Authors' copy of Edwards, K., Maslin, K., Andrade, J., Jones, R. & Shawe, J. (2021). Mobile health as a primary mode of intervention for women at risk of, or diagnosed with, gestational diabetes mellitus: a scoping review. *JBI Evidence Synthesis.* doi: 10.11124/JBIES-21-00294

Mobile health as a primary mode of intervention for women at risk of, or diagnosed with, gestational diabetes mellitus: a scoping review

Abstract

Introduction: Prevention and management of GDM and its associated adverse outcomes are important to maternal and infant health. Women with GDM report high burden of disease management and barriers to lifestyle change post-delivery which mHealth interventions may help to overcome. Evidence suggests apps could help GDM prevention and management, however, less is known about broader applications of mHealth from preconception to interconception and whether relevant behavior change techniques (BCT) are incorporated.

Objective: To map the extent of knowledge related to the use of mHealth as primary mode of intervention for the prevention and management of GDM and its long-term implications among women at risk of or diagnosed with GDM. We also sought to understand if mHealth for women at risk of or diagnosed with GDM incorporated relevant behavior change theory and techniques.

Inclusion criteria: Studies, published in English, considered for inclusion focused on mHealth use as primary mode of intervention for the prevention and management of GDM and its long-term implications. Telehealth or telemedicine were excluded as these have been reviewed elsewhere.

Methods: Six databases were searched during March 2021; MEDLINE (Ovid), CINAHL (EBSCO), EMBASE (Ovid), Cochrane Database (Wiley), Scopus, and TRIP. No limits were applied to database exploration periods to ensure retrieval of all relevant studies. Also gray literature; Open Grey, ISRCTN Registry, ClinicalTrials.gov, EU Clinical Trials register, and ANZCTR. Two reviewers independently screened abstracts and assessed full texts against the inclusion criteria. Data were extracted using an adapted version of the JBI results extraction instrument. Data are presented in narrative form accompanied by tables and figures.

Results: This review identified 2166 sources, of which 96 full-texts were screened. Thirty eligible reports were included, covering 25 different mHealth interventions. Over half (14/25) were for self-managing blood glucose during pregnancy. Common features included tracking blood glucose levels, real-time feedback, communication with professionals and educational information. Few (6/25) mHealth were designed for postpartum use and none for interconception use. Five for postpartum use supported behavior change to reduce risk of type 2 diabetes and included additional features such as social support functions and integrated rewards. Early development and feasibility studies used mixed

methods to assess usability and acceptability. Later stage evaluations of effectiveness typically used randomized controlled trial designs to measure clinical outcomes such as glycemic control and reduced body weight. Three mHealth interventions were developed using behavior change theory. Most mHealth incorporated two BCTs shown to be optimal when combined and those delivering behavior change interventions included a wider range. Nevertheless, only half of the 26 techniques listed in a published behavior change taxonomy were tried.

Conclusion: mHealth for GDM focusses on apps to improve clinical outcomes. This focus could be broadened by incorporating existing resources that women value, such as social media, to address needs such as peer support. Although nearly all mHealth interventions incorporated BCTs, findings suggest future development should consider selecting techniques that target women's needs and barriers. Lack of mHealth intervention for prevention of GDM recurrence and T2DM suggests further development and evaluation is required.

Keywords: diabetes**,** gestational; mHealth; postpartum period; interconception; behavior change techniques

Abstract word count: 499

Introduction

Rapid development of technology has led to a quickly growing market for mobile health (mHealth), defined as "use of mobile and wireless technologies, such as mobile phones and personal digital assistants (PDAs), to support the achievement of health objectives".[1] Globally, smartphone ownership is estimated to be 78% in 2020.[2] An mHealth economics report found that apps for diabetes were one of the strongest markets within digital health innovation[3], however, there are comparatively few apps targeting the prevention and management of Gestational Diabetes Mellitus (GDM).[4] GDM defined as "'carbohydrate intolerance resulting in hyperglycemia of variable severity with onset or first recognition during pregnancy'[5] presents as a significant pregnancy complication, and if not managed well, can result in adverse maternal, fetal and neonatal outcomes[6,7]. Longer-term implications for maternal health include reoccurrence of GDM in future pregnancies, and development of type 2 diabetes; two outcomes found to be independently associated with higher body mass index (BMI) (≥25kg/m^2)[8,9]. The prevalence of GDM is increasing worldwide[10] and in the UK, is expected to develop in 16 out of every 100 women.[11]

Effectively managing GDM following diagnosis is key to reducing the likelihood of adverse outcomes. Combinations of intervention such as dietary modification, exercise, blood glucose self-monitoring and/or pharmacological treatment are found to reduce most adverse perinatal outcomes compared to standard care.[12] mHealth interventions can offer highly scalable solutions to support disease management and prevention and have the advantage of being low cost, tailored to individual needs and have the ability to relay data to healthcare professionals. Commonly used mHealth technologies include apps, wearable sensors, social media, websites, and videoconferencing. In a recent survey of 63 women in the UK, most of whom had GDM, 43/63 (73%) used smartphones to obtain health or pregnancy related information, and only 16/63 (25%) expressed concerns about using an app to monitor diabetes, suggesting an appetite among women with GDM for digitally supported services.[13]

A recent literature review by Nikolopoulos et al. aimed to identify and appraise apps implemented by healthcare providers for GDM care.[14] Three apps for supporting blood glucose monitoring were included. The review concluded that apps were a useful and practical way of reducing the burden of GDM. A scoping review, conducted in 2017, consolidated knowledge around the implementation, functionality, impact, and role of health literacy of mobile apps for GDM.[15] Seven different apps described across 12 articles were included and authors concluded that mobile apps have the potential to support prevention and management of GDM. However, consideration of health literacy may enhance usability and engagement and larger scale trials are required to evaluate app impact on health outcomes. While both these reviews show encouraging support for mobile apps for use in GDM care, particularly during pregnancy, we aimed to broaden the scope of this knowledge in a number of ways.

Firstly, we sought to explore the development, implementation and evaluation of all types of mHealth (rather than just apps) including, wearable sensors, websites and social media. Secondly, while the reviews by Nikolopoulos *et al.*[14] and Chen *et al.*[15] focus on app use prior to and during pregnancy, this review aimed to also include studies looking at the development, implementation or evaluation of mHealth to support women in the postpartum and interconception periods. Risk of progression to T2DM is estimated to be 10 fold higher in women with GDM compared to their normoglycaemic counterparts[16] and reoccurrence of GDM is thought to arise in 30% to 84% of subsequent pregnancies.[6] Consequently, the interconception and postpartum periods provide key windows of opportunity to reduce the likelihood of future GDM pregnancies, as well as onset of T2DM.[17] However, women with previous diagnosis of GDM encounter several barriers to engaging in face-to-face interventions, including time and financial constraints, childcare duties, fatigue and lack of motivation.[18] Thus, delivery of care via telephone or internet has been suggested as an optimal way of supporting this population during this time.[19]

In addition, following delivery, the transition from maternity to primary care is often complex and women report feelings of abandonment.[20] Studies report a lack of consensus on responsibility for follow-up care among professionals[21] and inconsistencies in information provided to women.[22] With this in mind, this review also sought to understand, how, when and where mHealth were implemented across preconception, pregnancy, postpartum and interconception periods.

Consequently, we developed and published a protocol for a scoping review aiming to provide an overview of the extent of the knowledge related to the use of mHealth as a primary mode of intervention for the prevention and management of GDM and its long-term implications among women at risk of or diagnosed with GDM.[23] The objectives of the proposed review were to identify gaps in knowledge by mapping the characteristics of all types of mHealth, their implementation contexts, and how they were evaluated. The proposed review also sought to understand if mHealth were developed using relevant behavior change theory. These objectives remain. However, during data extraction we discovered limited acknowledgement of behavior change theory among mHealth development, a finding congruent with the findings of Chen et al.[15]. Behavior change is an important concept throughout GDM prevention and management. Women must enact significant changes to their lifestyle in order to control and monitor their blood glucose levels (BGL), and to reduce risk of T2DM or recurrent GDM in future pregnancies. In order to further understand if mHealth of GDM included theory-based components we additionally extracted data on inclusion of behavior change techniques (BCTs). BCTs were identified using the 26-item taxonomy developed by Abraham and Michie.[24] This taxonomy was developed using variety of theoretical accounts of behavior change and each BCT can be mapped to various theoretical frameworks and therefore serves as a 'proxy' measure of theory-based development. An evaluation of diabetes apps found few included relevant BCTs.[4] One commercially available app for GDM was included in Hoppe et al's review, however, to-date no review has examined the use of BCTs across mHealth interventions developed specifically for GDM.

The objectives of this scoping review were, therefore, twofold: 1) to provide an overview of the extent of knowledge related to the use of mHealth as primary mode of intervention for the prevention and management of GDM and its long-term implications among women at risk of or diagnosed with GDM and 2) to understand if mHealth for GDM incorporated relevant behavior change theory and techniques.

A preliminary search of PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews, JBI Evidence Synthesis and the JBI Database of Systematic Reviews and Implementation Reports was conducted and no current or underway systematic or scoping reviews on the topic were identified. To the best of our knowledge, this scoping review is the first to address the objectives stated above. This review was conducted in accordance with an *a priori* protocol[23] but with the addition of extracting data regarding BCTs.

Review question(s)

1) What is known about using mHealth as a primary mode of intervention for the prevention and management of GDM and its long-term implications among women at risk of and diagnosed with GDM?
2) Do mHealth interventions for women at risk of and diagnosed with GDM, incorporate relevant behavior change theory and techniques, where appropriate?

Inclusion criteria

Participants

This review considered studies that included women who are at risk of GDM, currently have or have previously had a diagnosis of GDM. We acknowledge that women who have pre-existing diabetes (type1 or type 2) will continue to experience diabetes during pregnancy; however, because the focus of this review was on GDM, we excluded studies primarily focused on, or including, women with pre-existing Type 1 or Type 2 diabetes. Because we wanted to understand use of mHealth among women with a previous diagnosis of GDM (inter-conception and postpartum periods) no limit was placed on time since pregnancy occurred. No limits were placed on the inclusion of women with regards to their age, body weight, other comorbidities, mode of conception (e.g. physiological, assisted), or pregnancy status (e.g. single, multiple).

Concept

This review considered studies examining mHealth for GDM. mHealth has been defined as the use of mobile and wireless technologies to support the achievement of health objectives.[1] We included studies examining all types of mHealth technologies such as smartphone apps, wearable sensors, and social media use. Other types of mHealth were considered for inclusion but did not feature in the

studies selected for inclusion in this review. Studies focused on telehealth or telemedicine for GDM care, were excluded as these have been systematically reviewed elsewhere.[25] In cases where studies included mHealth as one component of a broader interventional approach, mHealth must have been the primary mode of intervention delivery to be considered for inclusion in this review.

Context

This review considered studies that were conducted in any geographical location and any setting (such as diabetes clinics, other hospital settings, primary care, community care and at home). With no commonly established implementation route, we aimed to include all settings within this review. With reference to our aim of understanding mHealth use for GDM before, during and after pregnancy we considered studies that examined mHealth during preconception, pregnancy, inter-conception and postpartum periods. We posed no limit to the timeframe of these periods as definitions can vary across different contexts. We posed no limit on study date as mHealth is a relatively new concept and we aimed to ensure the retrieval of all relevant studies.

Types of sources

This scoping review considered both experimental and quasi-experimental study designs including randomized controlled trials, non-randomized controlled trials, before and after studies and interrupted time-series studies. Study protocols were also considered for inclusion. Any systematic reviews that met the inclusion criteria were retrieved and their original source papers were searched for eligibility for inclusion.

In addition, analytical observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies were considered for inclusion. We also considered descriptive observational study designs including case series, individual case reports and descriptive cross-sectional studies for inclusion. Qualitative studies were also considered that focus on qualitative data including, but not limited to, designs such as phenomenology, grounded theory, ethnography, qualitative description, action research and feminist research. Only studies published in English were included.

During the pilot search conducted during protocol development and prior to the full search strategy being developed, a google search of key words was undertaken and the first 5 pages reviewed. Only published literature was retrieved from this search and therefore this review focused on empirical studies only.

Methods

This scoping review was conducted in accordance with the Joanna Briggs Institute methodology for scoping reviews.[26,27] ~~This review was conducted in accordance with an *a priori* protocol[23] but with the addition of extracting data regarding BCTs.~~

Search strategy

The search strategy aimed to locate published studies. An initial limited search of Scopus and MEDLINE was undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy. The search strategy, including all identified keywords and index terms, was adapted for each included information source and a second search was undertaken. The full search strategies for each database are provided in Appendix I. The reference lists of all studies selected for inclusion were hand searched for additional studies.

Information sources

The databases searched were MEDLINE (via Ovid), CINAHL (via EBSCOhost, USA), EMBASE (via Ovid), Cochrane Database (via Wiley, USA) Scopus, and TRIP. Sources of unpublished studies and grey literature were searched using Open Grey, ISRCTN Registry, ClinicalTrials.gov, EU Clinical Trials register and ANZCTR.

Study selection

Following the search, all identified citations were collated and uploaded into Endnote X8, 2018 (Clarivate Analytics, PA, USA) and duplicates removed. Titles and abstracts were screened by two independent reviewers (KE, KM) for assessment against the review inclusion criteria. Potentially relevant studies were retrieved in full and their citation details imported into the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information.[28] The full text of selected citations were assessed in detail against the inclusion criteria by two independent reviewers (KE, KM). Full text papers that did not meet the inclusion criteria were excluded and reasons for the exclusion are provided in Appendix II. Any disagreements that arose between the reviewers at each stage of the study selection process were resolved through discussion, or with a third reviewer (JS).

Data extraction

Data was extracted from papers included in the scoping review by two independent reviewers (KE, KM) using a data extraction tool developed by the reviewers and adapted from the JBI results extraction instrument (Appendix III). During the extraction we discovered limited acknowledgement of behavior change theory in full text articles. In order to gain a full understanding of the inclusion of

theory-based behavior change components the decision was taken to additionally extract data regarding BCTs. We therefore adapted the data extraction tool to include both behavior change theory and BCTs. BCTs identified from included full text articles were categorized based on the 26-item taxonomy developed by Abraham and Michie.[24] This taxonomy has been used previously to identify BCTs within diabetes apps.[4] The data extracted was tabulated and included: author, year of publication, origin, study design, mHealth objective, population, outcome measures, intervention type and purpose (e.g. app), setting, timing, technology features, behavior change theory, BCTs and key findings related to review objectives. Any disagreements that arose between reviewers were resolved through discussion, and with a third reviewer (JS). Authors of papers were contacted to request missing or additional data, where required.

Data presentation

The data extracted from full text articles are presented in tabular and diagrammatic form according to scoping review guidelines. An overview of our key review findings are presented in graphic form and are accompanied by a narrative summary that describes how the results related to the review questions and objectives.

Results

Study inclusion

Database searches retrieved 2166 records (Figure 1).[29] Grey literature searches identified 511 records. After duplicates were removed, the remaining 1593 records were screened by title and abstract, and 1495 were excluded. The full text of 96 reports were assessed for eligibility, and another 66 were excluded with reasons documented (Appendix II). Most reports were excluded due to ineligible intervention type (n=25) (e.g. mHealth was not the primary component of the intervention under investigation). Thirty reports were included. [30-59]

<insert Figure 1 here>

Characteristics of included studies

The 30 reports originated from 15 countries: Norway[30,34,55], Iran[35], Israel[47], Spain[53], Oman[37], Germany[41], New Zealand[49], China[36], Nepal[52], USA[31,32,54], Russia[51], Australia[48,50,57,58], South Korea[39,40], Singapore[42,59], and the UK[33,38,43,44,46]. Twenty five different mHealth interventions were described across the 30 reports. Around half (14/30) of the studies were early development of the technology and/or pilot studies, the other half (16/30) were later large studies such as RCTs (Table 1).

Of the 25 studies that reported results, 1303 participants were included (range 5-170). These 1303 includes some ‘double counting’ (for example, participants reported in a qualitative sub study[55] and

different studies reporting results from the same service development project[38,43,46]). Six studies focused on postpartum women, the remaining 24 included, or aimed to include, women currently pregnant with GDM diagnosis (Table 1).

<insert Table 1 here>

Review findings

Appendix IV describes the relevant data from the included sources related to the review objectives including; mHealth purpose and features, study design, population, outcome measures, implementation and duration of use, behavior change theory and techniques and key study findings. A summary of this scoping review's main findings is provided in Figure 2.

<insert Figure 2 here>

mHealth purpose

All (25/25) mHealth required women to use an app, one of which enabled a mobile-based VR program with use alongside a VR headset[40] and one incorporated social media[60] (Table 1). Nearly all (24/25) mHealth were specifically developed for women experiencing GDM. One study described curating an ecosystem of five commercially available health and wellness apps to meet various self-management needs.[49]

For mHealth used during pregnancy there were three main purposes: 1) to support self-management for blood glucose control (BGC) 2) provide education and 3) to support behavior change for healthy lifestyle (Table 1). For mHealth used postpartum (6/25) there were two main purposes: 1) behavior change interventions for the prevention of T2DM and 2) providing education for lifestyle change.

mHealth features and key findings

Self-management for BGC: All GDM self-management apps included features that enabled BGL monitoring and management.[30,32,36,37,39,45,47,49,50,51,53,56,57,58] Many apps enabled interaction with healthcare professionals.[36,45,47,49,50,53,56,57,58] This interaction predominantly served to transmit BGL readings to HCPs who could provide feedback on BGL, diet and therapy adjustment where required. Some also enabled appointment booking[47], a call back service[45] and ability to ask questions[36,47].One app included a system to remind women to monitor their BGL twice per day.[37] One study described an in-app algorithm to predict BGLs and provide tailored feedback, based on data input by women and clinical guidelines.[39]

Some apps also enabled tracking of dietary intake and physical activity[49,51,56,58], one included an embedded accelerometer.[53] Some apps also included educational materials regarding diet, physical activity and general information on GDM.[30,32,36,37] Studies exploring apps for self-management of BGC

suggest they were used, easy to navigate and were generally satisfactory for women.[38,39,43,45,46,47,49,51,58]

Education: Two apps focused on delivery of education. One for use during pregnancy aimed to increase risk perception of T2DM[35] and one for use postpartum provided health education to Spanish-speaking Latina women[31] (Table 1). One app[35] included video, photo and text based educational materials as well as reminders for tests and medications and an FAQ section regarding GDM and T2DM. The Tu Puedes app included lessons about T2DM prevention that included culturally applicable information.[31]

Behavior change: Nine mHealth interventions were developed to provide behavior change support (table 1).[33,40,41,42,44,48,52,54,59] Of the four apps for use during pregnancy two[33,59] aimed to address weight management, one to increase self-efficacy to adhere to physical activity and dietary regimens[52] and one to motivate women to increase physical activity levels.[44] Five mHealth were developed for the purpose of creating and sustaining health behavior change to prevent onset of T2DM after pregnancy.[40,41,42,48,54]

Most apps included features to track physical activity, dietary intake and weight, track progress and receive feedback.[33,40,42,48,54,59] One app also included motivational messages and interaction with HCPs to provide feedback on progress.[44] mHealth for postpartum use included additional features of social support via use of Facebook and provision of rewards.[48,54] Studies exploring apps for behavior change suggest women's feedback at an early stage of design and development is important as some features and functions were valued more than others. [33,42,48,54]

mHealth implementation

When: During pregnancy app use usually started at time of diagnosis (typically 24-28 weeks gestation) and ceased on delivery (Appendix IV). Twelve of 19 mHealth required women to start using them at specified gestation periods that ranged from 12-35 weeks gestation.[30,32,36,37,44,45,47,50,52,53,56,57,59] One app implemented during pregnancy could be used up to three months after delivery.[30] Timing of postpartum mHealth delivery varied from soon after delivery[40,42], three to eight months[41] post-delivery, and up to five years postpartum.[54]

Where: mHealth for use during pregnancy were typically introduced to women in hospital settings (11/19), usually diabetes in pregnancy outpatient clinics (Table 1). One study describes recruiting women online for app use at home.[39] Two mHealth for use postpartum were introduced to women at their delivery location[40,42] and one from a community healthcare centre.[54]

How: Six studies detailing mHealth for use during pregnancy and two for use postpartum reported that women received training on how to use the technology, including face to face sessions[40,44,45,47,54,56,58] and a booklet.[35] Two studies relied on women's own capability to download

and start using apps.[30,36] Two apps included 'how-to' instructions. [50,54] Two studies report the app being set-up for women by researchers.[35,52]

Behavior change theory and techniques

Three studies described using behavior change theory to guide the development of mHealth interventions.[30,52,54] Borgen et al., based their app for self-management of BGC on Social Cognitive Theory.[30] Two apps designed to support behavior change, one during pregnancy[52] and one postpartum[54], used the Health Belief Model to guide intervention development.

However, nearly all (22/25) mHealth interventions incorporated at least two BCTs. Of the 26 BCTs on the Michie and Abraham taxonomy[24], 13 were identified as present across mHealth included in this review (Figure 2). The most common number of BCTs across all mHealth was 3 (Table 1).

mHealth developed specifically to deliver behavior change interventions typically included a broader range of BCTs (3-7) than those designed for education (1-4) or self-management of BGC (1-5).

All but one[49] mHealth intervention for supporting self-management of BGC, included both 'prompt self-monitoring behavior' and 'provision of feedback on performance'. These techniques mapped to functions that allowed women to monitor their blood glucose, physical activity, diet and weight and receive feedback on their performance, often in real-time.

mHealth for behavior change intervention during pregnancy included similar features to that included for self-management of BGC but additionally included identification of goals, information on health-behavior link and opportunity for social support. One also included motivational interviewing facilitated remotely within the app.[44]

mHealth to support behavior change postpartum included the widest range of BCTs per technology (5-7) (Table 1) and included self-monitoring features that tracked physical activity, dietary intake and monitored weight (Table 1). One technology[40] included techniques for stress management, one provided women with contingent rewards[54] and one provided opportunities for social support via social media.[48]

mHealth aimed at providing education for T2DM prevention included one[31] and four[35] techniques including 'prompt practice', 'information about behavior-health link' and 'information about consequence'. Although it could be argued that provision of education does not require behavior change, the evaluation of one educational app[31] included outcomes such as BMI, blood pressure and waist measurement suggesting the intended impact of the app was for women to make relevant lifestyle changes.

<insert Figure 3 here>

Study Design

Development: Of the two studies describing the mHealth development process, one used an iterative user-centered process with think-aloud interviews to assess usability[34], the other drew on clinical guidelines and evaluated usability and acceptability using online surveys.[39]

Pilot studies: For mHealth used during pregnancy, pilot studies typically used surveys to capture data on usability, usage and patient satisfaction after women had used the app from diagnosis to delivery .[33,34,38,39,43,46,51,57] One study used an observational prospective study to understand compliance with BGL monitoring compared to a historical cohort who used standard monitoring methods.[53] A further pilot study used a single center RCT design to capture preliminary effectiveness of app use vs standard care via obstetric outcomes and OGTT results at 5-12 weeks postpartum.[56]

For postpartum mHealth, two pilot studies used quasi-experimental designs[31,40] to determine impact of mHealth use on various weight parameters and self-reported lifestyle behaviors. A further pilot study used qualitative methods to gather feedback from women on a prototype of a postpartum mHealth program.[48] Seely et al. describe the development, feasibility and preliminary effectiveness of their app using a series of studies involving qualitative feedback, usability testing and a single arm plot trial.[54]

Efficacy evaluations: The majority of studies evaluating clinical efficacy of mHealth for use during pregnancy typically used non-blinded randomized control trials, either single or multi-center (Table 1).[30,32,36,37,44,45,47,52,56,58,59] Apps were used from diagnosis to delivery, and outcome measures focused on glycemic control (during pregnancy and at delivery), as well as various maternal, delivery and neonatal outcomes. Compliance with BG monitoring and satisfaction with the app were also measured. Postpartum (3 month) BGLs were measure as primary outcome in one trial however, significant loss to follow-up meant results could not be relied upon.[30]

For evaluations of postpartum mHealth, Lim et al. used a non-blinded single center RCT design to understand the impact of app use among 200 postpartum women on ability to restore booking weight at four months postpartum.[42] A parallel multi-center RCT with 64 postpartum women is planned to evaluate the Triangle app.[41] Primary outcome will be proportion of women reaching three or more of the five Diabetes Prevention Program lifestyle milestones. Secondary outcomes included physical activity, dietary intake, weight and BMI after six months of use.[41]

Discussion

This scoping review aimed to synthesize current knowledge on the use of mHealth as primary mode of intervention for the prevention and management of GDM and its long-term implications among women at risk of or diagnosed with GDM. We also aimed to understand if, where appropriate, mHealth for GDM incorporated relevant behavior change theory and techniques.

This review identified 30 sources of evidence that used mHealth as a primary mode of intervention to support women at risk of, and diagnosed with GDM. Despite broadening our search to include all types of mHealth (rather than just apps), all (25/25) required women to use an app. One study used an app to enable a mobile-based VR program with use of a headset, and only one included social media use. It is possible that other types of mHealth, such as websites, wearables and social media are not suited to address the clinical purpose of the mHealth described in this review. However, a recent study found women with experience of GDM frequently used and highly valued social media for meeting their informational and peer support needs.[60] These findings suggest future mHealth development should consider inclusion of existing online spaces women value in order to meet needs such as peer support, which have been found to impact women's ability to self-manage[61] and support behavior change.[62]

Building on the findings of Chen et al, this review included six studies evaluating the effectiveness of mHealth systems for self-management of BGC. In accordance with NICE guidelines[63] evaluations typically adopted RCT designs to measure the ability of mHealth to improve glycemic control in comparison to standard care. Women appeared satisfied with apps, however, the burden of managing GDM has been linked to feelings of depression and isolation among women [64] thus we suggest future evaluation of mHealth should consider wider reaching outcomes such as quality of life and wellbeing, in order to capture other important possible benefits for women. In addition, as recommended by Craig et al.[65] further qualitative exploration of women's experiences of app use could help to tease out barriers and facilitators that may enhance future adoption and efficacy.[66]

Only six of twenty five mHealth were designed for postpartum use and none were developed for the purpose of preventing GDM reoccurrence, despite high prevalence, particularly for those with high BMI.[67] mHealth for use after delivery typically focused on preventing progression to T2DM by creating behavior change for weight management, however, there is currently limited evidence examining their effectiveness. Weight increase during postpartum and interconception periods is an important modifiable factor known to increase the risk of progression to T2DM[68] and also recurrence of GDM in both normal and overweight/obese women.[69] Thus, finding effective, engaging and acceptable interventions is of key public health importance.

Because of a lack of published evidence, it was difficult to gain a thorough understanding of how, when and where postpartum mHealth was implemented. Both Lim and Kim demonstrated good engagement with intervention delivered soon after delivery. However, learning from evaluation of mHealth for use during pregnancy[30], large loss to follow-up postpartum means that this relatively early timing needs to be balanced with women's barriers to engagement, including the pressures of new motherhood.[18] In addition, it is well documented that the transition from maternity to primary care, following delivery, can be fragmented.[70] Thus, early consideration of future implementation strategies will be essential for mHealth to function effectively within wider healthcare systems.

In line with findings from Chen *et al*.[15] only one app for self-management and two apps for behavior change intervention were developed using behavior change theory. Although not all apps were designed to deliver a behavior change intervention, self-management of BGC and education for T2DM prevention require women to make changes to their lifestyle, suggesting a need for theory-developed behavior change components. This is reflected in the finding that nearly all apps (24/25) included at least two BCTs and those designed to support self-management of BGC nearly always included two techniques seen as 'optimum' when combined.[71] mHealth for behavior change intervention included a wider range of BCTs, nevertheless, of the twenty-six theory linked BCTs that have been described and tested[24], 13 were still not included within any mHealth reviewed. Clearly the inclusion of all techniques is not realistic for all mHealth interventions, however, referring to the 26-item taxonomy when developing mHealth for GDM could be advantageous for selecting specific BCTs that might support women with particular needs. For example, evidence has shown women experience a significant drop in motivation after delivery[18] and face-to-face motivational interviewing has shown some promise for creating behavior change among postpartum women.[72] Despite this, none of the mHealth interventions for postpartum behavior change included 'motivational interviewing' techniques suggesting potential disparity between the BCTs included in postpartum mHealth interventions and the barriers and needs women experience at this time.

Limitations

Our objective was to synthesize current knowledge and identify research gaps for future study, however scoping methodology does not include quality assessment and consequently this review is unable to identify the quality of included studies. In addition, due to lack of resource, only evidence published in English were included and thus our findings may have omitted evidence in other languages.

A further limitation was that BCTs were extracted using descriptions of mHealth provided in studies, rather than by direct examination and thus some features/techniques may have been missed. Direct examination of mHealth was beyond the scope of this review but is something that could be undertaken in future work.

The lack of studies focused on postpartum mHealth interventions may be reflected in our decision to include mHealth as the primary component of the intervention. For example, several studies were excluded where mHealth was used for postpartum intervention, but was not the main component (Appendix II). Postpartum interventions are typically more complex and may therefore require a broader approach. Nevertheless, of the 98 studies taken to full text screening, only 23 focused on postpartum usage and one for interconception care (Appendix II).

Conclusions

This scoping review has identified the majority of mHealth interventions for GDM are apps that aim to improve clinical outcomes during pregnancy. Further consideration of broader outcomes related to women's wellbeing and qualitative experiences is required to further inform improvement of these systems. In addition, consideration should be given to the inclusion of other existing resources such as social media that could help address needs such as peer support that impact on women's ability to self-manage.

It was previously unknown if BCTs were included within mHealth for GDM where appropriate. Our findings suggest most mHealth included BCTs. However, coming from a pragmatist position we suggest that in order for mHealth interventions to have maximum impact, intervention developers should consider referring to the 26-item taxonomy in order to select techniques that map to women's reported behavior change barriers. Overall, a lack of published studies examining mHealth for postpartum and interconception use indicates that further high-quality primary research is needed to better understand and identify effective ways of using mHealth to reduce risks associated with GDM recurrence and progression to T2DM. We suggest that once evidence is available regarding the impact of postpartum and interconception mHealth interventions, a systematic review is warranted to understand how specific features, BCTs and aspects of implementation may impact their efficacy.

Funding

The conduct of this review has not received funding.

Conflicts of interest

All authors declare no conflict of interest.

References

1. World Health Organization. mHealth: New horizons for health through mobile technologies: second global survey on eHealth [internet]. 2011 [cited 2021 May 25]. Available from: https://www.who.int/goe/publications/goe_mheal th_web.pdf.

2. Statista. Global smartphone penetration rate as share of population from 2016 to 2020 [internet]. 2021 [cited 2021 September 20]. Available from: https://www.statista.com/statistics/203734/global-smartphone-penetration-per-capita-since-2005/

3. Research2Guidance. mHealth Economics 2017 - Current Status and Future Trends in Mobile

Health [Internet]. 2017 [cited 2021 May 25]. Available from: https://research2guidance.com/%0Aproduct/mhealth-economics-2017-current-status-and-future-trends-inmobile-%0Ahealth/ %0A.

4. Hoppe CD, Cade JE, Carter M. An evaluation of diabetes targeted apps for Android smartphone in relation to behaviour change techniques. J Hum Nutr Diet 2017;30(3):326–38.

5. World Health Organization. Definition, diagnosis and classification of diabetes mellitus and intermediate hyperglycemia-report of a WHO/IDF consultation [internet]. 1999 [cited 2021 May 25]. Available from: https://apps.who.int/iris/handle/10665/66040.

6. Reece EA. The fetal and maternal consequences of gestational diabetes mellitus. J Matern Neonatal Med 2010;23(3): 199–203..

7. Landon MB, Mele L, Spong CY, Carpenter MW, Ramin SM, Casey B, et al. The relationship between maternal glycemia and perinatal outcome. Obstet Gynecol. 2011;117(2):218–24

8. Kim C, Berger DK, Chamany S. Recurrence of gestational diabetes mellitus. Diabetes Care 2007;30(5):1314–9.

9. Bellamy L, Casas JP, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. Lancet 2009;37:1773–9.

10. Chen L, Magliano DJ, Zimmet PZ. The worldwide epidemiology of type 2 diabetes mellitus - Present and future perspectives. Nat Rev Endocrinol 2012;8(4):228–36.

11. Diabetes UK. Everyday life with gestational diabetes [internet]. 2019 [cited 2021 May 25]. Available from: https://www.diabetes.org.uk/resources-s3/2019-10/Gestational-Guide-June-2019.pdf.

12. Farrar D, Simmonds M, Bryant M, Sheldon TA, Tuffnell D, Golder S et al. Treatmentes for gestational diabetes: a systematic review and meta-analysis. BMJ Open 2017;7;e015557.

13. Alqudah A, McMullan P, Todd A, O'Doherty C, McVey A, McConnell M, *et al.* Service evaluation of diabetes management during pregnancy in a regional maternity hospital: Potential scope for increased self-management and remote patient monitoring through mHealth solutions. BMC Health Serv Res 2019;19(1).

14. Nikolopoulos M, Karampela I, Antonakos G, Tzortzis E, Stratigou T, Diomidous M, *et al*. Mobile phone applications for gestational diabetes mellitus: appraisal and perspectives. Stud Health Technol Inform 2019;262:39–42.

15. Chen Q, Carbone ET. Functionality, Implementation, Impact, and the Role of Health Literacy in Mobile Phone Apps for Gestational Diabetes: Scoping Review. JMIR Diabetes. 2017;2(2):e25.

16. Vounzoulaki E, Khunti K, Abner SC, Tan BK, Davies MJ, Gillies CL. Progression to type 2 diabetes in women with a known history of gestational diabetes: Systematic review and meta-analysis. BMJ 2020;369.

17. Tieu J, Shepherd E, Middleton P, Crowther CA. Interconception care for women with a history of gestational diabetes for improving maternal and infant outcomes. Cochrane Database Syst Rev 2017;(8).

18. Nicklas JM, Zera CA, Ellen WS, Abdul-Rahim ZS, Rudloff ND, Levkoff SE. Identifying postpartum intervention approaches to prevent type 2 diabetes in women with a history of gestational diabetes. BMC Pregnancy Childbirth 2011;11:23.

19. Phelan S. Windows of Opportunity for Lifestyle Interventions to Prevent Gestational Diabetes Mellitus. Am J Perinatol 2017;33(13):1291–9.

20. McMillan B, Easton K, Goyder E, Delaney B, Madhuvrata P, Abdelgalil R, *et al.* Reducing risk of type 2 diabetes after gestational diabetes: a qualitative study to explore the potential of technology in primary care. Br J Gen Pract 2018;68(669):e260–7.

21. Rayanagoudar G, Moore M, Zamora J, Hanson P, Huda MSB, Hitman GA, et al. Postpartum care of women with gestational diabetes: Survey of healthcare professionals. Eur J Obstet Gynecol Reprod Biol 2015;194:236–40.

22. Pennington AVR, O'Reilly S, Young D, Dunbar JA. Improving follow-up care for women with a history of gestational diabetes: Perspectives of GPs and patients. Aust J Prim Health. 2017;23(1):66-74.

23. Edwards KJ, Maslin K, Andrade J, Jones RB, Shawe J. mHealth as a primary mode of intervention for women at risk of, or diagnosed with, gestational diabetes: a scoping review protocol. JBI Evid Synth 2020;19(3):660–8.

24. Abraham C, Michie S. A Taxonomy of Behavior Change Techniques Used in Interventions. Heal Psychol 2008;27(3):379–87.

25. Rasekaba TM, Furler J, Young D, Liew D, Gray K, Blackberry I, *et al.* Using technology to support care in gestational diabetes mellitus: quantitative outcomes of an exploratory randomised control trial of adjunct telemedicine for gestational diabetes mellitus (TeleGDM). Diabetes Res Clin Pract 2018;142:276–85.

26. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. Int J Evid Based Healthc. 2015;13(3):141–6.

27. Peters MDJ, Godfrey C, McInerney P, Baldini Soares C, Khalil H, Parker D. Chapter 11: Scoping Reviews. In: Aromataris E, Munn Z, editors. JBI Reviewer's Manual [internet]. Adelaide: JBI, 2017. [cited 25 May 2021]. Available from: https://reviewersmanual.joannabriggs.org/.

28. Munn Z, Aromataris E, Tufanaru C, Stern C, Porritt K, Farrow J, et al. The development of software to support multiple systematic review types: the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI SUMARI). Int J Evid Based Healthc 2019;17(1):36-43.

29. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 2021;372.

30. Borgen I, Småstuen MC, Jacobsen AF, Garnweidner-Holme LM, Fayyad S, Noll J, et al. Effect of the Pregnant+ smartphone application in women with gestational diabetes mellitus: A randomised controlled trial in Norway. BMJ Open 2019;9(11).

31. Castorino K, Alvarez S, Mathers HM, Larez AJ, Axelrod C. Tu puedes-an exploratory usability pilot of a postpartum education "app" for latina women with previous gestational diabetes. Diabetes 2018;67:A172.

32. Crimmins SD, Solaru O, Fahey J, Kopelman JN, Turan OM, Harman C. 411: does personalized smartphone glucose monitoring improve management of gestational diabetes? Am J Obstet Gynecol 2019;220(1):S279.

33. Dyson PA, Hirst JE, Bartlett CJ, Kenworthy Y, Hargreaves A, Roberts S, et al. GDm-Health Plus: Development of a remote behavioural lifestyle management system for women with

gestational diabetes. Diabet Med 2018;35:171.

34. Garnweidner-Holme L, Borgen I, Garitano I, Noll J, Lukasse M. Designing and Developing a Mobile Smartphone Application for Women with Gestational Diabetes Mellitus Followed-Up at Diabetes Outpatient Clinics in Norway. Healthcare 2015;3(2):310–23.

35. Ghaderi M, Farahani MA, Hajiha N, Ghaffari F, Haghani H. The role of smartphone-based education on the risk perception of type 2 diabetes in women with gestational diabetes. Health Technol (Berl) 2019;9(5):829–37.

36. Guo H, Zhang Y, Li P, Zhou P, Chen L-M, Li S-Y. Evaluating the effects of mobile health intervention on weight management, glycemic control and pregnancy outcomes in patients with gestational diabetes mellitus. J Endocrinol Invest 2019:42(6):709-714.

37. Hashmi I AL. The Accessibility and the Feasibility of a Self-Efficacy Enhancing Smart-Phone Application among women with Gestational Diabetes Mellitus [internet]. 2019 [cited 2021 May 25]. Available from: https://anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12619001278123

38. Hirst JE, Mackillop L, Loerup L, Kevat DA, Bartlett K, Gibson O, *et al.* Acceptability and user satisfaction of a Smartphone-based, interactive blood glucose management system in women with gestational diabetes mellitus. J Diabetes Sci Technol 2015;9(1):111–5.

39. Jo S, Park H-A. Development and evaluation of a smartphone application for managing gestational diabetes mellitus. Healthc Inform Res 2016;22(1):11–21.

40. Kim S-H, Kim HJ, Shin G. Self-management mobile virtual reality program for women with gestational diabetes. Int J Environ Res Public Health 2021;18(4):1–12.

41. Lechner A. Test Triangle - Multicenter randomized pilot study to test a smartphone-based lifestyle intervention for women who had gestational diabets [Internet]. 2017 [cited 2021 May 25]. Available from: https://www.drks.de/drks_web/navigate.do?navigationId=trial.HTML&TRIAL_ID=DRKS00012996

42. Lim K, Chan S-Y, Lim SL, Tai BC, Tsai C, Wong SR, *et al.* A Smartphone App to Restore Optimal Weight (SPAROW) in Women With Recent Gestational Diabetes Mellitus: Randomized Controlled Trial. JMIR mHealth uHealth 2021;9(3):e22147.

43. Loerup L, Gibson OJ, Hirst JE, Farmer AJ, Bartlett K, Blincowe JE, et al. GDm-Health: telehealth for remote monitoring and treatment of gestational diabetes. Diabetologia 2013;56:S506-S507.

44. Mackillop LH. Stay Active: a smartphone application to support the delivery of a physical activity intervention in women with gestational diabetes [Internet]. 2020 [cited 2021 May 25]. Available from: https://www.isrctn.com/ISRCTN11366562?q=&filters=condition:gestational diabetes&sort=&offset=2&totalResults=43&page=1&pageSize=10&searchType=advanced-search

45. Mackillop L, Hirst JE, Bartlett KJ, Birks JS, Clifton L, Farmer AJ, et al. Comparing the Efficacy of a Mobile Phone-Based Blood Glucose Management System With Standard Clinic Care in Women With Gestational Diabetes: Randomized Controlled Trial. J Med Internet Res 2018;20(3).

46. Mackillop L, Loerup L, Bartlett K, Farmer A, Gibson OJ, Hirst JE, et al. Development of a real-time smartphone solution for the management of women with or at high risk of gestational diabetes. J Diabetes Sci Technol 2014;8(6):1105–14.

47. Miremberg H, Ben-Ari T, Betzer T, Raphaeli H, Gasnier R, Barda G, et al. The impact of a daily smartphone-based feedback system among women with gestational diabetes on compliance, glycemic control, satisfaction, and pregnancy outcome: a randomized controlled trial. Am J Obstet Gynecol 2018;218(4):453.e1-453.e7.

48. O'Reilly SLSL, Laws R. Health-e mums: Evaluating a smartphone app design for diabetes prevention in women with previous gestational diabetes. Nutr Diet 2019;76(5):507–14.

49. Pais S, Parry D, Petrova K, Rowan J. Acceptance of using an ecosystem of mobile apps for use in diabetes clinic for self-management of gestational diabetes mellitus. Stud Health Technol Inform 2017;245:188-192.

50. Poulter S. Investigation of Blood glucose monitoring Via a Mobile application in Women with Gestational Diabetes Mellitus [Internet]. 2019 [cited 2021 May 25].. Available from: http://anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12619001047189

51. Pustozerov E, Popova P, Bolotko Y, Tkachuk A, Gerasimov A. Remote monitoring of diet for patients with gestational diabetes using a specialized mobile app diary. Diabetes Technol Ther 2017;19:A94.

626 52. Rawal S, Peters EN. Development and Testing of a Mobile Health Application for Management
627 of Gestational Diabetes [Internet]. 2019 [cited 2021 May 25]. Available from:
628 https://clinicaltrials.gov/ct2/show/NCT04198857

629 53. Rigla M, Martínez-Sarriegui I, García-Sáez G, Pons B, Hernando ME. Gestational Diabetes
630 Management Using Smart Mobile Telemedicine. J Diabetes Sci Technol 2018;12(2):260–4.

631 54. Seely EW, Weitzman PF, Cortes D, Romero Vicente S, Levkoff SE. Development and
632 Feasibility of an App to Decrease Risk Factors for Type 2 Diabetes in Hispanic Women With
633 Recent Gestational Diabetes (Hola Bebe, Adios Diabetes): Pilot Pre-Post Study. JMIR Form
634 Res 2020;4(12):e19677.

635 55. Skar JB, Garnweidner-Holme LM, Lukasse M, Terragni L. Women's experiences with using a
636 smartphone app (the Pregnant+ app) to manage gestational diabetes mellitus in a randomised
637 controlled trial. Midwifery 2018;58:102–8.

638 56. Sung J-H, Lee DY, Min KP, Park C-Y. Peripartum Management of Gestational Diabetes Using
639 a Digital Health Care Service: A Pilot, Randomized Controlled Study. Clin Ther
640 2019;41(11):2426-2434.

641 57. Varnfield M, Redd C, Stoney RM, Higgins L, Scolari N, Warwick R, *et al.* M THer, an mHealth
642 System to Support Women with Gestational Diabetes Mellitus: Feasibility and Acceptability
643 Study. Diabetes Technol Ther 2021;23(5):358–66.

644 58. Wickramasinghe N, John B, George J, Vogel D. Achieving value-based care in chronic
645 disease management: Intervention study. J Med Internet Res 2019;21(5).

646 59. Yew TW, Chi C, Chan SY, van Dam RM, Whitton C, Lim CS, et al. A randomized controlled
647 trial to evaluate the effects of a smartphone application–based lifestyle coaching program on
648 gestational weight gain, glycemic control, and maternal and neonatal outcomes in women with
649 gestational diabetes mellitus: The smart-gdm . Diabetes Care 2021;44(2):456–63.

650 60. Edwards KJ, Bradwell HL, Jones RB, Andrade J, Shawe JA. How do women with a history of
651 gestational diabetes mellitus use mHealth during and after pregnancy? Qualitative exploration
652 of women's views and experiences. Midwifery 2021;98:102995.

653 61. Craig L, Sims R, Glasziou P, Thomas R. Women's experiences of a diagnosis of gestational
654 diabetes mellitus: a systematic review. BMC Pregnancy Childbirth 2020;20(76).

62. Ingstrup MS, Wozniak LA, Mathe N, Butalia S, Davenport MH, Johnson JA et al. Women's experience with peer counselling and social support during a lifestyle intervention among women with a previous gestational diabetes pregnancy. Health Psychology and behavioral Medicine 2019;7(1):147-159.

63. National Institute for Health and Care Excellence. National Institute for Health and Care Excellence Evidence Standards Framework for Digital [internet]. 2019 [cited 2021 May 25]. Available from:https://www.nice.org.uk/Media/Default/About/what-we-do/our-programmes/evidence-standards-framework/digital-evidence-standards-framework.pdf.

64. Parsons J, Sparrow K, Ismail K, Hunt K, Rogers H, Forbes A. Experiences of gestational diabetes and gestational diabetes care: A focus group and interview study. BMC Pregnancy Childbirth 2018;18(1):1–12.

65. Craig P, Dieppe P, Macintyre S, Health P, Unit S, Michie S. Developing and evaluating complex interventions: new guidance. BMJ 2008;337.

66. Maar MA, Yeates K, Perkins N, Boesch L, Hua-Stewart D, Liu P, *et al*. A Framework for the Study of Complex mHealth Interventions in Diverse Cultural Settings. JMIR mHealth uHealth 2017;5(4):e47.

67. MacNeill S, Dodds L, Hamilton DC, Armson BA, VandenHof M. Rates and risk factors for recurrence of gestational diabetes. Diabetes Care 2001;24(4):659–62.

68. Bao W, Yeung E, Tobias DK, Hu FB, Vaag AA, Chavarro JE, *et al.* Long-term risk of type 2 diabetes mellitus in relation to BMI and weight change among women with a history of gestational diabetes mellitus: a prospective cohort study. Diabetologia 2015;58(6):1212–9.

69. Sorbye LM, Cnattingius S, Skjaerven R, Klungsoyr K, Wikström AK, Kvalvik LG, *et al.* Interpregnancy weight change and recurrence of gestational diabetes mellitus: a population-based cohort study. BJOG An Int J Obstet Gynaecol 2020;127(13):1608–16.

70. McCloskey L, Sherman ML, St. John M, Siegel H, Whyte J, Iverson R, et al. Navigating a 'Perfect Storm' on the Path to Prevention of Type 2 Diabetes Mellitus After Gestational Diabetes: Lessons from Patient and Provider Narratives. Matern Child Health J 2019;0(0):0.

71. Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective Techniques in Healthy Eating and Physical Activity Interventions: A Meta-Regression. Heal Psychol 2009;28(6):690.

684 72. Reinhardt JA, van der Ploeg HP, Grzegrzulka R, Timperley JG. Implementing lifestyle change
685 through phone-based motivational interviewing in rural-based women with previous gestational
686 diabetes mellitus. Health Promot J Austr 2012;23: 5–9.

Appendix I: Search strategy

MEDLINE (Ovid)

Ovid MEDLINE(R) and In-Process & Other Non-Indexed Citations 1946 to March 22, 2021

Search conducted on 22nd March 2021

#	Searches	Results
1	Diabetes, Gestational/	10831
2	"gestational diabet* ".ab,kf,ti.	14857
3	GDM.ab,kf,ti.	7316
4	(pregnancy adj3 diabetes).ab,kf,ti.	5558
5	((pregnan* or gestation* or maternal) adj3 glucose intolerance).ab,kf,ti.	356
6	((pregnan* or gestation* or maternal) adj3 impaired glucose tolerance).ab,kf,ti.	316
7	(hyperglyc#emia adj3 pregnan*).ab,kf,ti.	160
8	(hyperglyc#emia adj3 gestation*).ab,kf,ti.	53
9	(maternal adj2 hyperglyc#emia).ab,kf,ti.	126
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	20535
11	Telemedicine/	23311
12	telemedicine.ab,kf,ti.	12644
13	(ehealth or "e health").ab,kf,ti.	6479
14	(mhealth or "m health").ab,kf,ti.	5199
15	("mobile health" or "mobile technolog*").ab,kf,ti.	6171
16	("digital health" or "digital technolog*").ab,kf,ti.	3630
17	Smartphone/	4496
18	(smartphone* or "smart phone*").ab,kf,ti.	12266
19	Cell Phone/	8547
20	("cell* phone*" or "mobile phone*").ab,kf,ti.	11632
21	Mobile Applications/	6023
22	("mobile app" or "mobile apps" or "mobile application*").ab,kf,ti.	4702
23	Text Messaging/	2918
24	"text messag* ".ab,kf,ti.	4132
25	Social Media/	8027

26	"social media".ab,kf,ti.	11373
27	(website* or online or internet).ab,kf,ti.	172358
28	(whatsapp or facebook or twitter or instagram).ab,kf,ti.	6342
29	Internet/	73031
30	Computers, Handheld/	3611
31	("personal digital assistant" or PDA).ab,kf,ti.	11969
32	(tablet* adj3 (comput* or device*)).ab,kf,ti.	1648
33	bluetooth.ab,kf,ti.	1134
34	"monitoring device* ".ab,kf,ti.	3651
35	"wireless device* ".ab,kf,ti.	402
36	(smartwatch* or "smart watch*").ab,kf,ti.	421
37	("fitness tracker*" or fitbit*).ab,kf,ti.	727
38	Fitness Trackers/	560
39	11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38	289282
40	10 and 39	299

691

692 EMBASE (Ovid) <1974 to 2021 March 22>
693
694 Search conducted on 22nd March 2021

695

#	Searches	Results
1	pregnancy diabetes mellitus/	30420
2	"gestational diabet* ".ab,kw,ti.	23815
3	GDM.ab,kw,ti.	11938
4	(pregnancy adj3 diabetes).ab,kw,ti.	6887
5	((pregnan* or gestation* or maternal) adj3 glucose intolerance).ab,kw,ti.	567
6	((pregnan* or gestation* or maternal) adj3 impaired glucose tolerance).ab,kw,ti.	423
7	(hyperglyc#emia adj3 pregnan*).ab,kw,ti.	257
8	(hyperglyc#emia adj3 gestation*).ab,kw,ti.	70
9	(maternal adj2 hyperglyc#emia).ab,kw,ti.	174
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	36728

11	telemedicine/	22918
12	telemedicine.ab,kw,ti.	16568
13	(ehealth or "e health").ab,kw,ti.	7294
14	(mhealth or "m health").ab,kw,ti.	4530
15	("mobile health" or "mobile technolog*").ab,kw,ti.	6289
16	("digital health" or "digital technolog*").ab,kw,ti.	3828
17	smartphone/	11579
18	(smartphone* or "smart phone*").ab,kw,ti.	16237
19	mobile phone/	16365
20	("cell* phone*" or "mobile phone*").ab,kw,ti.	14061
21	mobile application/	10300
22	("mobile app" or "mobile apps" or "mobile application*").ab,kw,ti.	5445
23	text messaging/	4746
24	"text messag* ".ab,kw,ti.	5228
25	social media/	18892
26	"social media".ab,kw,ti.	15015
27	(website* or online or internet).ab,kw,ti.	244683
28	(whatsapp or facebook or twitter or instagram).ab,kw,ti.	8807
29	Internet/	107422
30	personal digital assistant/	1433
31	("personal digital assistant" or PDA).ab,kw,ti.	16548
32	(tablet* adj3 (comput* or device*)).ab,kw,ti.	2533
33	bluetooth.ab,kw,ti.	1688
34	"monitoring device* ".ab,kw,ti.	5135
35	"wireless device* ".ab,kw,ti.	530
36	(smartwatch* or "smart watch*").ab,kw,ti.	494
37	("fitness tracker*" or fitbit*).ab,kw,ti.	1006
38	activity tracker/	777
39	11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37	395248
40	10 and 39	647

Cochrane Library (https://www.cochranelibrary.com/)

698 Search conducted on 22nd March 2021

ID	Search	Hits
#1	MeSH descriptor: [Diabetes, Gestational] explode all trees	904
#2	MeSH descriptor: [Telemedicine] explode all trees	2343
#3	MeSH descriptor: [Cell Phone] explode all trees	1238
#4	MeSH descriptor: [Text Messaging] explode all trees	765
#5	MeSH descriptor: [Social Media] explode all trees	129
#6	MeSH descriptor: [Internet] explode all trees	3776
#7	MeSH descriptor: [Computers, Handheld] explode all trees	571
#8	MeSH descriptor: [Fitness Trackers] explode all trees	77
#9	MeSH descriptor: [Smartphone] explode all trees	314
#10	("gestational diabet*"):ti,ab,kw OR (GDM):ti,ab,kw OR ((pregnancy NEAR/3 diabetes)):ti,ab,kw OR (((pregnan* or gestation* or maternal) NEAR/3 glucose intolerance)):ti,ab,kw OR (((pregnan* or gestation* or maternal) NEAR/3 impaired glucose tolerance)):ti,ab,kw in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections (Word variations have been searched)	2945
#11	((hyperglyc#emia adj3 pregnan*)):ti,ab,kw OR ((hyperglyc#emia NEAR/3 gestation*)):ti,ab,kw OR ((maternal NEAR/2 hyperglyc#emia)):ti,ab,kw in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections (Word variations have been searched)	0
#12	#1 OR #10 OR #11 in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections	3015
#13	(telemedicine):ti,ab,kw OR ((ehealth or "e health")):ti,ab,kw OR ((mhealth or "m health")):ti,ab,kw OR (("mobile health" or "mobile technolog*")):ti,ab,kw OR (("digital health" or "digital technolog*")):ti,ab,kw in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections (Word variations have been searched)	6372
#14	((smartphone* or "smart phone*")):ti,ab,kw OR (("cell* phone*" or "mobile phone*")):ti,ab,kw OR (("mobile app" or "mobile apps" or "mobile application*")):ti,ab,kw OR ("text messag*"):ti,ab,kw OR ("social media"):ti,ab,kw in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections (Word variations have been searched)	10170
#15	((website* or online or internet)):ti,ab,kw OR ((whatsapp or facebook or twitter or instagram)):ti,ab,kw OR (("personal digital assistant" or PDA)):ti,ab,kw OR ((tablet* adj3 (comput* or device*))):ti,ab,kw OR (bluetooth):ti,ab,kw in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections (Word variations have been searched)	23186
#16	("monitoring device*"):ti,ab,kw OR ("wireless device*"):ti,ab,kw OR ((smartwatch* or "smart	1560

	watch*")):ti,ab,kw OR (("fitness tracker*" or fitbit*)):ti,ab,kw in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections (Word variations have been searched)	
#17	#13 OR #14 OR #15 OR #16 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections	35890
#18	#12 AND #17 in Cochrane Reviews, Cochrane Protocols, Trials, Clinical Answers, Editorials, Special collections	225

699

700 CINHAL (EBSCO) with Full Text – Boolean/Phrase

701 Search conducted on 22nd March 2021

702 MH= exact subject heading

703 TI = Title

704 AB = Abstract

705 N2, N3 = Finds the words if they are within two or three words of each other regardless of order

ID	Search	Results
S1	(MH "Diabetes Mellitus, Gestational")	6,870
S2	TI "gestational diabet*" OR AB "gestational diabet*"	7,372
S3	TI gdm OR AB gdm	2,992
S4	TI (pregnancy N3 diabetes) OR AB (pregnancy N3 diabetes)	2,441
S5	TI (((pregnan* or gestation* or 24maternal) N3 glucose intolerance)) OR AB (((pregnan* or gestation* or maternal) N3 glucose intolerance))	128
S6	TI (((pregnan* or gestation* or maternal) N3 impaired glucose tolerance)) OR AB (((pregnan* or gestation* or maternal) N3 impaired glucose tolerance))	126
S7	TI (hyperglyc#emia N3 pregnan*) OR AB (hyperglyc#emia N3 pregnan*)	269
S8	TI (hyperglyc#emia N3 gestation*) OR AB (hyperglyc#emia N3 gestation*)	71
S9	TI (maternal N2 hyperglyc#emia) OR AB (maternal N2 hyperglyc#emia)	168
S10	(S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9)	10,391
S11	(MH "Telemedicine") OR (MH "Telehealth")	19,804
S12	TI telemedicine OR AB telemedicine	5,116
S13	TI ((ehealth or "e health")) OR AB ((ehealth or "e health"))	3,466
S14	TI ((mhealth or "m health")) OR AB ((mhealth or "m health"))	1,817
S15	TI (("mobile health" or "mobile technolog*")) OR AB	2,991

	(("mobile health" or "mobile technolog*"))	
S16	TI (("digital health" or "digital technolog*")) OR AB (("digital health" or "digital technolog*"))	2,103
S17	(MH "Smartphone") OR (MH "Mobile Applications") OR (MH "Text Messaging") OR (MH "Computers, Hand-Held") OR (MH "Cellular Phone")	17,513
S18	TI ((smartphone* or "smart phone*")) OR AB ((smartphone* or "smart phone*"))	6,343
S19	TI (("cell* phone*" or "mobile phone*")) OR AB (("cell* phone*" or "mobile phone*"))	4,970
S20	TI (("mobile app" or "mobile apps" or "mobile application*")) OR AB (("mobile app" or "mobile apps" or "mobile application*"))	2,753
S21	TI "text messag*" OR AB "text messag*"	2,738
S22	(MH "Social Media")	14,813
S23	TI "social media" OR AB "social media"	10,578
S24	(MH "Internet")	49,301
S25	TI ((website* or online or internet)) OR AB ((website* or online or internet))	104,439
S26	TI ((whatsapp or facebook or twitter or instagram)) OR AB ((whatsapp or facebook or twitter or instagram))	7,490
S27	TI (("personal digital assistant" or PDA)) OR AB (("personal digital assistant" or PDA))	2,115
S28	TI ((tablet* N3 (comput* or device*))) OR AB ((tablet* N3 (comput* or device*)))	1,049
S29	TI bluetooth OR AB bluetooth	336
S30	TI "monitoring device*" OR AB "monitoring device*"	1,134
S31	TI "wireless device*" OR AB "wireless device*"	131
S32	TI ((smartwatch* or "smart watch*")) OR AB ((smartwatch* or "smart watch*"))	205
S33	(MH "Fitness Trackers")	191
S34	TI (("fitness tracker*" or fitbit*)) OR AB (("fitness tracker*" or fitbit*))	450
S35	S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34	190,978
S36	(S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34) AND (S10 AND S35)	222

706
707

708 Scopus (ELSEVIER)

709 Search conducted on 22nd March 2021

710 ((TITLE-ABS-KEY ("Gestational diabetes") OR TITLE-ABS-KEY ("gestational diabet*") OR
711 TITLE-ABS-KEY (gdm) OR TITLE-ABS-KEY (pregnancy W/3 diabetes) OR TITLE-ABS-KEY ((
712 (pregnan* OR gestation* OR maternal) W/3 glucose AND intolerance)) OR TITLE-ABS-KEY (
713 ((pregnan* OR gestation* OR maternal) W/3 impaired AND glucose AND tolerance)) OR
714 TITLE-ABS-KEY ((hyperglyc#emia W/3 pregnan*)) OR TITLE-ABS-KEY ((hyperglyc#emia W/3

gestation*)) OR TITLE-ABS-KEY ((maternal AND adj2 AND hyperglyc#emia)))) AND ((TITLE-ABS-KEY (telemedicine) OR TITLE-ABS-KEY ((ehealth OR "e health")) OR TITLE-ABS-KEY ((mhealth OR "m health")) OR TITLE-ABS-KEY (("mobile health" OR "mobile technolog*")) OR TITLE-ABS-KEY (("digital health" OR "digital technolog*")) OR TITLE-ABS-KEY ((smartphone* OR "smart phone*")) OR TITLE-ABS-KEY (("cell* phone*" OR "mobile phone*")) OR TITLE-ABS-KEY (("mobile app" OR "mobile apps" OR "mobile application*")) OR TITLE-ABS-KEY ("text messag*") OR TITLE-ABS-KEY ("social media") OR TITLE-ABS-KEY ((website* OR online OR internet)) OR TITLE-ABS-KEY ((whatsapp OR facebook OR twitter OR instagram)) OR TITLE-ABS-KEY (internet) OR TITLE-ABS-KEY ("handheld computer") OR TITLE-ABS-KEY (("personal digital assistant" OR pda)) OR TITLE-ABS-KEY ((tablet* W/3 (comput* OR device*))) OR TITLE-ABS-KEY (bluetooth) OR TITLE-ABS-KEY ("monitoring device*") OR TITLE-ABS-KEY ("wireless device*") OR TITLE-ABS-KEY ((smartwatch* OR "smart watch*")) OR TITLE-ABS-KEY (("fitness tracker*" OR fitbit*))))

587 records retrieved

TRIP Turning Research into Practice (https://www.tripdatabase.com/)

Search conducted on 22nd March 2021

#	Search	Results
1.	("Gestational diabetes") OR ("gestational diabet*") OR (gdm) OR (pregnancy diabetes) OR (((pregnan* OR gestation* OR maternal) glucose AND intolerance)) (((pregnan* OR gestation* OR maternal) impaired AND glucose AND tolerance)) OR ((hyperglyc#emia pregnan*)) ((hyperglyc#emia gestation*)) ((maternal AND hyperglyc#emia))))	4,370
2.	(((telemedicine) OR ((ehealth OR "e health")) ((mhealth OR "m health")) OR (("mobile health" OR "mobile technolog*")) (("digital health" OR "digital technolog*")) OR ((smartphone* OR "smart phone*")) (("cell* phone*" OR "mobile phone*")) OR (("mobile app" OR "mobile apps" OR "mobile application*")) OR ("text messag*") OR ("social media") OR ((website* OR online OR internet)) OR ((whatsapp OR facebook OR twitter OR instagram)) OR (internet) OR ("handheld computer") OR (("personal digital assistant" OR pda)) OR ((tablet* (comput* OR device*))) OR (bluetooth) OR ("monitoring device*") OR ("wireless device*") OR ((smartwatch* OR "smart watch*")) OR (("fitness tracker*" OR fitbit))))	172
3.	#1 AND #2	186

Open Grey

Search conducted on 22nd March 2021

#	Search	Results
1.	Gestational diabetes	42

ISRCTN Registry (https://www.isrctn.com/)

Search conducted on 22nd March 2021

#	Search	Results
1.	Gestational diabetes	194

ClinicalTrials.gov (https://clinicaltrials.gov/)

Search conducted on 22nd March 2021

#	Search	Results
1.	Gestational diabetes AND mHealth	11
2.	Gestational diabetes AND eHealth	5
3.	Gestational diabetes AND smartphone	13
4.	Gestational diabetes AND technology	26

EU Clinical Trails Register (https://www.clinicaltrialsregister.eu/)

Search conducted on 22nd March 2021

#	Search	Results
1.	Gestational diabetes	61

Australia and New Zealand Clinical Trials Registry (https://www.anzctr.org.au/)

Search conducted on 22nd March 2021

#	Search	Results
1.	Gestational diabetes	164

Appendix II: Studies ineligible following full text review

Adepoju IOO, Douwes R, Abugnaba-Abanga R, Van Der Heiden M, Apentibadek N, Zweekhorst M, et al. MHealth for improving quality of antenatal care in northern Ghana: The Bliss4Midwives project. Trop Med Int Heal. 2017;22:81.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Albert L, Capel I, Garcia-Saez G, Martin-Redondo P, Hernando ME, Rigla M. Managing gestational diabetes mellitus using a smartphone application with artificial intelligence (SineDie) during the COVID-19 pandemic: Much more than just telemedicine. Diabetes Res Clin Pract. 2020;169:108396.

Reason for exclusion: Ineligible source type

ANZCTR. Continuous Glucose Monitoring (CGM) for women with Gestational Diabetes Mellitus (GDM) study: pilot. [Internet]. 2018. [cited 2021 Mar 22]. Available from: https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=374153.

Reason for exclusion: Ineligible intervention: Not mHealth

Aranda MIF. Technological advances in the follow-up of diabetic pregnant women. Matronas Prof. 2017;18(4):e64–72.

Reason for exclusion: Article not available in English

Artola G, Torres J, Larburu N, Álvarez R, Muro N. Development and Usability Assessment of a Semantically Validated Guideline-Based Patient-Oriented Gestational Diabetes Mobile App. In Fred A, Salgado A, Aveiro D, Dietz J, Bernardino J, Filipe J. Eds. Knowledge Discovery, Knowledge Engineering and Knowledge Management. Spain: Springer Science and Business Media Deutschland GmbH. 2020; p.237–59.

Reason for exclusion: Unable to access full text

Bartholomew ML, Church K, Graham G, Burlingame J, Zalud I, Sauvage L, et al. Managing diabetes in pregnancy using cell phone/internet technology. Am J Obstet Gynecol. 2011;204(1):S113-S114.

Reason for exclusion: Ineligible intervention: Telemedicine

Bogaerts A, Ameye L, Bijlholt M, Amuli K, Heynickx D, Devlieger R. INTER-ACT: Prevention of pregnancy complications through an e-health driven interpregnancy lifestyle intervention - Study protocol of a multicentre randomised controlled trial. BMC Pregnancy Childbirth. 2017;17(1):1–9.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Borgen I, Garnweidner-Holme LM, Jacobsen AF, Bjerkan K, Fayyad S, Joranger P, et al. Smartphone application for women with gestational diabetes mellitus: A study protocol for a multicentre randomised controlled trial. BMJ Open. 2017;7(3).

Reason for exclusion: Background Article: Protocol with full study results available from included study [Borgen et al., 2019]

Bradley D, Landau E, Wolfberg A, Baron A. 500: Predicting the likelihood of developing gestational diabetes using data collected from a pregnancy mobile app. Am J Obstet Gynecol. 2019;220(1):S336.

Reason for exclusion: Ineligible population

Brough C, Schreder S, Northern A, Hadjiconstantinou M, Davies M, Khunti K. Development of a web-based prevention programme for women with post gestational diabetes (GDM): Baby steps. Diabet Med. 2019;36:100–1.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Cai M, Tan KH, Ang SB. I-ACT: Integrated study on effect of Activity on ComplicaTions in pregnancy: Study protocol of a multiethnic prospective cohort study. BMJ Open. 2019;9(4).

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Caretto A, Rossi MG, Laurenzi A, Triberti S, Gandolfi A, Barrasso M, et al. The “active ageing” app: Preliminary usability evaluation of a mobile application for diabetes self-management. Diabetes Technol Ther. 2018;20:A116.

Reason for exclusion: Ineligible population

Cheung NW, Blumenthal C, Smith BJ, Hogan R, Thiagalingam A, Redfern J, et al. A pilot randomised controlled trial of a text messaging intervention with customisation using linked data from wireless wearable activity monitors to improve risk factors following gestational diabetes. Nutrients. 2019;11(3):590.

Reason for exclusion: Ineligible intervention. mHealth not the main intervention component

Chan KL, Chen M. Effects of social media and mobile health apps on pregnancy care: Meta-analysis. JMIR mHealth uHealth. 2019;7(1).

Reason for exclusion: Ineligible source type: systematic review searched and no novel studies found

Chen Q, Carbone ET. Functionality, Implementation, Impact, and the Role of Health Literacy in Mobile Phone Apps for Gestational Diabetes: Scoping Review. JMIR diabetes. 2017;2(2):e25.

Reason for exclusion: Ineligible source type: scoping review, searched and no novel studies found

Collier J, Fortuin J, Adams S. Development of a gestational diabetes selfmanagement and remote monitoring mobile platform. J Diabetes Sci Technol. 2020;14(2):A24.

Reason for exclusion: Ineligible population

Ding B, Gou B, Guan H, Wang J, Bi Y, Hong Z. WeChat-assisted dietary and exercise intervention for prevention of gestational diabetes mellitus in overweight/obese pregnant women: a two-arm randomized clinical trial. Arch Gynecol Obstet. 2021;Epub ahead of print.

Reason for exclusion: Unable to access full text

Garg N, Shaima KA, Arora S, Kaur K. Application of Mobile Technology for Disease and Treatment Monitoring of Gestational Diabetes Mellitus Among Pregnant Women: A Systematic Review. J Diabetes Sci Technol. 2020.

Reason for exclusion: Ineligible source type; review searched and no novel studies found

Garnweidner-Holme L, Henriksen L, Torheim LE, Lukasse M. Effect of the Pregnant+ Smartphone App on the Dietary Behavior of Women With Gestational Diabetes Mellitus: Secondary Analysis of a Randomized Controlled Trial. JMIR mHealth uHealth. 2020;8(11):e18614.

Reason for exclusion: Ineligible source type

Gibson OJ, Loerup L, MacKillop L, Farmer AJ, Levy JC, Bartlett K, et al. GDm-health: Remote monitoring for gestational diabetes. J Diabetes Sci Technol. 2013;7(1):A51.

Reason for exclusion: Background article: full study included [Mackillop et al., 2018]

Hawkins M, Iradukunda F, Paterno M. Feasibility of a Sleep Self-Management Intervention in Pregnancy Using a Personalized Health Monitoring Device: Protocol for a Pilot Randomized Controlled Trial. JMIR Res Protoc. 2019;8(5):e12455.

Reason for exclusion: Ineligible population

Hirst JE, Mackillop LH, Loerup L, Farmer AJ, Kevat DA, Bartlett KJ, et al. GDm-health: Development of a real-time smartphone solution for the management of women with gestational diabetes mellitus (GDM). BJOG An Int J Obstet Gynaecol. 2015;122:403.

Reason for exclusion: Background article: full study included [Mackillop et al., 2018]

Honarvar B, Salehi F, Shaygani F, Hajebrahimi M, Homayounfar R, Dehghan S, et al. Opportunities and threats of electronic health in management of diabetes mellitus: An umbrella review of systematic review and meta-analysis studies. Shiraz E Med J. 2019;20(1):e81794.

Reason for exclusion: Ineligible population

Ilias I. Smartphones for gestational diabetes in the COVID-19 era. J Diabetes Metab Disord. 2021;3:1-2.

Reason for exclusion: Ineligible source type

Immanuel J, Simmons D. Apps and the Woman With Gestational Diabetes Mellitus. Diabetes Care. 2021;44(2):313–5.

Reason for exclusion: Ineligible source type

Isrctn. Comparing continuous glucose monitoring with self-monitoring of blood glucose in gestational diabetes. [Internet]. 2018. [cited 2021 Mar 22]. Available from: http://www.who.int/trialsearch/Trial2.aspx?TrialID=ISRCTN92877235.

Reason for exclusion: Ineligible intervention: Not mHealth

Kalhori SRN, Hemmat M, Noori T, Heydarian S, Katigari MR. Quality evaluation of english mobile applications for gestational diabetes: App review using mobile application rating scale (mars). Curr Diabetes Rev. 2021;17(2):161–8.

Reason for exclusion: Ineligible source type: review searched and no novel studies found

Larsen B, Micucci S, Hartman S, Ramos G. Feasibility and Acceptability of a Counseling- and mHealth-Based Physical Activity Intervention for Pregnant Women With Diabetes: The Fit for Two Pilot Study. JMIR mHealth uHealth. 2020;8(10):e18915.

Reason for exclusion: Ineligible population

Lau Y, Htun TP, Wong SN, Tam WSW, Klainin-Yobas P. Efficacy of Internet-Based Self-Monitoring Interventions on Maternal and Neonatal Outcomes in Perinatal Diabetic Women: A Systematic Review and Meta-Analysis. J Med Internet Res. 2016;18(8):e220.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Lee M, Park CY, Park SW, Lee DY, Sung J. Implementation and evaluation of gestational diabetes management using mobile health care service-a pilot study. Diabetes. 2018;67:A186-.

Reason for exclusion: Background article: full study included [Sung et al., 2019]

Leziak K, Strohbach A, Jackson J, Niznik CM, Yee LM. 302: Identifying low-income pregnant women's experiences and preferences with mobile health technology. Am J Obstet Gynecol. 2020;222(1):S203–4.

Reason for exclusion: Ineligible population

Loerup L, Gibson OJ, Hirst JE, Farmer AJ, Bartlett KJ, Kenworthy YM, et al. GDm-Health: A pilot study demonstrating the feasibility of mobile phone assisted treatment advice and medication adjustment for women with gestational diabetes. Diabet Med. 2014;31:148–9.

Reason for exclusion: Background article: full study included [Hirst et al., 2015]

Loerup L, Gibson OJ, Hirst JE, Farmer AJ, Bartlett KJ, Kenworthy YM, et al. A comparison of blood glucose metrics to assess the feasibility of a digital health system for management of women with gestational diabetes: The GDm-Health study. Diabet Med. 2015;32:18–9.

Reason for exclusion: Ineligible source type and Ineligible population

Mackillop LH, Bartlett K, Birks J, Farmer AJ, Gibson OJ, Kevat DA, et al. Trial protocol to compare the efficacy of a smartphone-based blood glucose management system with standard clinic care in the gestational diabetic population. BMJ Open. 2016;6(3).

Reason for exclusion: Background artilce: protocol with full study results available from included study [Mackillop et al., 2018]

McLean A, Osgood N, Newstead-Angel J, Stanley K, Knowles D, Van Der Kamp W, et al. Building research capacity: Results of a feasibility study using a novel mHealth epidemiological data collection system within a gestational diabetes population. Vol. 234, Studies in Health Technology and Informatics. 2017;234:228–232.

Reason for exclusion: Ineligible intervention type; passive data collection only

McMillan B, Abdelgalil R, Madhuvrata P, Easton K, Mitchell C. Reducing the risk of type 2 diabetes mellitus in primary care after gestational diabetes: a role for mobile technology to improve current care. Br J Gen Pract. 2016;66(653):631–2.

Reason for exclusion: Ineligible source type

Minschart C, Maes T, De Block C, Van Pottelbergh I, Myngheer N, Abrams P, et al. Mobile-based lifestyle intervention in women with glucose intolerance after gestational diabetes mellitus (Melinda), a multicenter randomized controlled trial: Methodology and design. J Clin Med. 2020;9(8):1–14.

Reason for exclusion: Ineligible intervention: mHealth not the main component

Nct. Trial of Remote Evaluation and Treatment of Gestational Diabetes Mellitus. [Internet]. 2013. [cited 2021 Mar 22]. Available from: https://clinicaltrials.gov/show/NCT01916694.

Reason for exclusion: Background article: full study included [Mckillop et al., 2018]

Nct. The Blossom Project: “BlossomUP” Methods to Decrease Sedentary Time in Pregnancy. [Internet]. 2016. [cited 2021 Mar 22]. Available from: https://clinicaltrials.gov/show/NCT02909725.

Reason for exclusion: Ineligible intervention. mHealth not the main intervention component

Nct. Group and Mobile Care for Gestational Diabetes. [Internet]. 2017. [cited 2021 Mar 22]. Available from: https://clinicaltrials.gov/show/NCT03026218.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Nct. Mobile-based Lifestyle Intervention in Women With Glucose Intolerance After Gestational Diabetes. [Internet]. 2018. [cited 2021 Mar 22]. Available from: https://clinicaltrials.gov/show/NCT03559621.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

907 Nct. iGlucose® Remote Patient Monitoring Device as an Adjunct to Routine Glucose Meter Devices
908 for Glycemic Management and Control in Gestational Diabetes. [Internet] 2019. [cited 2021 Mar 22].
909 Available from: https://clinicaltrials.gov/show/NCT04206748.

910 ***Reason for exclusion:*** Ineligible intervention: Not mHealth

911 Nct. A Behavioral Intervention to Prevent Gestational Diabetes Mellitus. [Internet]. 2019. [cited 2021
912 Mar 22]. Available from: https://clinicaltrials.gov/show/NCT03987412.

913 ***Reason for exclusion:*** Ineligible intervention: mHealth not the main intervention component

914 Nct. The Effectiveness of Rt-CGM to Improve Glycemic Control and Pregnancy Outcome in Patients
915 With GDM. [Internet]. 2019. [cited 2021 Mar 22]. Available from:
916 https://clinicaltrials.gov/show/NCT03981328.

917 ***Reason for exclusion:*** Ineligible intervention: Not mHealth

918 Nicklas JM, Leiferman JA, Bull SS, Arment S, Hovey DA, Barbour L. Development and modification of
919 a mobile health program for postpartum women at elevated risk for cardiometabolic disease. J Gen
920 Intern Med. 2018;33(2):156.

921 ***Reason for exclusion:*** Ineligible population

922 Nikolopoulos M, Karampela I, Antonakos G, Tzortzis E, Stratigou T, Diomidous M, et al. Mobile Phone
923 Applications for Gestational Diabetes Mellitus: Appraisal and Perspectives. Studies in Health Technol
924 and Inform. 2019;262:39–42.

925 ***Reason for exclusion:*** Ineligible source type: literature review, searched and no novel studies found

926 Nielsen KK, Dahl-petersen IK, Jensen DM, Ovesen P, Damm P, Jensen NH, et al. Protocol for a
927 randomised controlled trial of a co-produced , complex , health promotion intervention for women with
928 prior gestational diabetes and their families: the Face-it study. Trials. 2020; 21(1):146.

929 ***Reason for exclusion:*** Ineligible intervention: mHealth not the main intervention component

Northern A, Schreder S, Troughton J, Brough C, Liptrot C. Developing a complex intervention for the prevention of Type 2 diabetes in women who have had gestational diabetes: Baby steps-Walking away after gestational diabetes. Diabet Med. 2018;35:121.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

O'Sullivan EJ, Kennelly MA, Rokicki S, Ainscough K, McAuliffe FM. Cost-effectiveness of a mobile healthsupported lifestyle intervention for preventing gestational diabetes mellitus. Am J Obstet Gynecol. 2018;218(1):S380–1.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Peleg M, Shahar Y, Quaglini S, Broens T, Budasu R, Fung N, et al. Assessment of a personalized and distributed patient guidance system. Int J Med Inform. 2017;101:108–30.

Reason for exclusion: Background article: full sudy included [Mercedes et al., 2017]

Peleg M, Shahar Y, Quaglini S, Fux A, García-Sáez G, Goldstein A, et al. MobiGuide: a personalized and patient-centric decision-support system and its evaluation in the atrial fibrillation and gestational diabetes domains. User Model User-adapt Interact. 2017;27(2):159–213.

Reason for exclusion: Background article: Full study included [Mercedes et al., 2017]

Pustozerov EA, Chernykh VY, Popova P V, Vasyukova EA, Tkachuk AS, Yuldashev ZM. Health Monitoring System for Patients with Gestational Diabetes Mellitus Based on Nutrition Diaries and Fitness Bracelets. Biomed Eng. 2020;53(5):305–8.

Reason for exclusion: Ineligible population

Pustozerov EA, Popova P. Mobile-based decision support system for gestational diabetes mellitus. In: Proceedings "2018 Ural Symposium on Biomedical Engineering, Radioelectronics and Information Technology (USBEREIT)". 2018;45–8.

Reason for exclusion: Background article: full study excluded [Pustozervo et al., 2018]

Pustozerov E, Popova P, Tkachuk A, Bolotko Y, Yuldashev Z, Grineva E. Development and evaluation of a mobile personalized blood glucose prediction system for patients with gestational diabetes mellitus. J Med Internet Res. 2018;20(1).

Reason for exclusion: Ineligible source type and Ineligible population

Pustozerov EA, Tkachuk AS, Vasukova EA, Anopova AD, Kokina MA, Gorelova I V, et al. Machine Learning Approach for Postprandial Blood Glucose Prediction in Gestational Diabetes Mellitus. IEEE Access. 2020;8:219308-219321.

Reason for exclusion: Ineligible population and Ineligible intervention

Saha S. Compliance and barriers to self-monitoring of blood glucose in patients with gestational diabetes mellitus: A systematic review. Int J Health Sci (Qassim). 2019;13(3):44–52.

Reason for exclusion: Ineligible source type: Systematic review, searched and no novel studies found

Salvi D, Velardo C, Mackillop L, Tarassenko L. Algorithmic comparison of patient-reported blood glucose diary records with meters' memory in gestational diabetes. Informatics Med Unlocked. 2020;20:100397.

Reason for exclusion: Ineligible population

Seo Y, Kim EM, Choi JS, Park C-Y. Using a Mobile-based Nutritional Intervention Application Improves Glycemic Control but Reduces the Intake of Some Nutrients in Patients with Gestational Diabetes Mellitus: A Case Series Study. Clin Nutr Res. 2020;9(1):73–9.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Skau JKH, Nordin ABA, Cheah JCH, Ali R, Zainal R, Aris T, et al. A complex behavioural change intervention to reduce the risk of diabetes and prediabetes in the pre-conception period in Malaysia: Study protocol for a randomised controlled trial. Trials. 2016; 17(1):215.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Sukumar N, Dallosso H, Saravanan P, Yates T, Telling C, Shorthose K, et al. Baby Steps - a structured group education programme with accompanying mobile web application designed to promote physical activity in women with a history of gestational diabetes: study protocol for a randomised controlled trial. Trials. 2018;19(1):682.

Reason for exclusion: Ineligible intervention: mHealth not the main intervention component

Teoh SY, Mercieca P, Wickramasinghe N. The use of smart phones for accountable care and evidence-based decision making in the management of gestational diabetes. PACIS 2014 proceedings. 2014;219.

Reason for exclusion: Background article: full study included [Wickramasinghe et al., 2019]

Triberti S, Bigi S, Rossi MG, Caretto A, Laurenzi A, Dozio N, et al. The ActiveAgeing Mobile App for Diabetes Self-management: First Adherence Data and Analysis of Patients' in-App Notes. Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering (LNICST). 2018;253:129–138.

Reason for exclusion: Ineligible population

Wickramasinghe N, Cole S, Kliman L, Vogel D, Goldberg S. Exploring the possibility for a pervasive technology solution to facilitate effective diabetes self-care for patients with gestational diabetes. ECIS 2014 Proceedings - 22nd European Conference on Information Systems. 2014.

Reason for exclusion: Background article: full study included [Wickramasinghe et al. 2019]

Wickramasinghe N, Gururajan R. Innovation Practice Using Pervasive Mobile Technology Solutions to Improve Population Health Management: A Pilot Study of Gestational Diabetes Patient Care in Australia. J Healthc Qual. 2016;38(2):93–105.

Reason for exclusion: Background article: full study included [Wickramasinghe et al., 2019]

Wickramasinghe N, Singh M, Troshani I, Hill SR, Hague W, Goldberg S. A pervasive technology solution for diabetes using gestational diabetes as a model. In: 16th Americas Conference on Information Systems 2010 (AMCIS 2010). 2010;1651–60.

Reason for exclusion: Ineligible population

Wickramasinghe N, Teoh SY, Mercieca P. Using smartphones for accountable care and evidence-based decision making in managing gestational diabetes: An Australian case study. Commun Assoc Inf Syst. 2015;37(1):705–16.

Reason for exclusion: Background article

Yee LM, Jackson J, Leziak K, Niznik CM, Saber R, Yeh C, et al. 750: SweetMama: Usability testing of a novel mobile application for diabetes education and support during pregnancy. Am J Obstet Gynecol. 2020;222(1):S474–5.

Reason for exclusion: Ineligible population

Zulbahari SFA, Abdullah Z, Abdul Halim NH, Abu Bakar NS, Md Shaidin SA, Abd Rashid MF, et al. Complex lifestyle intervention to reduce the risk of diabetes in the pre-conception period; A community trial, challenges and key-learning. Med J Malaysia. 2017;72:54.

Reason for exclusion: Ineligible intervention. mHealth not the main intervention component

1015 # Appendix III: Data extraction instrument

Main category	Subcategory	Description
1. Authors		
2. Title		
3. Journal		
4. Year of publication		
5. Origin/country of origin		
6. Description of study	Type	Specify the type of study (e.g, Review, study protocol)
	Design	Specify the study design (e.g. RCT, qualitative study, quasi-experimental)
	Objective	Describe the study objective(s)
	Population	Describe the study population (e.g. at risk, pregnant, postpartum women) and their geographical location
	Outcome	State what the primary and secondary study outcomes are, where applicable
	Comparator	Describe the comparator intervention used, where applicable
7. Intervention implementation	Timing	Specify if the study states the timing of intervention implementation (e.g. Preconception, during pregnancy (weeks gestation), postpartum)
	Context	Specify if the study focuses on intervention delivery in a particular care setting (e.g. Primary, secondary, community care)
		Describe how and by whom the intervention is delivered
8. Description of the intervention	Type	Describe the type of intervention (e.g. app, wearable, social media,)
	Purpose	Describe the stated purpose of the intervention (e.g. Information giving, behavioral change, BGL monitoring, weight management)
	Length/intensity	Describe for how long and how often the intervention is delivered
	Theoretical background	Describe the theoretical background included in intervention development, where applicable
	Behavior change techniques	List of included behavior change techniques as categorized by the 26-item taxonomy developed by Michie and Abraham

9. Key findings	Engagement	Describe where applicable, study findings on engagement of intervention (e.g. motivation to use intervention, time spent using intervention)
	Usage/adoption/adherence	Barriers and facilitators to intervention use/adoption among stakeholders
	User experience	Description of study reporting on user experience (e.g. satisfaction, perception)
	Intervention feasibility	Barriers and facilitators to study implementation (e.g. recruitment, retention, study processes, study burden)

Appendix IV: Characteristics of included studies

Author/published year, country of origin / mHealth intervention	Study focus and design	mHealth type and purpose	mHealth features	Target population and sample	Outcome measures	Implementation context and duration of mHealth use	Behavior change theory and techniques	Key study findings
Borgen *et al.* [30] 2019 Norway Pregnant+ App	Evaluation Multicenter [a]RCT Intervention: App + standard care Control: standard care	App to support [b]GDM self-management	- 'blood glucose' monitoring with real-time visualization - Physical activity – written examples with images of how to perform activities - Culturally	Pregnant women aged 18+, with 2-hour [c]OGTT >9 mmol/L who owned a smartphone Intervention (n=112) Control (n=121)	Primary: postpartum [d]BGL 2hr OGTT at 3 months postpartum Secondary: induction of labor; mode of delivery; [e]NICU admission; Apgar Score; birth weight; infant feeding; cessation of breastfeeding; engagement with health via	App introduced at a diabetes outpatient clinic. Women downloaded the app themselves at hospital or at home. App used ≤33 weeks gestation to 3 months postpartum	Health Belief Model 1) Provides feedback on performance 2) Provide information about behavior-health link 3) Provides information on	Women who declined to take part (n=61), gave reasons such as too time consuming and no interest in the study. Large loss to follow up at 3 months postpartum meant the value and interpretation of findings is

			adapted information about diet - Diabetes information – general info about GDM, follow-up and postpartum. - Interaction with [f]HCPs is not possible but information from the app can be printed.		app		consequences and benefits 4) Prompts self-monitoring Provides instruction	restricted.
Castorino *et al.*[31] 2018 USA Tu Puedes App	Pilot study Quasi experimental design	Culturally and linguistically appropriate	- 4 'lessons' about [g]T2DM prevention - Culturally	Latina women previously diagnosed with GDM aged 18-40	Primary: qualitative experience of using the app Secondary: self-	Not reported	1) Information about behavior-health link	Findings suggest satisfaction with app use and intention

	with control Intervention : app use alone Control: classroom based education sessions	educational app for diabetes prevention among Latina women with pervious GDM	applicable information	(n=22) Intervention: (n=not reported) Control: (n=not reported)	perceived health; weight; [h]BMI; waist circumference; blood pressure			among women to continue use.
Crimmins *et al.*[32] 2019 USA Glucose Mamma (App)	Evaluation Prospective RCT Intervention : app use alone Control: standard care	App to support GDM self-management	- Manual upload of BGL readings with real-time feedback - Text messages with positive feedback Information on healthy eating, recipes and meal plans	Pregnant women diagnosed with GDM at 24-34 weeks gestation. Intervention (n=13) Control (n=20)	Primary: Need to start pharmacologic therapy (metformin, glyburide and/or insulin). Secondary: compliance; no. of BGL readings logged; mode of delivery; shoulder dystocia; preeclampsia; birthweight;	App offered to women at a tertiary medical center. App used from diagnosis (24-34 weeks gestation) to delivery	1) Prompt self-monitoring of behavior 2) Provide feedback on performance	Findings suggest compliance among women with weekly log review when using the app.

					NICU admission; phototherapy; hypoglycemia; completed 2hr OGTT; initiated birth control; arrived at postpartum visit; breastfeeding at 6 weeks postpartum; weight loss at postpartum visit			
Dyson *et al.* [33] 2019 UK GDmHealth Plus App	Pilot study Mixed methods evaluation	Mobile-phone based system for blood glucose management and behavioral lifestyle change during	See Mackillop et al. 2018 (GDmHealth app) for GDM self-management functions. - Weekly self-weighing - Carbohydrate	Pregnant women diagnosed with GDM (n=18)	System usage and satisfaction	App introduced to women at a large tertiary hospital. App used from diagnosis to delivery	1) Prompts self-monitoring behavior 2) Provide feedback on performance 3) Provides instruction	Findings suggest women interacted with the app and were satisfied with features aside from self-weighing and feedback about weight.

		pregnancy	counting - Physical activity monitoring - Real-time feedback on healthy behaviors via specialist dietician and midwives					
Garnweidner-Holme *et al.* [34] 2015 Norway Pregnant+ App	Development and usability User-centered iterative design and development process and think-aloud	See Borgen et al. 2019	See Borgen et al. 2019	Pregnant women diagnosed with GDM (n=21)	Design and develop an app	See Borgen et al. 2019	See Borgen et al. 2019	Findings suggest women's user experience was positive. Facilitators included making it easier to manage BGL and having real-time

	interviews.							feedback on levels. Inclusion of culturally appropriate information was also seen as key to adoption. Barriers included contradicting information between app and HCPs.
Ghaderi *et al.* [35] 2019. Iran Unnamed App	Evaluation Quasi-experimental design with control group Intervention: app + paper	Educational app to increase risk perception of T2DM among pregnant women with GDM	- Profile creation - Reminders for tests and medications - Video, photo and text education	Pregnant women with GDM diagnosis using insulin, aged 18-40, have android smartphone Intervention: (n=44)	Primary: Risk perception of T2DM measured before and 6 weeks after intervention delivery	App introduced to women at university hospital. App was installed for women, and provided with a guidance booklet. App	1) Prompts practice 2) Provide information about behavior-health link 3) Provide information about	No findings regarding engagement or user experience available.

	based education Control: paper based education		materials FAQ section regarding GDM and T2DM	Control: (n=43)		used for 6 weeks	consequence Provides instruction	
Guo *et al.*[36] 2019 China dNurse App	Evaluation Single center RCT Intervention: app use + standard care Control: standard care	App to support GDM self-management	- Manual upload of BGL readings with real-time feedback - BGL data transmitted to HCP - HCP available to answer questions Provision of information on diet, exercise, treatment and GDM	Pregnant women with GDM diagnosis (fasting BGL ≥5.1mmol/L or 1HR OGTT ≥10.00 mmol/L or 2hr OGTT ≥8.5 mmol/L) aged 21-45 years, able to use smartphone Intervention (n=64) Control (n=60)	Outcomes: Compliance with BGL monitoring; frequency of outpatient service use; [j]HbA1c before delivery; mode of delivery; no. of off-target BGL measurements; shoulder dystocia; hypoglycemia in newborn; fetal macrosomia; [K]GA at delivery;	App offered to women at university hospital and downloaded the app themselves. App used from 24-28 weeks gestation to delivery.	1) Real-time feedback 2) Prompt self-monitoring of behavior 3) Information on health-behavior link 4) Provides instruction	Findings suggest women successfully used the app for recording their BGL.

					BLG measured by OGTT 3 months postpartum			
Hashmi [37] 2019 Oman SESSPA (App)	Trial registration Feasibility RCT Intervention : app use alone	App to support GDM self-management	- health education content about GDM - goal setting and action planning - videos regarding recommended physical activities - video about the steps for blood glucose monitoring - photo	Pregnant women with GDM diagnosis aged 18+ (n=15)	Primary outcome: Feasibility measured by: rates of recruitment; retention rate; completion of intervention; participant satisfaction Secondary outcomes: Accessibility measured by: usage; focus groups	App introduced to women at university hospital. App used from 22 – 30 weeks gestation until delivery	1) Prompt intention formation 2) Prompts practice 3) Prompts self-monitoring behavior 4) Provides feedback on performance 5) Information on health-behavior link 6) Informati	N/A

			examples of the recommended healthy diet - tracking of physical activity, diet and BGL - progress charts of daily self-reported data on healthy diet, physical activity and blood glucose monitoring. - text messages reminder				on on consequences 7) Provides instruction	

			twice a day (8:00 am and 8:00 pm) to check their blood glucose level, maintain healthy eating, and maintain an active lifestyle.					
Hirst *et al*. [38] 2015; UK GDmHealth App	Pilot study Post questionnaire measuring satisfaction	See Mackillop et al. 2018	See Mackillop et al. 2018	Pregnant women with GDM diagnosis, not requiring pharmacological treatment (n=52)	Outcomes: Satisfaction with diabetes care; satisfaction with the GDmHealth system; relationship with diabetes care team	See Mackillop et al. 2018	See Mackillop et al. 2018	Findings suggest overall acceptability and satisfaction with app among women.
Jo and Park [39] 2016 Korea	Development and usability	App to provide tailored	App includes eight algorithms with	Pregnant women with GDM	Outcomes: Usability and acceptance	Women were recruited from an online	1) Prompts self-monitoring	Findings suggest women thought

Unnamed App	study Mixed methods evaluation of usability and acceptability	interventions for GDM self-management.	18 decision nodes which enable the app to generate generic and tailored recommendations based on patient's data and clinical guidelines.	diagnosis Initial Usability (n=5) Further usability (n=60)		diabetes group to test the app at home. App used for 1 week	behavior 2) Provides feedback on performance	the app was useful but responses were mixed regarding acceptability including intention and motivation to use.
Kim *et al.* [40] 2021 South Korea (Virtual Reality)	Evaluation Quasi-experimental study with control Intervention: VR program use Control: written educational	Mobile Virtual reality to support self-management to prevent type 2 diabetes	- 123 options of exercises - Nutrition program - Tracking of dietary intake with feedback on progress via graphs - Laughter therapy and deep	Postpartum women with prior GDM diagnosis, aged 20+ Intervention (n=57) Control (n=62)	Outcomes: Weight; body fat (%); fasting glucose level; HbA1C; diabetes knowledge; self-reported dietary habits; parenting stress; health promoting lifestyle behaviors	Women were asked to download and install the mobile ㄴVR program on their mobile phone the day before their scheduled delivery date or day after delivery. VR headsets were provided	1) Prompts self-monitoring behavior 2) Provides feedback on performance 3) Provides instruction 4) Model or demonst	No findings regarding engagement or user experience available.

	material		breathing for stress relief - Neonatal first aid program			to women at hospital delivery setting. How to use the equipment was demonstrated to women. VR use from birth for 12 weeks	5) Stress manage ment	
Lechner [41] 2017 Germany Triangle App	Trial registration (Evaluation) Parallel multi-center RCT Intervention : app use Control: one-time written and in-person lifestyle	App to deliver lifestyle intervention program to reduce risk of T2DM among postpartum women with prior GDM	Not reported	Postpartum women with prior GDM (3-18 months ago) aged 18-50 (n=64)	Primary outcome: Proportion of women reaching 3 or more of the 5 Diabetes Prevention Program lifestyle aims at final study visit (6 months) which are: 150 mins of high intensity	Women commence app use at 3 – 18 months postpartum for 6 months of use	Not reported	N/A

	counselling				physical activity per week; 15g fiber; 30% of energy from fat; 10% energy from saturated fat; BMI Achievement of pre-defined nutrition, exercise and body weight Secondary outcomes: BGL from baseline to follow up; change of insulin sensitivity; BMI; ^{m}V02 peak; body fat mass; psychological wellbeing			
Lim *et al.* [42] 2021 Singapore	Evaluation Single	App to support return to	- Track diet, exercise and	Postpartum women with prior GDM	Primary outcome: % of women	App introduced after delivery,	1) Prompt intention formation	Findings suggest that engagement

nBuddy app	center, open-label, RCT Intervention: app use Control: standard care (6 week postnatal check with dietary advice and repeat OGTT)	healthy weight	visualization of progress related to goals. - Personalized educational information - Real-time interaction with health and lifestyle coaches	diagnosis (between 24-34 weeks gestation), aged 21+. Intervention (n=101) Control (n=99)	achieving first trimester weight at 4 months postpartum If previous booking weight ≤23 kg/m^2 OR weight loss of at least 5% of first trimester weight in BMI >23kg/m^2. Follow up at 6 weeks and 4 months. Secondary outcome: Fasting BGL; HbA1c; mean weight loss; breastfeeding status; blood pressure; grip strength; waist circumference; caloric and	at University Hospital. Women asked to download the app and briefed on its use by a research assistant. App used for 4 months	2) Provides feedback on performance 3) Prompts self-monitoring 4) Information on health-behavior link 5) Provides instruction	with app was maintained at 4 month follow up.

					macronutrient intake; self-efficacy; health education; well-being			
Loerup *et al.* [43] 2013 UK GDmHealth App	Pilot study Feasibility of GDmHealth system in clinical practice including BG control and user satisfaction.	See Mackillop et al. 2018	See Mackillop et al. 2018	Pregnant women with GDM diagnosis Used the system (n=41) Returned questionnaires (n=31)	Outcomes: Usage and satisfaction	See Mackillop et al. 2018	See Mackillop et al. 2018	Results suggest that overall app usage was high.
Mackillop [44] 2020 Stay Active App UK	Trial registration Single Centre Feasibility study Intervention	App to motivate women to increase activity levels during pregnancy	- Remote motivational interview - Simple interface to provide two-way communication with a	Pregnant women with GDM diagnosis, using the GDmHealth app to monitor BGL, aged 18-45,	Primary outcomes: adherence to wearing accelerometer; acceptability; physical activity (average daily minutes of total	Women offered app in hospital setting and will be shown how to use it. App used from 24-33 weeks	1) Prompt intention formation 2) Prompt-self monitoring of behavior 3) Provides feedback on	N/A

	: app use alone		HCP to provide feedback on agreed goals. - Feedback is given via messages received via the app. - Physical activity goals can be reviewed within the app	have and use smartphone (n=60)	physical activity); recruitment rates Secondary: BGL from baseline to birth; physical activity time and intensity; attitude toward app and usefulness of components Maternal outcomes: weight at baseline to birth; need for pharmacological therapy; hypertension; GA at delivery Neonatal outcomes: birthweight;	gestation to 36-38 weeks gestation.	performance 4) Motivational interviewing	

					hypoglycemia; hyperbilirubinemia; nSCUB admission; shoulder dystocia Health economic outcomes: no. of clinic visits; time spent by clinical midwife delivering intervention			
Mackillop *et al.* [45] 2018 UK GDmHealth App	Evaluation Single center, non-blinded, parallel group RCT Intervention : app use + standard care	Mobile-phone based system for blood glucose management	- Bluetooth Transfer of BG readings direct to app, with real-time feedback - Meal details can be manually	Pregnant women with GDM diagnosis (via 75g OGTT), aged 18-45 yrs., with singleton pregnancy Intervention (n=103) Control	Primary: Rate of change in glycaemia (mmol/L28 days), from recruitment to delivery Secondary: maternal weight, BMI; hypertension; preeclampsia;	Women receiving care at large UK tertiary hospital were loaned a mobile phone with the preinstalled GDmHealth app and taught how to	1) Real-time feedback 2) Prompts self-monitoring 3) Provides instruction	Findings suggest women using the app were satisfied with their care and recorded their BGL using the app.

	Control: standard care		attached to BG readings - Women can request a call back to discuss concerns with HCP. - HCPs can view BGL readings and meal tags via an online portal	(n=103)	GA at delivery; birthweight; ºLGA; birth mode; perineal trauma; shoulder dystocia; birth injury; neonatal hypoglycemia, neonatal hyperbilirubinemia; NICU admission	record, tag, and review blood glucose readings by a research midwife. App used at <35 weeks gestation to delivery		
Mackillop *et al.*[46] 2014 UK GDmHealth App	Development and usability Co-design followed by beta testing (focus groups) and	See Mackillop et al. 2018	See Mackillop et al. 2018	Pregnant women with GDM diagnosis, not requiring pharmacological intervention. Beta testing	Outcomes: Usability and reliability	See Mackillop et al. 2018	See Mackillop et al. 2018	Findings suggest women used the app and complied with BGL monitoring.

	service development (capture of system usage data)			(n=7) Service development (n=50)				
Miremberg *et al.* [47] 2018 Israel Glucose Buddy App	Evaluation Prospective, Single center RCT Intervention: app use + standard care Control: standard care	Mobile-phone based system for blood glucose management	- Manual upload of BGL measurement - Daily reports of BGL emailed to HCP - Individualized feedback on BGL emailed to women daily - Emails also include positive messaging, dietary tips, modifications to insulin treatment, and appointment scheduling - Interaction with HCP	Pregnant women with GDM diagnosis (fasting ≥95 mg/dL, 1-hour ≥180 mg/dL, 2-hour ≥155 mg/dL, 3-hour ≥140 mg/dL) aged 18-45 years Intervention (n=60) Control (n=60)	Primary: Compliance with BGL monitoring Secondary: mean BGL; need for insulin therapy; % of off targe BGL measurements; polyhydramnios; preeclampsia, hypertension; mode of delivery; shoulder dystocia; perineal trauma; birthweight; LGA; NICU admission;	App offered at diabetes in pregnancy clinic at tertiary hospital. All women received a 10 minute demo regarding the use off the app alongside an information leaflet. App used form diagnosis (<34 weeks gestation) to delivery	1) Personalized feedback 2) Prompt to self-manage 3) Provides instruction	Findings suggest compliance with BG monitoring and satisfaction among women using the app.

			regarding questions about GDM management		infant hypoglycemia; phototherapy; respiratory morbidity; neonatal death; composite adverse neonatal outcome			
O'Reilly *et al.* [48] 2019 Australia Health-e mums Program (App with virtual coaching and social media)	Pilot study User-centered - qualitative focus groups	App for T2DM prevention in women with prior GDM	- Tracks weight, exercise and dietary intake - Provides T2DM screening results - Personalized push notifications regarding feedback on body weight,	Postpartum women with prior GDM (n=26)	Feedback on functionality and user experience	N/A	1) Prompts self-monitoring behavior 2) Provides feedback on performance 3) Provides opportunities for social comparison	Facilitators for perceived app use included the app being a reliable and credible source of information that was conveniently accessible. The connection with Facebook was seen as a positive way to connect with other

			diet, and physical activity progress - Virtual health coach guides through seven educational modules				4) Prompts practice 5) Prompt intention formation 6) Information on health-behavior link 7) Provides instruction	postpartum women. Barriers to perceived app use included the usefulness of video segments and applying milestones related to diabetes prevention guidelines.
Pais *et al.* [49] 2017 New Zealand My Meal Mate (App) Glucose Buddy (App) On Track (App) Doctor Diet (App) HealthVault (App)	Pilot study Qualitative interviews / focus groups	Five commercially available health and wellness apps to aid self-management	Apps had a mixture of functionalities including food diaries, exercise tracking, glucose monitoring and ability to export data to clinicians.	Pregnant women with GDM diagnosis (n=5)	Outcomes: Perceived usefulness and perceived ease of use	N/A	1) Prompts self-monitoring behavior	Findings suggest women perceived the ecosystem of apps to be useful. Facilitators for use included sharing data with clinicians and control

								over access of data.
Poulter [50] 2019 Australia Net Health (App)	Trial registration (Pilot) Non-randomized trial Intervention: app use Control: historical control using standard care	App to support self-management of blood glucose levels	- Automatic upload of BGLs in real time to a secure server for review remotely by clinicians. - Automatically generates email alert to clinicians if BGLs are out of target range. - Allows messaging from HCPs to women	Pregnant women with GDM diagnosis, aged 18-45, singleton pregnancy, has and uses smartphone Intervention (n=100) Control (n=100)	Primary outcome; Feasibility (clinic workload); acceptability and patient satisfaction; usage of the system Secondary outcomes: mean weekly BGL; composite neonatal outcomes.	App introduced at diabetes services clinics. The app contains some instructions about its use and women will have direct contact details for the diabetes educators to obtain support. App used from 24-30 weeks gestation to delivery	1) Prompts self-monitoring behavior 2) Provides feedback on performance 3) Provides instruction	N/A

			via the app for dose titration where required.					
Pustozerov *et al.* [51] 2017 Russia Unnamed App	Pilot study App usage data and post study survey	Mobile system for personalized blood glucose prediction	- BGL readings automatically uploaded via continuous glucose monitoring system - Logging of dietary intake - In-built algorithm provides personalized advice regarding upcoming meals	Pregnant women with GDM (n=138)	System usage and patient satisfaction	N/A	1) Provides feedback on performance 2) Prompts self-monitoring behavior	Findings suggest usage of the app among women .Facilitators to using the app were convenience and helpful information. Barriers to usage included lack of food items in the food database when logging meals.

			based on BGL.					
Rawal and Peters [52] 2019 Nepal mGDM (App)	Trial registration User-centered design + Parallel open label RCT Intervention : app use + standard care Control: standard care	App for increasing knowledge and self-efficacy to adhere to healthy lifestyle behaviors	- Health education - Identification and setting of health goals Facilitates support from family members	Pregnant women with GDM diagnosis aged 18+ (n=60)	Primary outcomes: maternal BGL at 6 weeks postpartum; birth weight; mode of delivery; app usage; adherence to BGL monitoring; usability; acceptability	App introduced to women at sub-urban tertiary level university hospital. App will be set up for women on their smartphone. App used from 28 weeks gestation to delivery – maximum of 16 weeks	Social cognitive theory 1) Prompt intention formation 2) Provide opportunities for social comparison 3) Provide information about behavior health link	N/A
Rigla *et al.* [53] 2017 Spain	Pilot study Survey and	AI augmented mobile	- Automatic upload of BGL - Messaging	Pregnant women with GDM	Outcomes: Compliance with BGL	App introduced to women at	1) Prompts self-monitoring	Findings suggest the system to be

MobiGuide App	Observational prospective study Intervention: app use Control: historical control of standard care users	system for GDM self-management	system with HCPs to provide personalized advice regarding meals and BGL - Embedded accelerometer to track physical activity	diagnosed aged 18+ Intervention (n=20) Control (n=247)	monitoring; satisfaction; blood pressure; need for insulin therapy; BGL; GA delivery; Mode of delivery; birth weight; LGA	hospital setting. App used from diagnosis (34 weeks gestation) to delivery	behavior 2) Provides feedback on performance	feasible and acceptable among women who were compliant with BGL monitoring when using the app.
Seely *et al.* [54] 2020 USA Hola Bebe, Adios Diabetes! App	Pilot study Development, feasibility and preliminary effectiveness Intervention: app use alone	App to reduce risk factors associated with T2DM progression among Hispanic women	- Six audio-visual educational modules on healthy eating and physical activity - personal action plans for healthy eating and	Postpartum women with GDM diagnosis in past 5 years, aged 18-45. Acceptability (n=11) Usability (n=4) Pilot (n=21)	Outcomes: Acceptability and usability	A research assistant helped women to download the app and review the 'how-to section'. Women were asked to complete one module,	Social cognitive theory 1) Provide contingent rewards 2) Provide information about behavior-health link 3) Provide	Findings suggest the app to be acceptable and usable for women. Facilitators included features such as audio-visual modules, badges, weight-tracking

			staying active - Educational and motivational messages targeting self-efficacy - weight tracking - recipes - tiered badges to reward achievements			corresponding action plan, weigh themselves and enter this into the app at app introduction. App used for 8 weeks	instruction 4) Prompt-self monitoring of behavior 5) Prompt specific goal setting 6) Prompt intention formation	graphics and recipe features most useful. Findings from app data suggest good levels of engagement with the app over 8 weeks of use.
Skar *et al.* [55] 2018 Singapore Pregnant+ (App)	Evaluation (qualitative) Qualitative process evaluation (nested in RCT	See Borgen et al. 2019	See Borgen et al. 2019	Pregnant women with GDM diagnosis who had been allocated to the intervention	Outcomes: Understand women's experiences of using the Pregnant+ app	See Borgen et al. 2019	See Borgen et al. 2019	Barriers to usage included technological difficulties, feelings of obsession around BGL monitoring and

	Borgen et al. 2019)			arm of the RCT (n=17)				frustration at differences in information between the app and HCPs. Findings overall suggest mixed levels of engagement with the app.
Sung *et al*. [56] 2019 Korea Unnamed App	Pilot study Pilot, single center RCT Intervention; mHealth use + standard care Control: standard care	Mobile system to support GDM self-management	- Automatic upload of BGL readings - BGL data transmitted to clinical team who provide feedback via app 2x per week - Recoding of dietary intake - Interaction	Pregnant women with GDM diagnosis with singleton pregnancy Intervention (n=11) Control (n=10)	Obstetric outcomes: GA at delivery; LGA; C-section rate Maternal outcomes: BMI; weight; % of body fat; OGGT result at 5-12 weeks postpartum	App introduced to women at hospital setting and were trained on how to use the device on assignment. App used from 24-28 weeks gestation until delivery	1) Prompts self-monitoring behavior 2) Provides feedback on performance 3) Provides instruction	No findings regarding engagement or user experience available.

			with HCP who send tailored medical and nutritional guidance via in-app messages.					
Varnfield *et al*.[57] 2020 Australia MOTHer App	Pilot study Feasibility, satisfaction and preliminary effectiveness Intervention: app use alone	App for remote management of blood glucose levels	- Manual upload of BGL readings - BGL readings viewed by HCP via online portal Interventions are tailored based on BGL data	Pregnant women with GDM diagnosis aged 16+. (n=40)	Primary outcome: Usage (number and frequency of BGL readings uploaded); user satisfaction. Secondary outcomes: comparison with historical data regarding: no. of clinical reviews; frequency of antenatal contact; need for	App introduced to women after referral from GP to antenatal care maternity services. App used from 24-28 weeks gestation to delivery	1) Prompts self-monitoring behavior 2) Provides feedback on performance	Findings indicate satisfaction with the app. Facilitators to app use included easy access and convenience. Barriers included technological issues with connectivity.

					pharmacological treatment; service usage.			
Wickramasinghe *et al.* [58] 2019 Australia DiaMOnd App	Evaluation 2x2 un-blinded, singe center, cross-over trial Intervention: App + standard care Control: standard care	Mobile-based system for blood glucose self-management and monitoring	- Manual upload of BGL reading - BGL readings sent to HCP who provide real-time feedback and recommendations for diet, exercise and insulin titration - System keeps a log of diet, physical activity and	Pregnant women with GDM Diagnosis (n=10)	Outcomes: proof of concept; usability; fidelity measured by: patient compliance; patient satisfaction; level of glycemic control achieved; health professional satisfaction	4 weeks	1) Real-time feedback 2) Prompts self-monitoring behavior 3) Provides instruction	Findings suggest women were satisfied with the app. Motivation for using the app was focused on doing the best for their baby. Facilitators for use included the inclusion of a food diary, recommendations for exercise and voice recognition to avoid data entry burden. Facilitators also included

			insulin use for future review					receiving support to use the app by HCPs.
Yew *et al.* [59] 2020 Singapore Habits GDM App	Evaluation Parallel, open label, single center RCT Intervention : app use + standard care Control: standard care alone	App to promote behavior change during pregnancy for a healthy lifestyle	- Tracks diet and physical activity - Provides lifestyle coaching via in app messaging - Interactive lessons to support patient education	Pregnant women with GDM diagnosis (WHO 2013 criteria) aged 21+, had smartphone, Intervention: (n=170) Control: (n=170)	Primary outcome: Proportion of women with excessive gestational weight gain; Secondary outcomes: adherence to BG monitoring; BG control; no of off target BG measurements; requirement of pharmacological therapy; Maternal outcomes: hypertension; preeclampsia delivery and	App introduced at national university hospital and used from 12-30 week's gestation diagnosis.	1) Prompts self-monitoring behavior 2) Provide feedback on performance 3) Information on health-behavior link 4) Provides instruction	No findings regarding engagement or user experience available.

					neonatal outcomes			

[a]RCT – randomized control trial

[b]GDM – gestational diabetes

[c]OGTT – oral glucose tolerance test

[d]BGL – blood glucose level

[e]NICU – neonatal intensive care unit

[f]HCP – health care professional

[g]T2DM – type 2 diabetes mellitus

[h]BMI – body mass index

[J]HbA1C - glycated hemoglobin

[k]GA – gestational age

[L]VR – virtual reality

[m]V02 – oxygen uptake

[n]SCUB – special care baby unit

1032 [o]LGA - large for gestational age