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The influence of mobile app in Glycemic Control and Prevention of Hypoglycemics in Diabetic management: A Systematic Review

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Review article

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Introduction. The use of technology in the treatment of diabetes can facilitate the medium of communication between nurses and clients in data collection to create a comfortable life for patients. The use of mobile health technology in diabetic education is an innovative learning method that can engage patients and influence positive health behaviors.

Aim. This study aims to find out the influence of mobile-based education applications in the Haemoglobin A1c control and prevention of hypoglycemia in patients with type 2 diabetes mellitus.

Methods. Database search for article are from four databases such as Pubmed, Sciencedirect, Proquest, and Cochrane is limited to the publication of the last ten years from 2010 to 2021 and full text article in English. Authors individually screened the titles and abstracts, then full articles in order to obtain papers that met inclusion criteria

Results. a total of 664 references were found. After duplicates were removed, 391 potentially relevant references remained from the database searches. Eight articles were finally designated as articles to be reviewed and use RCT design. Most studies put a Haemoglobin A1c (HbA1c) as a primary outcomes, and hypoglycemia as a secondary outcomes. Through the use of mobile app, there are reductions in HbA1c which affect the hypoglycemia events in Type 2 DM patients.

Conclusion. Mobile application can enhance HbA1c and hypoglycemia control among T2DM patients. Because providing patient education face to face is time-consuming, the use of mobile application may be an effective complement or alternative for healthcare professionals to manage the rapidly increasing number of diabetes patients.

Keywords: Mobile app, Type 2 DM, Glycemic control, Hypoglicemia prevention

Introduction

Diabetes mellitus, particularly type 2, is a global health issue in the worldwide. The International Diabetes Federation (IDF) estimated an escalation of diabetes prevalence from 424.9 million in 2017 to about 628.6 million by 2045 [1]. More than 10,3 million people had diabetes mellitus in Indonesia [2]. Ninety percent (90%) of diabetes cases is type 2 diabetes mellitus with characteristics of insulin sensitivity disorders and/or impaired insulin secretion [3]. The prevalence of diabetes mellitus in Indonesia based on doctor's diagnosis in the population aged ≥15 years has increased from 1.5% in 2013 to 2.0% in 2018 [4,5]. Administration of insulin therapy causes the main side effect of hypoglycemia. Another side effect is the immune response to insulin which can lead to insulin allergies or insulin resistance [3]. Hypoglycemia is a condition in which glucose levels in the blood decrease below the value of 70 mg / dl or less [6,7].The prevalence of hypoglycemia with type II diabetes mellitus patients can reach 70-80%, which has a serious impact on morbidity, mortality, and quality of life [8]. Severe occurrence of hypoglycemia in type 2 diabetes mellitus patients reaches 3-73 episodes per 100 patients annually [6]. A common phenomenon in the clinical practice is that many patients argue that mild hypoglycemia as a consequence of hypoglycemic control [9]. In addition, many patients misunderstand the symptoms of hypoglycemia as a symptom of ketoacidosis, because they need to reduce or delay insulin administration [10]. Patients attempted to lower blood sugar levels without knowing the effects of using the drug where patients may experience severe hypoglycemia as the result. One of the reasons for the lack of patient knowledge about hypoglycemia is the lack of information provided by healthcare professionals [11]. Shreds of evidence have shown that the potential use of smartphone-based technology has helped people with diabetes in self-care management by staying connected with health care providers. Futuristic features are provided with all the ease to understand and use [12,13]. A well-suited App could transform a mobile phone into a medical device helping ease the burden of diabetes, preventing complications, and improving a patient’s quality of life. However, an overwhelming number of products and services are available to patients with diabetes. Patients and providers must recognize the characteristics of these products and services to capitalize on the advantages while avoiding harmful deficiencies [14]. The use of technology in the treatment of diabetes can facilitate the medium of communication between nurses and clients in data collection to create a comfortable life for patients. An important goal of treatment with electronic media is to enable patients the opportunity to maintain effective they education without interruption [12]. Interest in mobile health apps in supporting self-management of health arises because it is easily accessible, portable, low cost, convenient for users, and has a widespread. Furthermore, 50% of smartphone users will have at least one mobile health app [13]. The use of mobile health technology in diabetic education is an innovative learning method that can engage patients and influence positive health behaviors [14].

This review aims to collate and provide evidence related to mobile application for Glycemic Control, and prevention of hypoglycemia of Diabetes Melitus patients.

Methods

Design

This study is a systematic review based on Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA). PRISMA is an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses. PRISMA focuses on the reporting of reviews evaluating randomized trials, but can also be used as a basis for reporting systematic reviews of other types of research, particularly evaluations of interventions. Authors must use PRISMA as a guideline and theory underlying aims to help authors improve the reporting of systematic reviews and meta-analyses (PRISMA Statement, 2015).

Eligibility

Inclusion criteria for this systematic review are (1) adult-elderly patients (18-85 years), (2) uncomplicated or non co morbid diabetes mellitus patients, and (3) patients who are conscious and cooperative (4) study design that include in this review is randomized control trials (RCT). Exclusion criteria in this systematic review are (1) patients experiencing complications (stroke, heart, kidney), and (2) patients who have dementia and aphasia.

Search Methods

Database search for article are from four databases such as Pubmed, Sciencedirect, Proquest, and Cochrane is limited to the publication of the last ten years from 2010 to 2021 and full text article in English. Keywords used in the article search of all databases are combination of "diabetes mellitus" OR “Type 2 DM” AND "glycemic control” OR “Hypoglicemia prevention” OR “HbA1c” AND "health education" AND “m-health" OR “Mobile app”. The next step after the articles that meet the criteria are collected is to analyze and form the articles according to the specified inclusion and exclusion criteria. The article search process was carried out in August 2021. The article search uses keywords that have been determined by the researchers and limits the inclusion and exclusion criteria. The data obtained are then selected one by one by the researchers to determine the suitability of the articles desired by the researchers and delete the same articles or those that do not fit the criteria. After getting the articles according to the researchers, the articles are analyzed one by one and grouped to get the results. The next step is to discuss based on the points obtained from the selection results.

Critical appraisal

The included quantitative studies were appraised using the McMaster Critical Review Form for quantitative studies [18]. The critical appraisal process was undertaken independently by the two authors. Discrepancies in scoring were then resolved through discussions until consensus was achieved.

There are 13 question items that can be answered with yes, no, and not addressed options. Scores are given as a percentage, and one point for each question item if available. 90% were categorized as high quality, 70% medium, and low quality for the rest.

Data Abstraction

Two authors independently reviewed the abstracts of studies retrieved from the database Search and read the full-text of potentially relevant articles. For studies that met the inclusion criteria, data extraction was independently conducted by two investigators using our data extraction tool adapted from existing guidelines and other review articles of mobile application for DM [19,20]. Using this tool we extracted the general and mobile app features of the papers including the outcome, study design, characteristics of the intervention, evaluation method and main findings. Disagreements in data extraction were solved by a third investigator.

Data Analysis/ Synthesis

Data of the studies included were synthesized thematically in order to understand the effectiveness of mobile application. Thematic analysis involves discovering, interpreting and reporting patterns and clusters of meaning within the data. Using this frame-work and by reading the included articles several times, themes were identified. Subsequently, these themes were further examined for their similarities, differences and contradictions. The subject matter of the findings from the quantitative studies was examined, and the resulting information was placed under the qualitative themes. This integration of quantitative findings to the qualitative themes was completed by the first author. The second author reviewed the matched themes and quantitative studies. Any disagreement was resolved through mutual discussion. Due to the heterogeneity and insufficient number of the studies included, we could not conduct meta-analyses.

Results

Search Results

Combining the output of the searches in the various databases, a total of 664 references were found. After duplicates were removed, 391 potentially relevant references remained from the database searches. 283 articles removed by reasons of irrelevant, review/report, not full text, book chapter. Eight articles were finally designated as articles to be reviewed. PRISMA flowchart for Study selection can be presented in Figure 1.

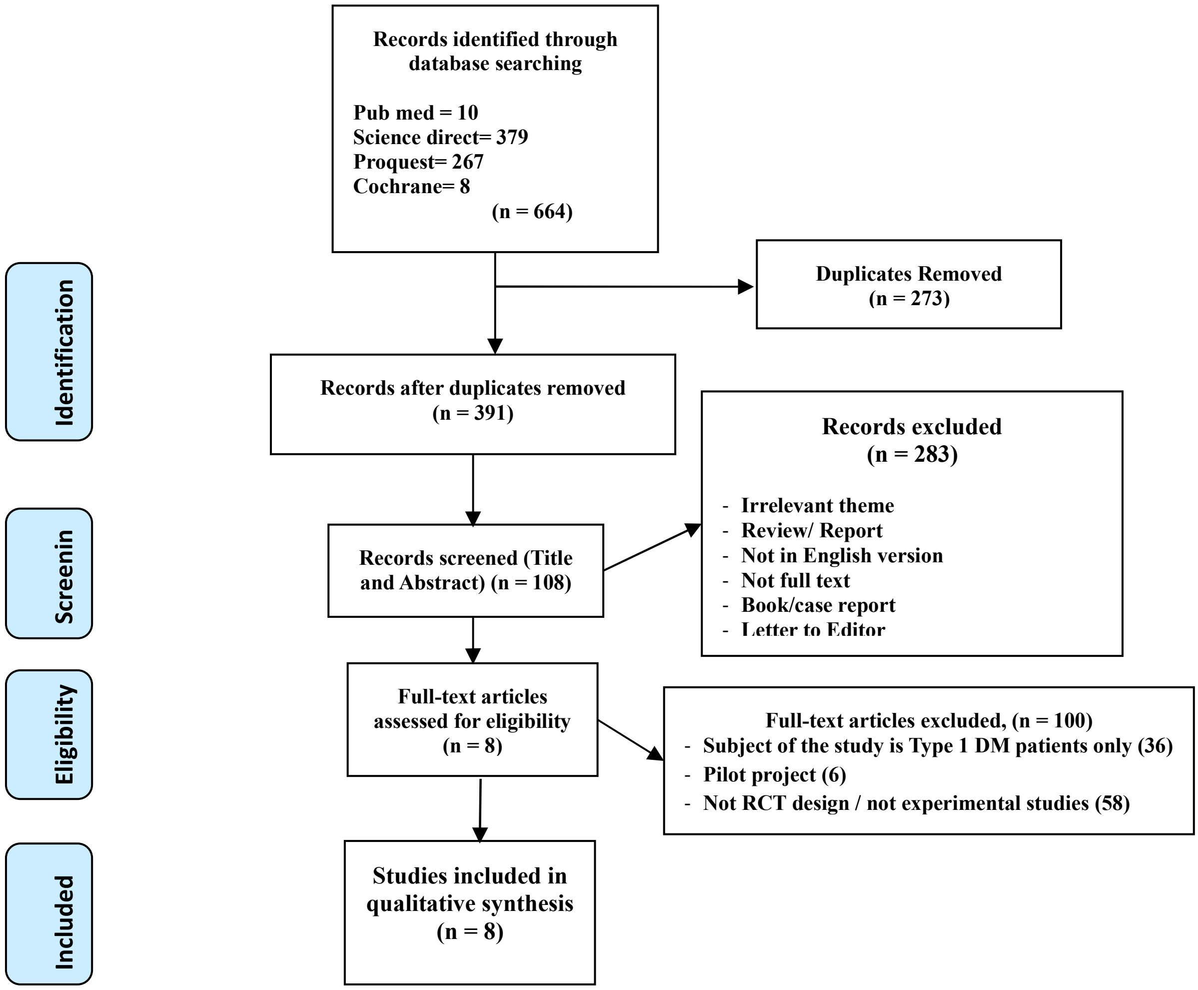

Figure 1. *PRISMA flowchart for Study selection*

The main focus of this systematic literature review is the effects of mobile app on hypoglycemia prevention. However, to optimize the interpretation of these effects, we will first clarify the methodological quality and characteristics of the studies, as well as the characteristics of the mobile app under review. The authors developed tables for data analysis with the type of diabetes addressed in the review article, the types of technology used for the intervention along with outcomes measured. The most common health outcome measure was hemoglobin A1c (A1c), and hypoglycemia may present in secondary outcome. This shared data element allowed comparison between the varying interventions addressed in these reviews.

In Table 1 we reported the articles included in our study.

Author, year, Country	**Outcome**	**Study design, participant**	**Intervention**	**Evaluation method**	**Findings**
Holmen et al., 2014, Norway	Primary: Change in HbA1c Secondary: self-management, Lifestyle changes, Quality of life	RCT, 151 participants divided into 3 groups	- 1-year intervention to increase self-management comprised of 3 intervention groups: the Few Touch Application (FTA) intervention group, the FTA with health counseling (FTA-HC) intervention group, and the control group -	Self-reported, The Health Education Impact Questionnaire (heiQ), SF-36	- The change in HbA1c level did not differ significantly between the 3 groups after 1 year. - HbA1c level declined within all groups
Waki Et al., 2014, Japan	Lifestyles changes, HbA1c	RCT, 54 type 2 diabetes more than 5 years	- 3-month intervention - the DialBetics group received a smartphone, NFC-enabled glucometer, and Bluetooth-enabled BP monitor, and pedometer with a unique communicator	Questionnaire	HbA1c and FBS values declined significantly in the DialBetics group: HbA1c decreased an average of 0.4% compared with an average increase of 0.1% in the non-DialBetics

			that transmitted the readings by wireless network to the DialBetics server - Participants in the non-DialBetics group would continue self-care regimen without any devices		group (P= .015)
Quinn et al., 2011, USA	Change in glycated hemoglobin	RCT, 163 type 2 diabetes for ≥ 6 months	- Group 1: control– usual care (UC), group 2: coach-only (CO), group 3: coach PCP portal (CPP), and group 4: coach PCP portal with decision-support (CPDS) - The intervention was a patient-coaching system and provider clinical decision support - Patients received a One Touch Ultra 2 glucose meter and supplies. Patients in the three active treatment groups received identical study materials: mobile phones, 1-year un limited data and service plan, study mobile diabetes management	Self-reported in mobile phone application	- Participants had a mean baseline glycated hemoglobin of 9.4% - the CPDS patients had a significantly greater decrease in m ean glycated hemoglobin than the UC patients (P 0.001) - CO and CPP mean glycated hemoglobin levels decreased over 12 monthsbthan UC (CO, P =0.02; - CPP, P =0.45)

			software, and access to the web-based patient portal.		
Franc et al., 2020, France	The mean change in HbA1c from baseline to 12 months	RCT, 665 patients of type 1 and type 2 diabetes with intensive insulin therapy	- Arm 1 (standard care), arm 2 (DIABEO alone), and arm 3 (DIABEO + telemonitoring delegated by the diabetologists to a nursing staff) - A reference nurse initiates the patient to the use of the DIABEO app on his smartphone. The patient enters relevant data (glycemia, physical activity, and ingested carbohydrates) and DIABEO calculates the insulin dose (an eventual dose adaptations). - Intervention conducted in 12 months	Classification of Hypoglycemia Adjudication Committee	- A significant and meaningful reduction of HbA1c versus standard care after 12 months of follow-up: mean difference - 0.41% for arm 2—arm 1 (P = 0.001) and - 0.51% for arm 3
Xu et al., 2021, China	The primary outcome was diabetic symptom scores Secondary: blood glucose level including fasting blood glucose, 2-h postprandial blood glucose (2 hPG), and glycated hemoglobin (HbA1c) at	RCT, 89 patients	- Control group: a face-to-face individualized health education was conducted for each patient for 4 times, 30 min each time within 4 days - Experimental group: Patients in the experimental group were required to	the summary of diabetes self-care activities (SDSCAs),	the HbA1c in the experimental group decreased significantly more than the control group after intervention ($P < 0.05$)

	baseline and 6 months after intervention		install the software and individualized self-management programs based on TCM theory. participants were reminded to submit their management status including food intake, exercise, blood glucose readings, mental status to the "interactive follow - up" module every day - All the participants were followed up for 6 months		
Zhang et al., 2019, China	The primary outcome was glucose control, including the changes (from baseline to months 3 and 6) in the HbA1c level. The secondary outcomes included the changes in FPG, body weight, and lipids.	RCT, 194 with type 1 or 2 diabetes (aged 18-65 years)	- Group A: received usual care and did not install Welltang on their smartphone. They learned diabetes-related knowledge and skills by self-learning and summarizing, and adopted lifestyles and behaviours voluntarily. - Group B: requested to install Welltang on their smartphone. They learned diabetes-related knowledge and skills by using	Venous blood measurement	- the mean HbA1c levels in groups A, B, and C were 7.80% (SD 1.14%), 8.04% (SD 1.38%), and 7.57% (SD 1.18%)

			the app, including glycemic control, diet, exercise, medication, and the use of insulin. 1 clinician involved. - Group C: received interactive management online with 1 dietician and 1 health manager		
Sun et al., 2019. China	Glycemic control, treatment adherence, the rate of occurrence of adverse events (hypoglycemia), and satisfaction.	RCT, 91 patients of Type 2 DM	- the intervention group were provided training to independently use the mHealth management app and upload the glucometer data, which was then automatically transmitted to the medical server - the control group received a free glucometer and were followed up through conventional outpatient clinic appointments	Physical examination, blood biochemical tests, follow-up clinic visits. Questionnaire for satisfaction measurement.	- the HbA1c level in the intervention group was significantly lower than that at baseline (6.84% [SD 0.765%] - vs 7.84% [SD 0.73%], P<.001) and that in the control group at 6 months (6.84% [SD 0.765%] vs 7.22% [SD 0.87%], P=.02). The extent of decrease in HbA1c level from baseline level in the intervention group was more than that in the control group (1.07% [SD 0.89%] vs

					0.62% [SD1.00%], P=.045
Quinn et al., 2016, USA	The change in HbA1c	RCT, 118 patients with Type 2 DM	- the control group were cared for as usual under the direction of their primary care physician. Patients in the intervention group received a patient coaching system (PCS) and provider clinical decision support - The PCS included a mobile diabetes management software application (MDMA), which allowed patients to enter diabetes self-care data (blood glucose values, carbohydrate intake, medications, and other diabetes management information) on a mobile phone and receive automated, real-time messages that were educational, behavioral, motivational, and specific to the entered data.	Blood test	- Among older patients, HbA1c changed by −1.8% (95% confidence interval [CI] = [−2.4, −1.1]) in the intervention group and −0.3% (95% CI = [−0.9, 0.3]) in the control group over 12 months. - Among younger patients, HbA1c changed by −2.0% (95% CI = [−2.5, −1.5]) in the intervention group and −1.0% (95% CI = [−1.6, −0.4]) in the control group over 12 months

Table 1. *Data extraction of studies included*

The result of Critical review

The results of the critical appraisal of the studies are presented in Table 2, respectively. The data that contributed to the generation of these themes are presented narratively in the following results subsection, with the appropriate source references identified.

	Dolmen et al.,	Waki et al., 2014	Quinn et al., 2011	Franc et al., 2020	Xu et al., 2021	Zhang et al., 2019	Sun et al., 2019	Quinn et al., 2016
Study purpose								
Was the purpose clearly	√	√	√	√	√	√	√	√
Literature								
Was relevant background	√	√	√	√	√	√	√	√
Sample								
Was the sample described in	√	√	√	√	√	√	√	√
Was the sample size	√	√	√	√	√	√	√	√
Outcomes								
Were the outcome measures	√	√	√	√	√	√	√	√
Were the outcome measures	√	√	√	√	√	√	√	√
Intervention								
Intervention was described in	√	√	√	√	√	√	√	√
Contamination was avoided?	NA	NA	NA	NA	NA	NA	NA	NA
Co-intervention was	NA	NA	NA	NA	NA	NA	NA	NA
Results								
Results were reported in								
Were the analytical methods	√	√	√	√	√	√	√	√
Clinical importance was	√	√	NA	√	√	√	√	√
Drop-outs were reported?	NA	NA	NA	√	√	NA	NA	√
Conclusions and implications								
Conclusions were appropriate given the study methods and	√	√	√	√	√	√	√	√
Fleiss Kappa	0.755	0.567	0.806	0.409	0.409	0.755	0.755	0.451

Table 2. *Critical review for Quantitative studies included*

Critical appraisal of quantitative research studies: As outlined in Table 2, all of the studies had a clear purpose and relevant literature reviews. All of the studies reported appropriate conclusions, given their study purpose. Table 2 shows the value of Cohen's kappa coefficient in each article with a range of 0.41 to 0.806 with a moderate to strong category. This coefficient is the result of two reviewers who evaluate each article separately.

Study Characteristics

Most of the selected reviews used research from locations around the globe. Articles that meet the inclusion criteria come from several countries including China [21–23], USA [24,25], Norway [26], Japan [27], and France [28]. The mean age range reported was from 38 to 68 years old. Duration of the intervention was 3 months [27], 6 months [21,22,26], 9 months [23], and 12 months [24,25,28]. The number of participants involved in the study was in the range of 54 to 665 patients divided into intervention and control groups.

Outcomes Measured, Primary Focus

Primary outcomes

Change in HbA1c level after 1 year was chosen as the primary outcome because it is the main target measure when treating diabetes and is frequently used when evaluating interventions. HbA1c data were collected through the GPs and were assessed primarily with the Siemens DCA Vantage Analyzer a maximum of 2 weeks before or after the follow-up to reduce measurement bias [26].

In the study of Waki and colleague, HbA1c as a primary outcome was measured from baseline to 3-month follow-up for each patient with an intention-to-treat analysis in intervention and control groups [27].

The primary outcome of Quinn [25] study was change in glycated hemoglobin comparing control usual care (UC) and maximal treatment (Coach primary care providers portal with decision support (CPDS) at baseline versus 12 months. Medical chart reviews were used to ascertain patient data. For patients without a glycated hemoglobin within 4 months of the desired measurement, a glycated hemoglobin test was offered at no charge at baseline to determine eligibility and at 12 months. At baseline, glycated hemoglobin was measured using one device, the Bayer DCA 2000, by trained staff blinded to patient group assignment. At follow-up, if glycated hemoglobin was not ascertained within 14 days of the 12-month time point, reminders were provided to patients and physicians to complete the test. Glycated hemoglobin level at intermediate time points (3, 6, and 9 months) was collected from patients' medical charts [24,25].

Franc et al. determined the primary outcomes of their study was the mean change in HbA1c from baseline to 12 months (primary endpoint), and the occurrence of hypoglycemia. An independent "Hypoglycemia Adjudication Committee" validated the classification of all declared hypoglycaemic episodes. A severe hypoglycemic episode means that the patient required the indispensable assistance of a third person. A symptomatic hypoglycemic episode refers to those symptoms of hypoglycemia associated with rapid recovery after self-administration of sugar [28].

The primary outcome in Xu et al study [22] was diabetic symptom scores. It was assessed by the diabetes symptom grading and quantitative scale according to the Guidelines for the Clinical Research of Chinese Medicine New Drugs. Secondary outcome was blood glucose level including fasting blood glucose, 2-h postprandial blood glucose (2 hPG), and glycated hemoglobin (HbA1c) at baseline and 6 months after intervention. Serum HbA1c level reflects a patient's blood glucose concentration during the previous 2–3 months, so it was taken into consideration as an essential indicator [22].

The primary outcome in Zhang et al. study [29] was glucose control, including the changes (from baseline to months 3 and 6) in the HbA1c level. The major adverse event was hypoglycemia. Hypoglycemia was defined as BG $\leq$3.9 mmol/L [21].

In the Sun study, there were intervention and control groups. Primary outcome was self-administered blood glucose level. HbA1c level was measured at 3 and 6 months [23].

The primary outcome of Quinn study [24] was the change in HbA1c (% of total hemoglobin) in the control group versus in the intervention group, at baseline versus at 12 months. HbA1c levels were recorded at baseline and at 3, 6, 9, and 12 months. Patient data were retrieved from medical charts [24].

Intervention Features

We will describe a mobile application intervention based on each of the studies that we included in this review. Holmen et al., [26]: To increase self-management comprised of 3 intervention groups: the Few Touch Application (FTA) intervention group, the FTA with health counseling (FTA-HC) intervention group, and the control group. The FTA-HC group received health counseling for the first 4 months of the project period. The health counseling was based on the transtheoretical model of stages of change and a problem-solving model, and used motivational interviewing as a counseling technique. The health counseling in the present study was part of the mHealth intervention.

Waki et al., [27]. DialBetics is composed of 4 modules. First is the data transmission module: patients' data—blood glucose, blood pressure, body weight, and pedometer counts. Second is the evaluation module: data are automatically evaluated following the Japan Diabetes Society (JDS) guideline's targeted values. Third is the communication module: about meals, and advice on lifestyle modification. Fourth is dietary evaluation: patients' photos of meals are sent to the server.

Quinn et al., [25]. The mobile software allowed patients to enter diabetes self-care data (blood glucose values, carbohydrate intake, medications, other diabetes management information) on a mobile phone and receive automated, real-time educational, behavioral, and motivational messaging specific to the entered data. The patient web portal augmented the mobile software application and consisted of a secure messaging center (for patient-provider communication), personal health record with additional diabetes information (e.g., laboratory values, eye examinations, foot screenings), learning library, and logbook to review historical data.

Franc et al., [28]. A reference nurse initiates the patient to the use of the DIABEO app on his smartphone. The patient enters relevant data (glycemia, physical activity, and ingested carbohydrates) and DIABEO calculates the insulin dose (an eventual dose adaptations). These data are sent every 2 h to a platform that is continuously visible by the reference nurse and the investigator.

Xu et al., [22]. The smartphone app for diabetes management was composed of 4 modules: syndrome differentiation, body differentiation and health preservation, thesaurus, and interactive follow-up. A reminder message would be received if the patients forget to complete that in time. The diabetes educators can track the data from the app and provide specific guidance and suggestions for the clients.

Zhang et al., [21]. Welltang app mainly comprises 4 parts: education, self-management (including records of SMBG, diet, exercise, medication, body weight, and other diabetes data), patient community, and communication between patients and clinicians. For clinicians, Welltang mainly provided the real-time uploading of data from patients.

Quinn et al., [24]. Mobile diabetes management software application (MDMA) allowed patients to enter diabetes self-care data (blood glucose values, carbohydrate intake, medications, and other diabetes management information) on a mobile phone and receive automated, real-time messages that were educational, behavioral, motivational, and specific to the entered data.

Sun et al., [23]. Patients uploaded the glucometer data to the mHealth management app which was then automatically transmitted to the medical server (glucometer was connected to the mobile phone via Bluetooth). The medical teams sent medical advice and reminders to patients to monitor their glucose levels via the personal messaging app or telephonically every 2 weeks.

Discussion

This systematic review provides an overview of studies on mobile applications in improving HbA1c and hypoglycemic control among T2DM patients. The highest decrease in HbA1c was 1.9% which is relatively high compared to several previous studies, which found a decrease in HbA1c of 0.49% [30] and 0.51% [31]. There was no subgroup analysis in studies involving patients in different age groups. In general, it can be concluded that mobile application interventions can provide the same benefits for younger (<55 years) or older (≥55 years) T2DM patients. It is inconsistent with findings from a previous systematic review [30], which suggested that ST interventions were more effective for younger T2DM patients than older patients. The mobile applications in the included studies are complex and generally include more than one component. Almost all studies evaluate mobile applications related to lifestyle modification and self-monitoring of blood glucose. Therefore, it is logical to conclude that a decrease in HbA1c is associated with improving the patient's lifestyle. Although quality improvement programs are usually multi-component, they are more oriented towards targeting changes in health care provider behavior or service delivery models [32]. Interventions using mobile applications have a stronger focus on empowering patient behavior change. A systematic review Barreira et al., [33] showed that exercise effectively reduced HbA1c. Of the four included studies, which have included a component of exercise adherence monitoring [23,26,27], this suggests that a mobile application may be an effective adjunct to controlling HbA1c, or It is more common to enhance lifestyle modification efforts among type 2 DM patients. These studies also suggest considering the mobile application as a complementary intervention that can be used in diabetes self-care strategies more effectively through lifestyle modification and self-monitoring blood glucose. In the included studies, self-monitoring of blood glucose was also included as part of a mobile application intervention, while its effectiveness in controlling DM was uncertain.

A previous systematic review study Xu et al., [34] concluded that SMBG only contributed to a 0.46% decrease in HbA1c. Available evidence suggests that SMBG can promote self-management, increase medication adherence rates, and improve the patient's ability to detect hypoglycemia [35]. However, the UK National Institute for Health and Care Excellence guidelines state that SMBG is not recommended as part of routine DM management but should be considered in subgroups of patients, such as those receiving insulin therapy and patients prone to hypoglycemia [36]. Current clinical practice guidelines recommend close monitoring of HbA1c and titration of drug therapy instead [37]. It was difficult for us to find relevant literature on mobile applications to reduce the risk of hypoglycemia in both type 1 and type 2 DM patients. Several studies that we included in this review made hypoglycemia a secondary outcome. The results obtained from the two studies stated that there was no significant difference between the intervention group and the control group. Reports of signs and symptoms of hypoglycemia occurred only once or twice in 1 year of follow-up [25,28]. However, post hoc analyses of the Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial indicated an increased hypoglycemia risk in type 2 diabetic participants with poorer glycemic control than subjects with more desirable HbA1c levels, irrespective of assigned treatment group [38]. Based on this statement, it can be concluded that from all studies included in this review, the mobile application can provide an effect on controlling hypoglycemia levels in Type 2 DM patients, although it is not clearly stated how the mechanism is. Little is known about the relationship between glycemic control and hypoglycemia in the usual care setting, where clinical decision-making about treatment intensity occurs and is modified throughout a patient's life [39].

Based on the two studies included in this review, it appears that there is no significant effect of the use of mobile phone applications on the quality of life of people with diabetes. The possible cause of no significant change in the quality of life before and after using the application is the age of the participants, most of which are in the elderly who feel less interested in using technology, especially smartphone-based [26]. The elderly need more intensive guidance regarding the use of technology applications, usually the elderly ask to be accompanied by family members or people who care for them. For the elderly who feel the exhaustion of their illness, they often hand over the responsibility to the people who take care of them [40,41].

Conclusion

In conclusion, mobile application can enhance HbA1c and hypoglycemia among T2DM patients. Because providing patient education face to face is time-consuming, the use of mobile application may be an effective complement or alternative for healthcare professionals to manage the rapidly increasing number of diabetes patients. Because providing patient education face to face is time-consuming, the use of mobile application as an educational media may be an effective complement or alternative for healthcare professionals to manage the rapidly increasing number of diabetes patients. The evidence suggests that organizations, diabetes educators, policy makers, and payers should consider these solutions in the design of diabetes self-management education and support services for population health and value-based care models. With the widespread adoption of mobile phones, digital health solutions that incorporate evidence-based, behaviorally designed interventions can improve the reach of and access to diabetes self-management education and ongoing support.

Limitation

We have identified several limitations in this study, including limited access to several good-quality databases, which are expected to provide broader search results. In addition, studies that matched our inclusion criteria were also very limited with regard to hypoglycemic control. We also considered potential bias related to different intervention/app, duration of intervention, and the limited numbers of RCTs included. Also, in the search strategy, some important databases are missing.

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Competing interests statement

There are no competing interests for this study.

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