Using experiences of mobile application from the perspective of patients with diabetes mellitus: A qualitative meta-synthesis

Xiaoyan Lv¹, Yingjuan Cao²*, Jinghua Xia¹, Ran Tan², Polun Chang³

1. School of Nursing, Shandong University, Ji’nan, Shandong, China
2. Qilu Hospital of Shandong University, Ji’nan, Shandong, China
3. Institute of Biomedical Informatics, School of Medicine, National Yang-Ming University, Taipei, Taiwan

* Corresponding Author

Corresponding Author: Yingjuan Cao

Yingjuan Cao
Vice Director of Nursing Deptment of Qilu Hospital of Shandong University
107, Wen-Hua-Xi Road, Shandong Ji’nan, 250012, China
Phone: 18560082789
Email: qlcaoyingjuan@163.com

Abstract

Background: Mobile application has become a new tool for management of chronic disease like diabetes mellitus (DM). Up to date, most of the studies related to mobile application focus on the effectiveness of self-management, rarely take perceptions and experiences of users into account.

Objective: To conduct a meta-synthesis of qualitative researches which associated
with mobile application using experiences among diabetic patients in order to better understand those factors which facilitate or hinder patients’ embracement, and to provide recommendations for future mobile application design and disease management strategies.

**Methods:** Literatures focused on experiences and perceptions of users in diabetes application were searched in PubMed, Web of Science and Cochrane Library between inception and June 2018. The Jonna Briggs Institute (JBI) Critical Appraisal Tool for qualitative studies was utilized to evaluate the quality of the selected studies. The searching results were synthesized by employing Integrating Methods.

**Results:** Four studies were included for analysis, 17 findings were subsequently integrated into 6 categories and finally 2 synthesized results were defined, including the use of mobile application for diabetes can improve patients’ self-management and confidence in disease control, obtain more support from health care professionals, and reduce negative emotions; Problems and negative effects in use.

**Conclusions:** Mobile application is a helpful tool to initiate and maintain self-management among diabetic patients and more improvements are necessary for the sake of easy use and effectiveness. Further high-quality qualitative study is needed to better understand requirements and using experience of diabetics, health care professionals or other stakeholders.

**Key words:** mobile application; diabetes; qualitative meta-synthesis

**Background**

The prevalence of diabetes is increasing worldwide which has become one of the most important chronic public health problems. In 2017, 451 million people were
estimated to have diabetes, approximately 80% lived in low and middle income countries in aged 18 to 99 years old and the number is expected to reach 693 million by 2045[1]. Diabetes can cause multi-organ dysfunction and has been the fourth cause of death except for cardiovascular disease, cancer and chronic respiratory disease in the world [2], about 400 died of diabetes for those aged 20 to 79 years which is equivalent to one death every eight seconds and that is higher than the combined number of deaths from all infectious diseases [1]. Diabetes is also a costly disease to patient and society due to variety complications, global medical expenditure for diabetes treatment and related complications has reached 727 billion USD in 2017 which is 8% higher than the previous statistics released in 2015, but still insufficient [1].

According to the studies, patients’ self-management behavior is highly related to the control of the blood glucose effectively and the quality of life can be significantly improved[3, 4]. Therefore, self-management plays a key role in diabetes which includes diet, exercise, blood glucose monitoring, medication and foot care [5, 6].

Due to the popularity and convenience of smart phones, mobile application (APP) has become a new platform to manage diabetes. Most of APPs provide with blood glucose recordings, education and consultation function which help patients to monitor their conditions and improve self-management [7-10]. The use of APP can alleviate the contradiction between the increasing number of patients and the shortage of medical resources, visits are reduced and less cost as a result of individualized feedback through it no matter how far from health care professionals(HCPs) [11, 12]. Although
the applications were proliferating, most patients with diabetes have low utilization and satisfaction with APP, 44% of them didn’t use a APP because of not suitable or no benefit from it [13]. Besides, the effectiveness among different studies has been inconsistent and the best way for designing is inconclusive [14, 15].

The most studies related to mobile APP were focus on the effectiveness of it in self-management [3, 15-16], but rarely take the perceptions and experiences of users into account. The objective of the study was to conduct a meta- synthesis of qualitative researches which associated with mobile APP using experiences among diabetics for better understanding the advantages and shortcomings which may facilitate or hinder patients to employ and provided recommendations for future research.

**Methods**

PICo model was adopted to set out inclusion and exclusion criteria which was developed from PICO and recommended by Joanna Briggs Institute [17]. PICo were the abbreviation of Population, Population of Interest, and Context.

**Inclusion criteria**

Population and context

Diabetics who have used diabetes APP.

Population of Interest

Perceptions and experiences in APP using of diabetics.

Types of studies

Phenomenological, grounded theory, ethnography, action research and studies that described the experiences or perspectives of diabetes APP were included in this
meta-synthesis.

**Search strategy**

Two databases were searched through inception to June 2018 including PubMed and Web of Science and Cochrane Library, using the following search terms: (smartphone OR app OR mhealth OR application) AND (perception* OR experience* AND diabet*)

**Quality appraisal**

Two reviewers independently assessed the identified primary studies to inclusion in the review using a standardized critical appraisal instrument: The Joanna Briggs Institute Qualitative Assessment and Review Instrument (JBI-QARI). 10 questions were answered and a four-point scale was applied: yes, no, unclear, and not applicable [18]. The disagreements that arose between them were resolved through discussion with the third one.

**Data Extraction and Synthesis**

The data extracted from the studies included specific details about diabetics' experiences of diabetes APP, using the JBI-QARI data extraction tool. Following the critical appraisal, the reviewers individually reviewed the four studies using JBI-QARI reviewer's matrix, collecting data in a unified format. Data extraction both from quotations of participants and paraphrases by the authors of the primary studies were extracted using the JBI procedure for meta-synthesis [17].

**Meta-syntheses**

Meta-synthesis is a systematic evaluation method for qualitative research. It is a
method of collecting, understanding, comparing, analyzing and inducing the results of qualitative researches in the process of systematic evaluation [19]. By integrating the results of multiple qualitative researches, new comprehensive concepts, explanations, or conclusions can be formed. The integrated results can describe the meaning of each topic more reliable and comprehensive and reflect the generality and universality of each study make the results more generality.

Results

Preliminary search and screening

Fig.1 demonstrates the search results using a PRISMA flow diagram and four studies were included at last. One was focus on gestational diabetes, one was concentrated on Type 2 diabetes mellitus (T2DM) and the rest of them were related to Type 1 diabetes mellitus (T1DM). Table 1 summarizes the studies included in synthetic analysis which covers general information about APP.
Fig. 1 PRISMA Flow Diagram.
Table 1. Profiles of Studies included in synthetic analysis.

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Name of APP</th>
<th>Interview and analysis approach</th>
<th>Main functions</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gitte Reventlov Husted[20]</td>
<td>Purposive sampling. 20 young patients who with type 1 diabetes were included after a 12-month RCT was completed</td>
<td>Young with Diabetes</td>
<td>individual interview; Thematic analysis provided by Braun and Clarke</td>
<td>My page; Chat room; Information about; My department; Carbohydrate counting; Tips package; Reminder</td>
<td>Theme 1: Not Feeling Alone Living With T1DM Anymore Theme 2: Gaining Competence by Sharing Experiences and Practical Knowledge Theme 3: Feeling Safer Having the APP Theme 4: Breaking the Ice by Starting to Share Thoughts and Feelings and Asking for Help Theme 5: Lack of Motivating Factors</td>
</tr>
<tr>
<td>Brigid A. Knight[21]</td>
<td>7 participants with type 1 diabetes who had previously received flexible MDI (multiple daily injection) education program by attending the Dose</td>
<td>RapidCalc</td>
<td>Focus group interview; Thematic analysis provided by Braun and Clarke</td>
<td>counting carbohydrates; monitoring blood glucose levels; learn the impact of physical activity and alcohol on blood glucose and make anticipatory adjustments; record BG and additional</td>
<td>Theme 1: Bolus calculator features and trust Theme 2: Diary report features Theme 3: Satisfaction and control</td>
</tr>
</tbody>
</table>
**Adjustment for Normal Eating (DAFNE) program.**

**Sarah Pludwinski**[22]  
11 participants with type 2 diabetes were invited by phone or in person after completing the trial (ClinicalTrials.gov Identifier: NCT02036892)  
unspecified  
individual interview; Thematic analysis  
unspecified  
Theme 1: Smartphone and software  
Theme 2: The health coach  
Theme 3: Overall experience  
Theme 4: Frustrations in managing chronic conditions

**Jeanette B**[23]  
Purposive sampling, a total of 17 women who with gestational diabetes mellitus were interviewed 3 to 10 months postpartum after completing all parts of the Pregnant+ RCT  
Pregnant+  
individual interview; interpretative phenomenological analysis  
four main icons (blood sugar, food and beverages, physical activity, diabetes); real-time feedback on blood sugar values; information about healthy eating and drinking; information about physical activity  
Theme 1: Reactions to diagnosis  
Theme 2: Self-Management of GDM  
Theme 3: Experiences of using the Pregnant+ app  
Theme 4: The APP's impact on women's self-management of GDM and their diet  
Theme 5: Cooperation with health professionals
Quality appraisal

The outcomes of quality appraisal are demonstrated in Table 2. Three studies [20-22] illustrated qualitative research methods, and did not explain the philosophical perspective, so it was impossible to determine whether the philosophical perspective of the studies were consistent with the research methodology. The researcher plays a substantial role in the qualitative research process, there was no description on cultural background and individual values about researchers as well as the interactions between participants and researchers. In addition to the above defects, the other contents were clearly described. The totals of four studies were included for meta-synthesis.
Table 2. Quality appraisal results for included studies.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there congruity between the stated philosophical perspective and the research methodology?</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Unclear</td>
</tr>
<tr>
<td>Is there congruity between the research methodology and the research question or objectives?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Is there congruity between the research methodology and the methods used to collect data?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Is there congruity between the research methodology and the representation and analysis of data?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Is there congruity between the research methodology and the interpretation of results?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Is there a statement locating the researcher culturally or theoretically?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Is the influence of the researcher on the research, and vice-versa, addressed?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Are participants, and their voices, adequately represented?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
**meta-syntheses**

17 research results were extracted from the 4 studies through repeated understanding and analysis, similar results were combined into 6 new categories and integrated into 2 major themes.

**Theme 1.** Self-management and confidence are enhanced in disease control and diabetics obtain more support from HCPs.

*Self-management can be enhanced by adopting a diabetes APP*

Self-management includes measuring and recording blood glucose, exercising, maintaining a diabetes diet, and taking medication regularly [15]. Patients were interested in the feedbacks which were reply automatically by APP or HCPs after inputting blood glucose, diet, medication or exercise data. They would like to consider behaviors changing and employ rational reactions for better controlling. Data summarization and presentation, especially blood glucose, enable patients to understand their own health and disease management more intuitively, and choose advisable methods and habits with intent. APP can adjust insulin dosage according to the amount of exercise and alcohol consumption, reduce the incidence of hypoglycemia and it is convenient for patients to decide insulin usage amount, but there were also participants who ignored the function of insulin calculation, because the problem of the preset time frame cannot be fully included in the patient’s diet and movement. Reminders messages for monitor and recording can also strengthen the compliance of self-management.

*Have a better understanding of diabetes and strengthening confidence in management*

Patients felt more secure about disease management by reason of APP covered variety aspects of diabetes relevent minor problems and emergency management.
They thought it was more convenient to obtain knowledge in APP, just to make a click. Patients would be given more advice when diagnosed, but the information quality was uneven and they described that the health information in APP was consistent with the contents provided by HCPs, and the sources was reliable. In addition, it can make up for the deficiency of patients in outpatient education, because it was difficult for them to remember. It was more beneficial for the newly diagnosed to learn about diabetes due to their absence and lack of attention in the knowledge of how diabetes affected health. Creating a hobby checklist or guide related to personal life can facilitate patient recording and allow them to better understand the interaction between blood glucose and activities which can relieve the uncertainty and fear towards diabetes.

*Strengthen interaction with HCPs and peers, get more support from family members, and reduce negative emotions.*

HCPs can obtain dynamic data related to diabetes and give individualized guidance and feedback through APP. Patients were willing to share data and inner feelings through the online platform to facilitate communication for better understanding cause of disease and blood glucose fluctuations. Diabetics became more positive and motivated to participate in APP using and disease management under the supporting of HCPs.

Peers were familiar with disappointed, worry and challenges that patients faced. Patients can obtain new knowledge and skills in the process of experience exchange with peers. They changed self-care practices and applied new methods to cope with disease, especially in special situations, which was one of the ways to solve problems associated with diabetes. At the same time, they got more sense of control for diabetes, lower feelings of fear and loneliness and felt like being normal.

For patients, APP was a platform to break ice with their families which login APP
can observe disease data and challenges of living with diabetes, including psychological experience, negative emotions. Consequently, their families gain a deeper perspective on difficulties they faced in self-management. Families seemed more active in provide appropriate help instead of oral admonish.

Most patients felt sad and overwhelmed for the diagnosis of diabetes and didn’t know what the diagnosis implied. It was beneficial for them to gain more favor and understanding from HCPs, peers and families which played a positive role in their self-manage and assisted to alleviate negative emotions, such as frustration, concerns and feeling to be isolated.

**Theme 2. Problems and negative effects in use**

*Function defects and technic problems of APP*

Some of APPs needed to input blood glucose manually which is time-consuming for patients. Problems with the automatic transfer of blood glucose reading were happened in APP with wireless transmission function. Some patients expressed that they didn’t willing to take time in filling in manual. Meanwhile, the time segment can’t be distinguished and input error can’t be modified when filled readings manually.

*Gap between HCPs and APP using*

Health care providers knew less about APP, and provided little help when problems arise, and lack of guidance for APP using. Patients pointed out that in outpatient clinic visits, some doctors would ask them to show a paper record of blood glucose rather than the data recorded by the APP and just asked them whether they had used the APP superficially, so part of them stopped using APP because "the doctor always asked for my recording paper." Some of them said they had no interest in APP and preferred paper records.
**Adverse effects and improve recommendations**

Feedback also allowed patients to focus too much attention on blood glucose monitoring, resulting in excessive monitors or be intentional to input untrue data to get better feedback. Although they realized that self-management had positive effects on diabetes control, some of them still had a poor compliance in blood glucose recording, diet and drugs intake. Secondly, they were unconfident in relation to accuracy of blood glucose readings reflected in APP and considered APP as a burden. Patients who suffered comorbidities needed to pay attention to many aspects which hindering the use efficiency of APP.

In the later period of APP using, no content updated and less peer communication reduced the frequency and motivation of using willingness. Patients expected a comprehensive brochure for using guidance and delivered more detailed and in-depth health information in APP for specific conditions, notes and retrospective editing were needed for data recording. It was commendable for them to remove or hind features to simplify the user interface to structure a personalized screen. As for data safety, patients preferred to store data based in Web for the sake of protecting data in the situation of losing device. Despite these shortcomings, most patients still indicated that APP was very helpful and planned to continue to use.

**Discussions**

Diabetes APP is a promising tool for engaging patients in their own health care due to most people owns a smartphone and the number of APP increases rapidly as there are increasing diabetics globally. Part of the current diabetes APPs are equipped with comprehensive functions [10, 24-26], and some of them are designed for a specific aspect of self-management [27-31]. In general, APPs are provided with education, professional consultation, social support and data tracking which include
self-monitoring of blood glucose, medications, physical activity, diet and reminders[8]. It is feasible for patients to access different self-care guidance and reduce time-consuming in visit HCPs. In addition, APP seems a viable tool to strengthen the perception of self-care by contributing better information and health education to patients [32]. Multiple studies have convinced that diabetes APP plays a positive role in lifestyle modification and significant reduction in HbA1c in different types of diabetes [3, 15, 16]. Otherwise, it remains unclear how their functions contribute to the efficacy of apps and who benefit most from them [33].

Patients were fear about their disease when diagnosed and faced distress caused by their condition [34]. Symptoms of depression and distress are prevalent[35], depression has been reported to affect up to 40% of patients with diabetes, the incidence of diabetes-related emotional distress was 18%–45% which was associated with higher HbA1c and lower self-care[36]. Patients become more motivated and self-confident to deal with their diabetes through mobile health intervention, mainly by reducing the fear of not knowing how to deal with abnormal conditions. On the other hand, the influence on depression and distress was inconsistent between quantitative study and patient experience, a secondary analysis of a cluster randomized controlled trial indicated that there was no significant effect on depression and distress [28]. Otherwise, Chew et al. concluded that initial negative feelings should not be seen as a necessarily adverse factor in diabetes care [37]. More studies are needed to explore the effect of APP in diabetes-related negative
emotions.

Diabetes APPs should be safe and clinically effective for physicians to recommend them, should reduce costs of care for insurers to support them, and should be acceptable and engaging for users to adopt and retain them [33]. There are 1019 Android and 1303 iOS APPs for diabetes self-management [38]. However, most of them lacked a theoretical foundation and did not take patient requirements and preferences into account in the development process [25]. The contents were inconsistent with medical guidelines or clinical best practices. Few of them have been assessed and approved by regulation bodies and it is hard to ensure the quality and efficacy of APPs. As a result, it is difficult for HCPs and patients to choose a safe and reliable APP among the available APPs [39]. In addition, the needs are different according to the type of diabetes, T1DM are more desirable functions of ratio wizard, logging of insulin and glucose-monitoring compared with T2DM [40]. It is essential for researchers to realize in-depth demand in target people using user-centered design and holistic approach which aimed at promote active involvement in APP development process and enables designers and users to learn from each other through understanding each other’s perspectives and priorities through focus group, individual interview, workshop or usability evaluations [41,42]. The information in APP should be evidence-based and in accordance with clinical guidelines to instruct patients in a right way. The needs are also significant different between older and
younger diabetics [8], cognitive and physical skills are declining in older adults and experiences in handling smartphone are limited [43]. The elderly focused on additional benefits and ease of use for the acceptance of diabetes APP [44]. They could benefit a lot from diabetes APP due to rapid prevalence. However, few studies showed sufficient consideration of usability requirements of the elderly. It is worth paying attention to develop APP for the management of diabetes in them. Collecting feedbacks from users are also necessary for designers which is an effective way to improve usability and satisfactory of diabetes APP.

In order to make patients have a better use of experience, it is necessary to make and provide a user guide for target people to improve the usability of APP. Tutorial is a considerable approach for facilitating independent use [4]. Established a helpline and solve technical confusions by professionals which may happen in using process are positive factors for long-term usage. The attitude of HCPs towards diabetes APP affects the use of patients. Patients are more inclined to adopt and trust it under the recommendation of HCPs. Most of studies are focus on patient’s using experiences, using readiness and experiences are less explored in HCPs. There were challenges for HCPs to introduce and support APP, reasons include a lack of technical competence, experience with APP , they may require additional training and guidance to feel comfortable introducing the APP to patients [25].Researches directed at APP using in HCPs are needed more to promote diabetes APP’ promotion
and patient’s long-term use.

Limitations

There is a possibility that some literatures have not been included due to the limited purchase of databases in organization where we study, in addition, grey literatures exit that were not included either, results of our study may be supplemented if those could include. Secondly, this meta-synthesis is limited by our inclusion criteria which deliberately focused on researches in English and lead to selection bias.

Conclusions

The purpose of this study was to provide a comprehensive understanding of the experiences of diabetics which using diabetes APP to manage their condition. Diabetes APP is a helpful tool to initiate and maintain self-management of diabetics and provides an exchange platform among patients, HCPs and families in which patients have more opportunities to obtain social support and professional care. Guide brochure and the introduction of HCPs have a positive effect on patients’ adoption. Updating functions interface or content in regular is beneficial to improve user experience and promote long-term use. There are challenges for HCPs to introduce and support APP to users and specific training is also necessary for them. Further high-quality qualitative study is needed to better understand requirements and using experience of diabetics, HCPs or other stakeholders.

Conflict of interest

None declared.

Authors’ contributions

Xiaoyan Lv led and coordinated the project. She participated in conceiving the research questions, developed the research design, coordinated other team members’ efforts, collated and analyzed the data, extracted findings, and drafted the manuscript.
Yingjuan Cao participated in designing, and conceiving, refining and focusing the project’s research question. She reviewed the projects findings and participated in editing the manuscript.

Jinghua Xia & Ran Tan analyzed the data, extracted findings, participated in thematic development and edited the drafted.

Polun Chang participated in conceiving, refining and focusing the project’s research question. He reviewed the projects findings and participated in editing the manuscript.

Acknowledgement

This work was supported by Shandong science and technology agency [grant numbers 2017GSF218001].
References:


18. Jordan Z, Lockwood C, Munn Z, Aromataris E. Redeveloping the JBI Model of Evidence Based


27. Munster-Segev M, Fuerst O, Kaplan SA, Cahn A. Incorporation of a Stress Reducing Mobile App in the Care of Patients With Type 2 Diabetes: A Prospective Study. JMIR Mhealth Uhealth 2017 May; 5(5): e75. [DOI: 10.2196/mhealth.7408][ PMID: 28554881]


34. Jacobs B, Men C, Bigdeli M, Hill PS. Limited understanding, limited services, limited resources:


42. Castensoe-Seidenfaden P, Reventlov HG, Teilmann G, Hommel E, Olsen BS, Kensing F. Designing a Self-Management App for Young People With Type 1 Diabetes: Methodological Challenges,


**Abbreviations:**

HCP: health care professional

JBI-QARI: Joanna Briggs Institute Qualitative Assessment and Review Instrument

T2DM: Type 2 diabetes mellitus

T1DM: Type 1 diabetes mellitus