

# The use of M-Health interventions for gestational diabetes mellitus: A descriptive literature review

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## Abstract

This study was attempted to review the evidence for or against the effectiveness of m-health interventions on health outcomes improvement and/or GDM management. Based on our findings, m-health interventions could enhance GDM patients' pregnancy outcomes. M-health can be one of the most prominent technologies for the management of GDM.

## Abbreviations:

GDM= gestational diabetes mellitus

SMS= short message service

M-Health= mobile health

## 1. Introduction

High-risk complications are estimated to occur in 10 percent of pregnancies and the evidence reveals the growing rate of high risk pregnancies(1). One of the most common complications that can occur during pregnancy is gestational diabetes mellitus (GDM) (2, 3), accounting for more than 80% of diabetes cases during pregnancy(2). GDM is found in 2% to 16% of all pregnancies(4), affecting about 150,000 pregnancies annually (5, 6). GDM affects both mother and child(7), and poses mother and child at risk of preeclampsia, cesarean delivery, congenital anomalies, fetal macrosomia, and the later development of type 2 diabetes(8). Given the increasing prevalence of GDM, new challenges are developed for health care professionals in antenatal care (9). High-risk pregnancies are often managed by hospitalizing patients for days and sometimes even weeks, leading to increase of financial burden (10) and stress for the patients (11). By proper monitoring, the risk and the disease costs will be reduced for a pregnant woman (12-14).

The recent advances in medical devices couple with development of intelligent sensors, Internet of Things (IoT), efficient telecommunication and information based smart decision support system (DSS), and m-health technologies have unlocked the door of ample opportunities for patients' remote monitoring and health parameters tracking , thus enabling a paradigm shift in maternal health care (13, 15).

Recently, the dramatic advancements of information and communication technologies (ICTs) in health care has led to the development of m-health, creating substantial improvement in the provision of health services (16). M-health interventions have been developed along with technology advances (17). The widespread

adoption of mobile phone technologies offers a promising opportunity to promote diabetes care and self-management (18-20) through creating an active interaction between patients and healthcare professionals (9, 20).

The increasing storage capacity of mobile phones along with Wi-Fi accessibility represent the opportunity to offer mobile applications with the capabilities of tracking one or more health parameters such as glucose, diet, exercise and medication (19, 21-25). Mobile phone text messaging has enabled the provision of timely access to health advice, prompt self-monitoring, and individuals education about preventive health care services (26). Immediate delivery of short messages or direct calls to individuals is facilitated by mobile phone. Patients can be reminded over the cell phone at the time of the blood glucose measurement or other event (medication), leading to improvement of HbA1c levels and self-care regarding diet, medication, and exercise (20). Following emergent of m-health interventions in GDM, the development and evaluation of individual interventions have attracted more attention by the researchers. The previous systematic reviews either have focused on the effectiveness of m-health interventions (4, 16, 27-34) or on a single condition (35-38). However, minimal evidence has been provided on the healthcare utilization or cost analyses.

Therefore, the present study was attempted to systematically review the effectiveness of GDM-related m-health interventions from different perspectives. Recently, m-health has been introduced as a novel approach in GDM management. The delivery of face-to-face support has been examined in previous research; however, little is known about the implementation of m-health as a possible alternative form of health service delivery for GDM patients. The aim of this descriptive literature review was to assess the evidence provided for or against the efficacy of m-health in GDM monitoring.

## 2. Material and Methods

### 2.1 Search strategy

Based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), we did our study (39). Databases of PubMed, Web of Science, Embase, and Scopus were searched from 2000 to July 10, 2018. The searches were not limited by language (studies in other languages were omitted due to incompatibility with the aim of this study).

The searches were done using the keywords of mobile health (m-health) and GDM. For the purpose of this review, m-health was defined as the use of technology to provide healthcare for patients with GDM using short message service (SMS), mobile application, and telemedicine system based on smartphones.

The stages for building the search query for the PubMed database are shown in table 1. With respect to the instructions provided for each database, equivalent searches were then performed. Findings of each study were analyzed, relevant information was extracted, and finally obtained data were synthesized. The objectives and findings of each study are summarized in table 2.

#### Table1. PubMed search query

### 2.2 Inclusion and exclusion criteria

In this study, all articles evaluated the effectiveness of m-health on GDM management by using m-health tools such as telemedicine system based on smartphones, m-Health, short message service (SMS), and mobile applications were included. Reviews and unpublished dissertations, commentaries, opinion papers, editorials, summaries were not considered. Studies that used telemedicine intervention without mobile phone, reported functions and implementation of the interventions unclearly, or presented descriptions of information technology were excluded.

### 2.3 Selection of studies

Selection of studies was done using four stages and based on PRISMA flow-diagram (39). In the first stage, identification, studies identified through database searching were collated in ENDNOTE software,

and duplicates were omitted. In the second stage, two reviewers independently screened the titles and abstracts and removed irrelevant articles.

In the third stage, the full-text articles were independently evaluated for eligibility by the reviewers. In the fourth phase, the two reviewers (MZ and ZK) compared and verified their findings. Any disagreement was resolved either through discussion or involving a third reviewer (YGH). Information such as author, year, study design, m-health intervention, outcome, and results were retrieved.

## Results

In Figure 1, the article selection process is demonstrated. Observing our defined inclusion and exclusion criteria, 27 studies were selected: 12 randomized controlled trials (RCTs); eight pilot studies; one cross-sectional study; two non-randomized controlled trials; one case study; one prospective observational study; one qualitative study; and one development and test study.

### Figure 1. PRISMA Flow diagram of search strategy.

The findings of the included studies with regard to efficacy of m-health interventions are summarized in Table 2.

Among the 27 studies, 26% (7/27) used smartphone, without referring to its type, 14.9% (4/27) used the SMS, 33.3% (9/27) used mobile-based applications, 18.5% (5/27) used telemedicine based on smartphones, and 7.1% (2/27) used SMS reminder system to investigate the efficacy of m-health interventions. Mostly, these studies supported the efficacy of m-health interventions (n=4) (40-43).

### Table2. Reviewed papers' characteristics and M-Health interventions and results from studies

## 3. Discussion and Conclusions

To manage disease and reduce the impact of chronic diseases, mobile health technologies can be useful through promotion of healthy behavior (15, 66, 67). These newly introduced technologies can be served as self-monitoring tools for individual patients (68-70) and can effectively enhance women's health (71).

Literature review has supported the efficacy of mobile-health interventions in the management of diabetes, contributing patients, especially GDM patients (to control their blood sugar levels (20, 31, 72-80).

In the current investigation, all findings in this regard are presented using a structure composed of four main categories of m-health intervention. In the following these four branches are explained:

**1. smartphone-based:** Smartphones to support various aspects of care and patient-clinician interactions, provide high quality care and to support self-management of GDM (46, 47, 54, 57, 58, 62), The use of m-health can increase GDM patients' compliance with lifestyle interventions and reduce future risk of T2DM and its sequelae (81); however, this result was not supported by McLean et al (41).

**2. Smartphone-based telemedicine system:** The impact of telemedicine interventions on GDM management have been investigated by a number of studies (43, 44, 48, 63, 65). For instance, some studies have revealed the efficacy of telemedicine system in monitoring glucose, improving pregnancy outcomes in women with GDM, and enhancing quality of life of pregnant women with diabetes (44, 48, 63, 65). These findings are in line with the results of other studies (4, 82, 83). Nevertheless, Homko et al (43) and Rasekaba et al (82) found no association between using a telemedicine system and pregnancy outcomes improvement.

**4. SMS and reminders:** Studies have demonstrated the potential and important role of SMS in altering the current paradigm of pregnancy care among women suffering from GDM (49, 52, 61). Poorman has supported the usefulness of SMS for maternal and infant health, especially for women who cannot outreach traditional communication methods (33). Another study has revealed that Text4baby, a free mobile health information service delivering health-related SMS to pregnant and postpartum women, can enhance physical activity participation (84). Given that most of women suffering from GDM do not present for postpartum glucose testing despite recommendations, SMS can play an important role in increasing *postpartum return*

rate of *women* with GDM for diabetic screening test (56), However, Van Ryswyk has not confirmed this finding (40).

**3. Mobile application:** Nine out of 27 selected studies have evaluated the efficacy of mobile applications. Eight ones have provided evidence supporting the usefulness of mobile applications for managing GDM (9, 45, 50, 51, 53, 55, 59, 64). In contrast, Kennelly et al (42), in line with two other studies (85, 86) have reported lack of association between GDM management and using mobile applications.

Patient's satisfaction is one of the key issues in using mobile devices. We found that six studies (46, 47, 49, 51, 57, 61) have addressed the effect of m-health interventions on patient's satisfaction, revealing higher satisfaction level in pregnant women who received prenatal support via mobile phone. This finding is in line with findings of previous study (87, 88), Kim et al., also have demonstrated the association between high level of user satisfaction and using diabetes notepad application and the positive effect of this application on diabetes self-management (75).

Six studies have evaluated disease costs and reported that m-health intervention are economically cost effective benefit and can reduce disease costs (49, 51, 54, 58, 61, 64).

Considering the widespread use of mobile phones, various m-health tools have been developed for disease management and monitoring. However, the most effective tool for the management of GDM has not been reported yet. Therefore, in this systematic review, we have summarized the findings of previous studies on the effect of m-health interventions on GMD management.

The major limitation of this study is that only 4 databases were searched that could have led to missing of high-quality articles on m-health intervention for GDM. Published studies on GDM-related m-health interventions are increasing; however, the results are not consistent. Therefore, further evaluations are needed to obtain consistent conclusions regarding the usefulness of m-health interventions for GDM management. Future research are recommended to evaluate m-health interventions using multiple functions or stages, especially those popular outside clinical practice. we can conclude that m-health intervention is one of the most important technologies for GDM management.

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**Key Message:** Due to the risks of gestational diabetes and the growing incidence of this disease, by proper monitoring, the risk and the disease costs will be reduced for a pregnant woman. The widespread adoption of mobile phone technologies offers a promising opportunity to promote diabetes care and self-management by promote healthy behavior.

**Conflicting interests:** None Declared/ The Author(s) declare(s) that there is no conflict of interest.**Ethical approval:** Not Applicable**Contributorship:** MZ and YGH researched literature and conceived the study. MZ and YGH designed the study and conducted the search. MZ, AY, ZK, MA and MS selected articles for inclusion according to the inclusion/exclusion criteria. MZ wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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**Table1. PubMed search query**

Step in search Strategy	Search term
1	mobile health OR mobile OR mhealth OR m-health OR mobile technology OR smartphone OR m
2	(Diabetes, Pregnancy-Induced) OR (Diabetes, Pregnancy Induced) OR (Pregnancy-Induced Diab
3	2000/01/01:2018/11/15[dp]
4	1 AND 2 AND 3

**Table2. Reviewed papers' characteristics and M-Health interventions and results from studies**

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
		study design	smart- phone	telemedicine system based on smart- phones *	SMS	App	
Ping Yang, 2018(44)	The effect of WeChat platform- based treatment on the risk of perinatal complica- tions among women with GDM.	Non- Randomized Study					WeChat platform- based treatment could effectively reduce FBG and 2-h PBG and improve pregnancy outcomes.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Skar, 2018(45)	The effect of smart- phone app (the Preg- nant+ app) on controlling blood glucose levels and receiving health and nutrition informa- tion in women with GDM.	RCT				*	Smartphone app could assist women with GDM to control their blood glucose and increased their confidence in self- management.
Miremberg, 2018(46)	The impact of a smartphone- based daily feedback and communi- cation platform on GDM patients' compli- ance, glycemic control, pregnancy outcome, and satisfaction	RCT	*				Smartphone- based technology could enhance the adherence to self- performed BG moni- toring and glycemic control parame- ters such as mean blood glucose, off-target measure- ments, and the need for insulin treatment.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Mackillop, 2018(47)	The use of a mobile phone-based real-time blood glucose management system to control GDM patients' blood glucose.	RCT	*				Remote monitoring of blood glucose is safe in women with GDM.
Rigla, 2018(48)	The efficacy of smart mobile telemedicine in monitoring blood glucose of GDM patients.	Pilot Study		*			This study This decision support system was a feasible and well-accepted system for monitoring GDM.
Kennelly, 2018(42)	The impact of a healthy lifestyle package using smart-phone application technology on the prevalence of GDM in overweight and obese women.	RCT				*	This intervention could not decrease the prevalence of GDM.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Johnson, 2018(49)	The effect of short messaging reminders on diabetes self-management in women with GDM	RCT			*		. The use of daily text messages was acceptable for patients with GDM seems. In addition, an overall satisfaction with the messages and willingness to use the messages in future pregnancies and to recommend the messages to friends with GDM were obtained.
Garnweidner-Holme, 2018(9)	The usefulness of culture-sensitive pregnant application for pregnant women with GDM according to health care professionals' perspectives	Qualitative Study				*	M-Health intervention was a useful tool to improve the care provided by health care professionals to women with GDM.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Peleg, 2017(50)	The Mo- biGuide's feasibility and potential impacts on patients and care providers using two various clinical domains.	Pilot Study				*	This system has provided multiple benefits for both patients and physicians and increase the patients' sense of safety and involvement. MobiGuide's is feasible for patients and clinicians and has led to high compli- ance to self- measurement recom- menda- tions and enhance the satis- faction of patients and care providers.
Peleg, 2017(51)	The system's feasibility and potential impacts on patients and care providers using two various clinical domains.	Pilot Study				*	

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
McLean, A. 2017(41)	The efficacy of real-time smart- phone data in improving clinical manage- ment and outcomes of women at GDM risk	Pilot Study	*				Real-time individual health and sensor data can be readily collected and analyzed efficiently while con- fidentiality is main- tained; however, improved prediction of GDM is not obtained.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Nicholson, 2016(52)	The efficacy of a web-based pregnancy and postpartum behavioral intervention in contributing women with GDM to control weight and glucose during pregnancy and postpartum.	RCT			*		The web-based behavioral intervention coupled with text messages and emails and tailored to the needs of women with GDM is feasible and well received by participants. This study also shows that GooD-Moms can change the current paradigm of pregnancy care for women with GDM.



Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Marko, 2016(53)	The feasibility of remote monitoring of patients for prenatal care using a mobile phone application and connected digital devices.	Prospective Observational Study				*	This intervention is feasible for prenatal care.
Wickramasinghe, 2015(54)	The usefulness of mobile technology for supporting and enabling superior diabetes monitoring and management.	Case Study	*				Mobile technology is an appropriate choice to minimize costs and provide high-quality care.
Jo, 2015(55)	The efficacy of an application providing tailored recommendations based on user's lifestyle and clinical data.	Development and Test Study				*	The GDM management knowledge and tailored recommendations provided in this study were beneficial in managing GDM.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Van Ryswyk, 2015(40)	The effect of SMS reminder system on postpar- tum oral glucose tolerance test, fasting plasma glucose, and HbA1c completion.	RCT			*		The SMS reminder system cannot enhance postpar- tum OGTT, fasting plasma glucose, or HbA1c completion.
Mohd Suan, 2015(56)	The prevalence and char- acteristics of patients who did and did not return for the OGTT and the reasons provided by women for failure to return for OGTT test.	Cross- sectional Study			*		The prevalence of women who returned for the postpar- tum diabetic screening test was high. This study also provides valuable insights into several obstacles that render the return for the glucose tolerance test.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Hirst, 2015(57)	Women's satisfaction with using the GDM-health system and their attitudes toward their diabetes care.	Pilot Study				*	GDM-health was acceptable and convenient for a large proportion of women.
Teoh, 2014(58)	The efficacy of smart-phones on GDM Monitoring among Australian women.	RCT	*				The use of smart-phones to support GDM self-management facilitates superior monitoring and management of GDM and supports the accountable care paradigm.
Kaplan, 2014(59)	Efficacy of a mobile application and web-based system in promoting self-management of women with GDM.	Pilot Study				*	This mobile application and web-based system can promote self-management of women with GDM

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Grabosch, 2014(60)	The feasibility of a text message reminder system for pregnant women with diabetes from a low-income population, and its impact on adherence to a diabetes care regimen and subsequent glycemic control	RCT			*		The text message reminder system is feasible for pregnant women with diabetes from a low-income population and Text4baby can be used as an educational tool to improve outcomes in women with diabetes.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Shivanath, 2014(61)	The feasibility of 'Simple Tele-health' for women with gestational diabetes, patients' treatment satisfaction with this intervention, and the economic benefit of this system in conjunction with routine antenatal diabetes care.	Pilot Study			*		Short-term use of 'Simple Tele-health' is associated with high treatment satisfaction levels amongst patients with GDM and some economic benefits.
Homko, 2012(43)	The impact of an enhanced telemedicine system on glucose control and pregnancy outcomes in women with GDM.	RCT		*			Enhanced telemedicine monitoring system increased contact between women with GDM and their healthcare providers but did not influence on pregnancy outcomes.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Shea, 2011(62)	The effect of a reminder system on screening rates.	RCT	*				Reminders can be an effective method for reinforcing guidelines for post- partum diabetes screening.
P ´erez- Ferre, 2010(63)	The feasibility of a telemedicine system based on Internet and a short message service for pregnant women with GDM and its influence on their delivery and neonatal outcomes.	RCT			*		A telemedicine system can be a useful tool in the treatment of GDM patients. This study suggests this inter- vention as a comple- ment to conven- tional outpatient clinic visits, especially in cases requiring tighter glycemic control or with difficulties in accessing to medical center.

Author, Year	study objective		the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	the type of mHealth medium	Outcome (Main findings)
Wickramasinghe, 2010(64)	The effect of a wireless technology on man- agement of GDM	Pilot Study	*				DiaMonD is a conve- nient, cost- effective, and superior interven- tion to manage GDM.
Dalfrà, 2009(65)	The effect of a telemedicine approach on diabetic pregnancy manage- ment, glycemic control, quality of life, and maternal and fetal outcomes.	Non- Randomized Study		*			The use of a telemedicine system for glucose monitor- ing has improved pregnancy outcome and quality of life in women with GDM

Figure 1. PRISMA Flow diagram of search strategy.

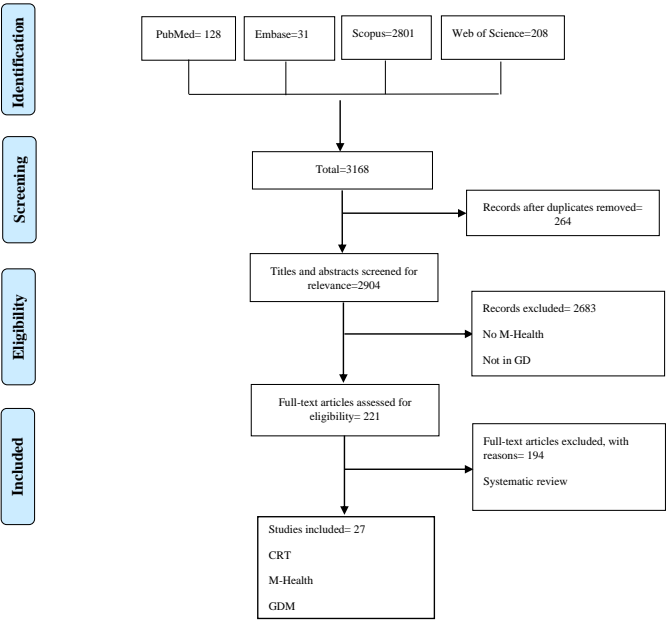


Figure 1. PRISMA Flow diagram of search strategy.