based on GRADE (Grading of Recommendations, Assessment, Development and Evaluations).A transparent framework for developing and presenting summaries of evidence.

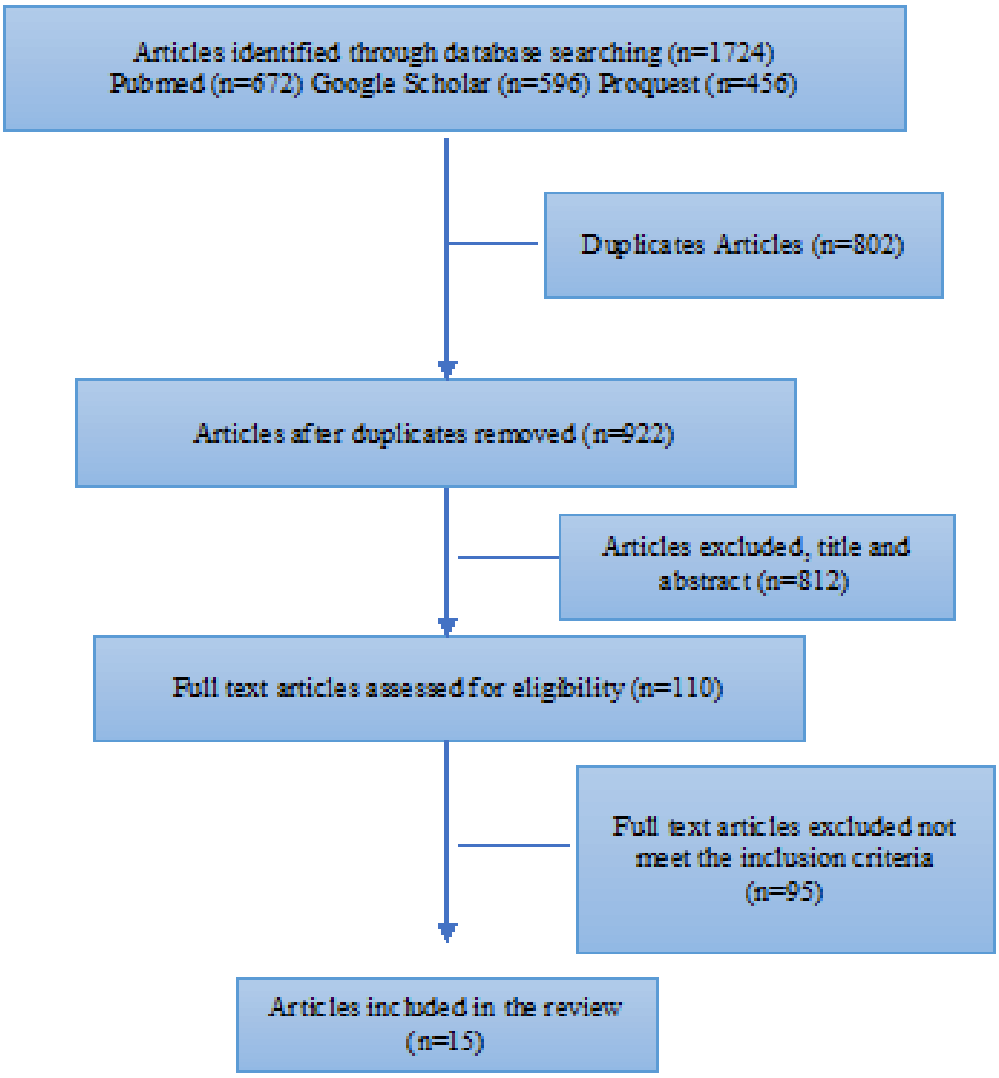

Figure 1: PRISMA diagram for study selection

Results

General Study Characteristics

In our review, we included all individual studies involving mobile application for managing diabetes treatment; with the following exclusion criteria are applied: studies on the creation of Mobile application programs and studies involving the prevention of diabetes. After applying inclusion and exclusion criteria, fifteen articles were selected. The characteristics and results of this study are summarized in Table 1.

Mobile Phone App Development

Our review revealed that mobile technology-based applications have demonstrated their role in improving communication, being accessible, facilitating self-management processes, improving compliance with the treatment, and can ultimately improve blood sugar control. Features in mobile applications must be based on evidence-based recommendations which further conducted trials with users to identify barriers and improve accuracy, usability, and acceptance to improve patient adherence in using the application well [12]. Also, the involvement of multidisciplinary health teams should be an integral part of the process of developing and testing the diabetes mobile application to ensure that medical guidelines and clinical practice have been implemented based on the correct standards [15].

All the 15 trials reviewed in this study that the development of mobile app functionality was varied. However, the feature for monitoring blood sugar levels is present in almost all research, 15/15 (100%). There were of 6/15 (40%) studies had features for diet management[16-21], Six studies (40%) which had a physical activity function [16-

21], three studies (20%) include the compliance reminder function [22, 23].

Seemed to be every study has different features in design MA, which affects the results varied on the 15 studies reviewed.

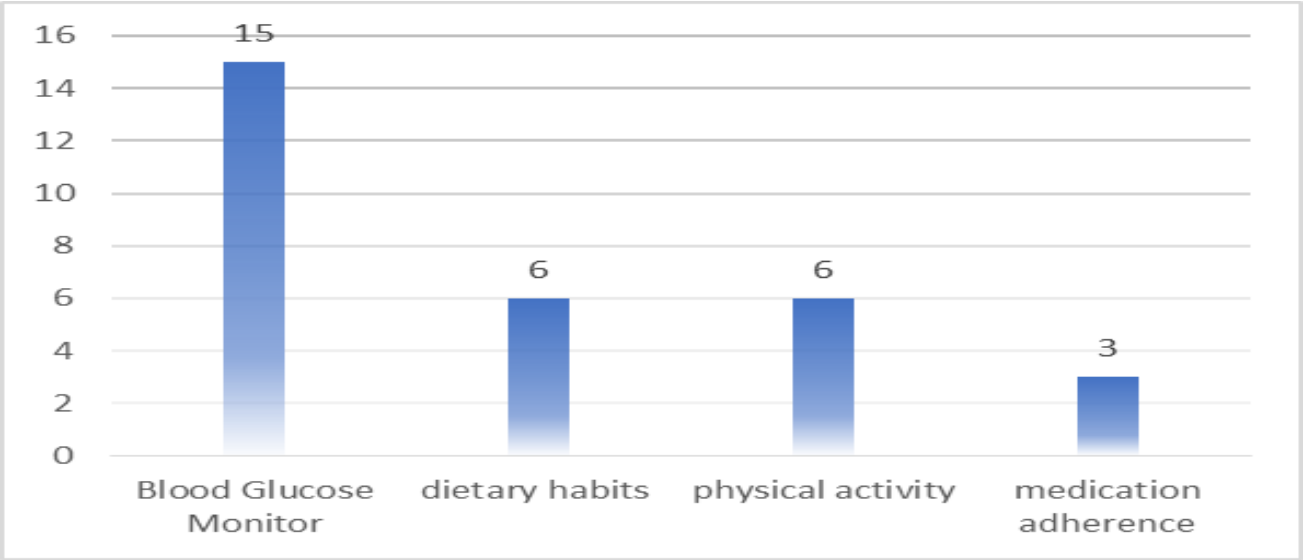

Figure 2: Feature of mobile applications

Types of study participants

Based on the type of participants, most of the participants in the mobile application studies which focused on type 2 diabetes patients, 8 studies (53.3%) [18-21-24-27]. Six studies involved both type 1 and type 2 diabetes patients (40%) [8, 16, 28-30, 31] and one study specific to type 1 diabetes patients (6.7%) [17]. There is no provision classification associated age, but almost all studies involve participants with age > 18 years.

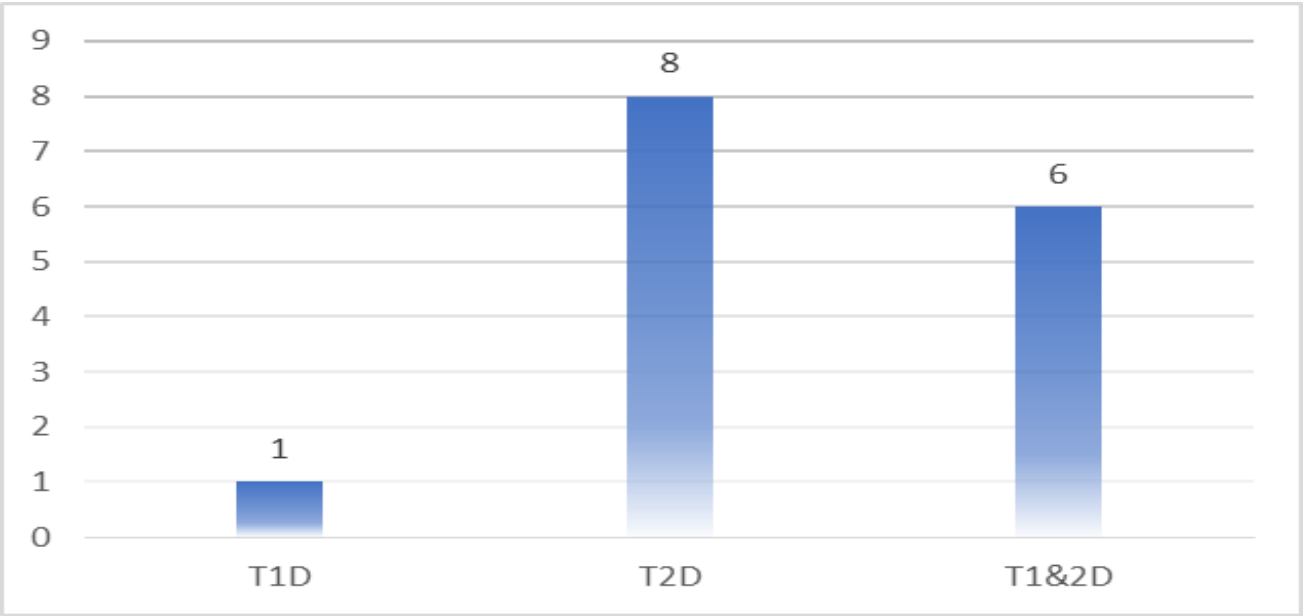

Figure 3: Types of participants

Types of intervention

The type of intervention of the whole study was mostly using telemonitoring 8/15 (53.3%) interventions [17, 25, 27-32, 31].Self-care was found in one study (6.7%) [28] and the combined intervention of telemonitoring Self-care as many as 6 studies (40%) [10, 11, 18, 20, 24, 26]. Telemonitoring interventions aim to monitor patients with blood sugar levels, and drug use, while self-care aims to provide support to support changes in behavior such as healthy eating, physical activity, and problem-solving skill. Self-care interventions aim to improve and alter behavior patients regarding eating habits, physical activity [2, 33].

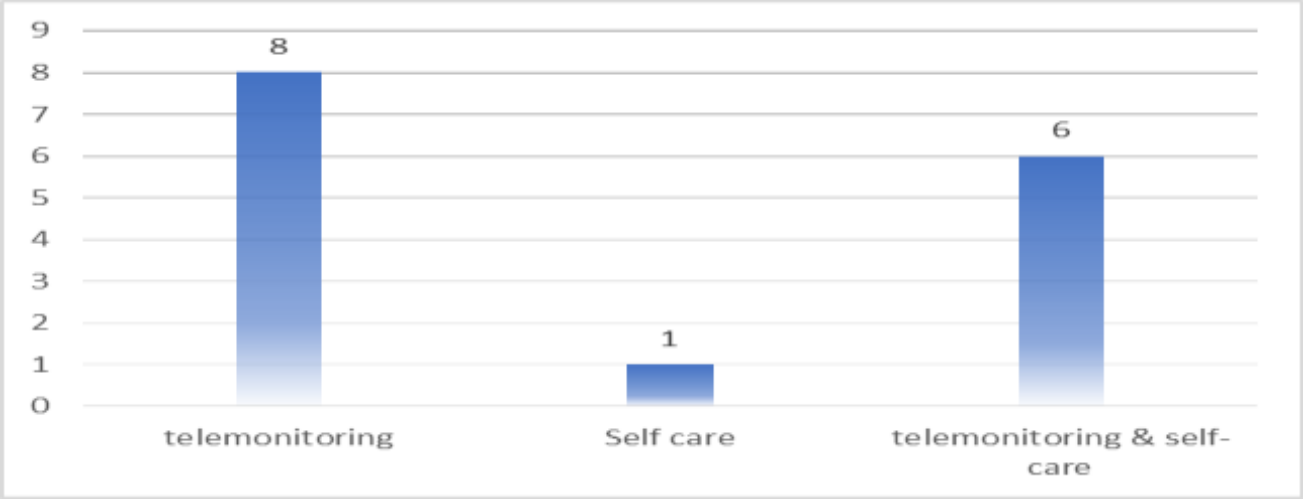

Figure 4: Types of interventions

Types of Outcome Measures

Around fifteen individual studies highlighted that MA effectiveness on the success of diabetes management is assessed based on the HbA_{1c} indicator, fasting blood glucose levels, HBGI and BGI as many as 6 studies (40%) [6, 25, 27, 28, 30, 31], knowledge in one study (6.7%)[29], and compliance with drug-taking in two studies (13.3%)[17, 29], and measuring indicators of combination (HbA_{1c} rate, self-efficacy, self-care and quality of life) as many as 6 studies (40%)[10, 11, 18, 20, 22, 26].The results of the use of MA differ greatly.

In the HbA_{1c} measurement, a total of 4/15 studies reported no differences in HbA_{1c} reduction in patients who used MA significantly [18, 24, 32, 31], and 5 studies reported significantly decreased HbA_{1c} [17, 20, 25, 29, 30]. Against self-efficacy, self-care and quality of life, two studies reported a positive impact and self-improvement efficacy [11, 19]; yet three studies reported no significant change in self-efficacy and quality of life [17, 18, 24].In regard to the patient's knowledge, MA has an impact on increased patients' awareness [11], but does not affect compliance with medication [17].

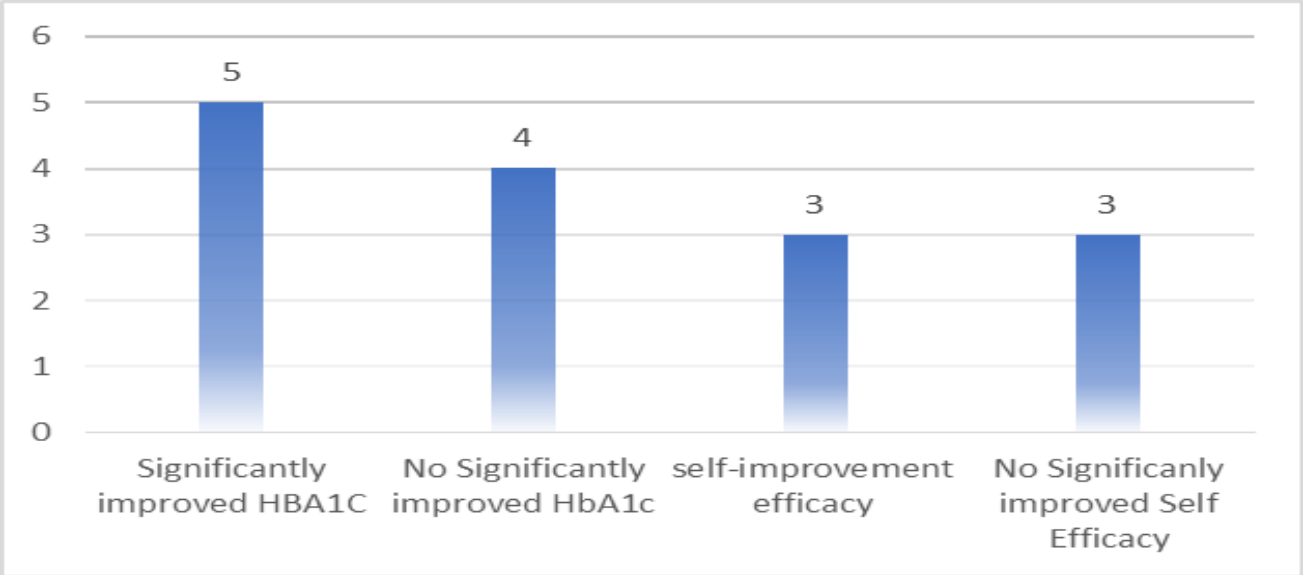

Figure 5: Types of outcome measures

Users Involvement

Several studies were conducted to identify the involvement of patients in designed features in MA, and the involvement of PHTs in the development of MA to educate diabetic patients. Our review shows that only one study (6.7%) that clearly described users' involvement in the design of its MA [16].

Users' involvements in design process increase the success rate of MA system usability [11]. To achieve long term effective glucose improvement, interactive management between patient and PHTs can help achieve rapid and sustained glycemic control [30].

Clinical Expert Involvement

In addition to patients, the involvement of PHTs is also important factors in setting quality health information based on treatment standards thereby preventing legal implications, and protect patients from incorrect and misleading information. Our review shows that only 1 in 15 Studies involving patients and health professionals in the use of Apps, which have an impact on improving patient knowledge and self-efficacy significantly [16].However, there are no one a study involving the inter collaboration of PHTs such as physicians, pharmacists, and nurses. Granting education to patients is a process that requires cooperation from PHTs, to address the complex problems related to the compliance of drug medication and success rate of therapeutic efficacy. This finding highlights possible issues with the effectiveness, efficiency and relevance of these MA to user participation of PHTs.

Table 1: Summary of study characteristics

Author (year)	Type of Participants	Type of Interventions	Outcomes and Measures	Users involvement in designed MA	Health Care Expert Involvement in designed MA
1.Kirwan et al [17]	Type 1 Diabetes, N = 72	Telemonitoring, self-care (diet, exercise, monitoring of sugar levels, compliance with medication)	Significantly improved HbA_{1c}, but no significant change for self -Efficacy, self-care, and quality of life	No user involvement in MA feature development	No involvement of PHTs in MA feature development
2.Waki et al. [20]	Type 2 Diabetes, N = 44	Telemonitoring, self-care (diet, exercise, monitoring fasting sugar content, weight loss)	Significantly improved HbA_{1c}, and fasting blood sugar. No significant in BMI	No user involvement in MA feature development	No involvement of PHTs in MA feature development
3.Holmen et al. [18]	Type 2 Diabetes, N = 151	Telemonitoring, self-care (diet, exercise, monitoring)	There was a decrease in HbA_{1c} but there was no significant difference between the 3 groups. There is no difference in the significance of changes in quality of life, and lifestyle	No user involvement in MA feature development	No involvement of PHTs in MA feature development
4.Kim et al. [25]	Type 2 Diabetes, N = 35	Telemonitoring (HbA_{1c}, TC, TG, HDL)	Significantly improved HbA_{1c} in patients who use MA and are satisfied. An increase in HbA_{1c} in patients using MA and dissatisfied	No user involvement in MA feature development	No involvement of PHTs in MA feature development
5. Liang et.al. [32]	Type 2 and type 1 Diabetes, N = 1627	Telemonitoring (HbA_{1c})	Significantly improved HbA_{1c} in patients with type 2 diabetes, but no significant change for patients with type 1 Diabetes	No user involvement in MA feature development	No involvement of PHTs in MA feature development
6. Quin et.al. [26]	Type 2 diabetic patients, N = 163	-Telemonitoring (HbA_{1c}), Self-Care (management stress and diet)	Significantly improved HbA_{1c} in patients with type 2 diabetes, and improved lipid profile and diabetes stress	No user involvement in MA feature development	No involvement of PHTs in MA feature development
7. Olmen et.al. [31]	Diabetic patients, N = 781	Telemonitoring (HbA_{1c})	the proportion of subjects with controlled HbA1c was 2.8% higher in the intervention group than in the control group (difference not statistically significant)	No user involvement in MA feature development	No involvement of PHTs in MA feature development

8.Zhang et.al [30]	Patient Type 1, and Type 2 Diabetes. N = 276	Telemonitoring (HbA_{1c})	Significantly improved HbA_{1c} in patients with Interactive management app greater than in groups of patients using their own apps and those without using the app	No user involvement in MA feature development	No involvement of PHTs in MA feature development
9.Tavsanli et.al [27]	Diabetes Patient Type 2 N = 48	Telemonitoring (HbA_{1c}) and Glucose blood	Significantly improved HbA_{1c} and glucose blood in the treatment group	No user involvement in MA feature development	No involvement of PHTs in MA feature development
10.Gatwood et.al [28]	Diabetes patients type 1 and type 2, N = 75	Self-Care Management	Declines in adherence were observed in both groups over time but no significant differences were observed between groups or from baseline to the end of the active study period	No user involvement in MA feature development	No involvement of PHTs in MA feature development
11.Wang, et.al [21]	Diabetes patients type 2, N = 26	Telemonitoring (HbA_{1c}) self-care (diet, exercise, compliance with medication)	Decrease of HbA_{1c}, weight, but not significance.	No user involvement in MA feature development	No involvement of PHTs in MA feature development
12.Sittig et.al [19]	20 Type 2 Diabetes patients	Telemonitoring (blood glucose) Self-efficacy (exercise, diet)	Significantly improved to exercise and diet occur	No user involvement in MA feature development	No involvement of PHTs in MA feature development
13. Adu et.al [11]	Type 1 and type 2 diabetes patients	Self-efficacy, motivation and patient knowledge (diet, sugar content monitoring, and physical activity	Significantly improved patient knowledge, self-efficacy	user involvement in MA feature development	No involvement of PHTs in MA feature development
14.Vehi et.al [29]	Diabetes patients Type 1 and type 2. N = 211	Telemonitoring HbA_{1c}, HBGI, and BG	Significance reduction of HbA_{1c}, BG, and HBGI values	No user involvement in MA feature development	No involvement of PHTs in MA feature development
15.Agarwal et.al [24]	Diabetes patients Type 2, N=223	Telemonitoring (HbA1c), Self - Management (self-efficacy, quality of life and healthy behavior)	No significant changes in the value of HbA_{1c}, self-efficacy, quality of life and healthy behavior)	No user involvement in MA feature development	No involvement of PHTs in MA feature development

Discussion

To our knowledge, this is the first review discussing about mobile applications in improving health care and developing patient's considerations, which involve users and clinical expert. Currently, there is no collaborative care between clinical experts such as doctors, pharmacists and nurses in developing mobile applications based on DSME.

Persistent poor glycemic control in diabetic patients is a common, complex, and serious problem initiating significant damage to the cardiovascular, renal, neural and visual system [17]. As many factors affect blood glucose level, reasons for poor glycemic control is multifactorial and complex. There are several factors that cause uncontrolled

blood glucose level in diabetes' patients such as a delay in initial treatment, poor adherence of patients to treatment, life style and educations. Diabetes self-management educations (DSMEs) is a sustainable process of facilitating knowledge, skills and ability that are needed to change the behavior of life style and help patients manage their conditions by evidence-based standard [34]. Advances in digital technology, have led to a plethora of innovative strategies aiming to improve the self-management skills of patients, particularly MA.

Unfortunately, the majority of studies reviewed were mostly not based on DSME and involved PHTs. Support from PHTs will help prevent occurrence complications and give support on patients to improve clinical outcomes, health status and quality of life. But many of the studies reported were designed without the involvement of PHTs [22]. The use of MA, especially in the context of self-management, is complex intervention, several studies show insignificant results about their quality [11].

This finding highlights potential problems with the effectiveness and efficiency. Design processes can use research tool such as questionnaires, and focus group discussions to explore user's requirements to increase user satisfaction and involve medical feedback [23]. In addition, secondary aspects, such as low cost, convenience, simple-and fun to use functions, should be considered to attract active user participation [25].

There are several limitations to this review. The primary limitation of this study was the small sample size, which did not produce a large enough statistical power for us to detect statistically significant changes in the engagement of mobile application in diabetes management. Retrieval study has been limited for the last 10 years alone, using the 3 databases reference sources of Google Scholar, PubMed, and ProQuest Medical, so that the study outside of 3 sources of databases cannot be identified.

During the data extraction process, there is a possible risk of error due to miss or misunderstand when reading and interpreting the study that was studied, because not all studies clearly describe the description of the research conducted. With this restriction, we expect this review to provide useful information for Mobile Application development in diabetic patients. Finally, this evaluation is expected to provide a robust evidence base and beneficial perspective value for optimizing MA design and use for diabetes mellitus self-management.

Conclusion

Mobile applications are a promising area of continued development for the self-management of diabetes to improve self-efficacy and the quality of life of patients. However, much remains to be discovered, a variation of the results of the use of MA associated with less information about factors considered in the development of applications used as interventions for diabetes self- management.

It is important to continuously upgrade the application based on user feedback. Mobile applications cannot replace the role of PHTs, but rather become one of the tools to enhance collaboration between patients and Professional Health teams to achieve their goals. Moreover, the role of PHTs is important for the successful implementation of the fast-developing sensor and transfer app in the medical sector. It is the role of PHTs to select adequate devices, apply them, and evaluate their effectiveness and economic feasibility.

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