Women's experiences with using a smartphone app (the X[1] app) to manage gestational diabetes mellitus in a randomised controlled trial

Introduction

Gestational diabetes mellitus (GDM), defined as glucose intolerance with first onset or recognition during pregnancy, is an increasing health challenge worldwide (Ferrara, 2007; Galtier, 2010). According to a previous population-based study, the prevalence rate of GDM varies from 1% to 22% (Galtier, 2010). This large range may be attributable to differences in screening and diagnostic criteria, as well as heterogenic study populations (Buckley et al., 2012). Risk factors for developing GDM include obesity, advanced maternal age, a family history of diabetes, GDM in a previous pregnancy and ethnicity (Hoffmann et al., 1998; Schneider et al., 2011). Although blood glucose values stabilise after birth for most women, both the women diagnosed with GDM and their offspring have an increased risk of developing diabetes type 2 (T2DM) later in life (Ferrara, 2007; Kim, 2010).

A past review of the experiences of women with GDM emphasised the need for individually tailored and culturally appropriate information, as well as the importance of developing a GDM management routine that is in line with the context of a woman's life, values and priorities (Devsam et al., 2013).

Mobile health (mHealth) technologies can potentially serve as a new tool for managing chronic disease and promoting healthy behaviour (WHO, 2011). There is growing evidence on the impact of mHealth interventions for the management of diabetes outside pregnancy (Liang et al., 2011; Wu et al., 2017). For example, a recent systematic review on mobile app–based interventions to support diabetes self-management suggested that these interventions led to a clinically significant HbA1c reduction among adult outpatients with diabetes, especially those with T2DM (Wu et al., 2017). Further, a review on the use of telemedicine technology for managing diabetes in pregnancy (not just GDM) showed a modest but statistically significant improvement in HbA1c levels (Ming et al., 2016). These authors called for more studies focused on patient satisfaction and the costs of care delivery, which may be where the use of these technologies is the most helpful (Ming et al., 2016). Therefore, while the use of smartphone apps for the management of GDM appears promising, more studies are needed (Mackillop et al., 2014; Ming et al., 2016).

In response to the positive attention that mHealth and self-monitoring have received in the medical and public health literature, critical discourses of the use of mHealth are also emerging (Lupton, 2013; Sharon, 2016). Critics of mHealth claim that most research to date has focused on the impact on behavioural change, the medical accuracy of app content and legal and regulation issues, while little is known about the experiences of people using these technologies (Lupton, 2013).

According to Lupton (2013), these technologies involve a shift in the understanding of the body. While people used to rely on their own sensations, these technologies produces a virtual body considered more objective than personal experiences. The fear is that people's trust in subjective and intuitive knowledge will decrease (Lupton, 2013). Another critical aspect of mHealth is that these technologies encourage individuals to take responsibility for their own health. This may add further to the burden of those who are ill or can not "choose health" (Lupton, 2013). Moreover, while mobile technology has many potential advantages for providing health information, content usability, literacy levels, app security and user privacy are limitations that need to be considered (Boulos et. L, 2014).

Due to their complexity, mHealth interventions are hard to evaluate (Maar et al., 2017). However, evaluation of the implementation process can reveal how an intervention works, how it is received by different recipients and any unanticipated effects (Maar et al., 2017). Qualitative studies can contribute to this process by assessing an intervention (i.e., the use of mHealth technology) from the patient's or provider's point of view (Maar et al., 2017; Pludvinski et al., 2015).

The X RCT

Current treatment for women with GDM in Norway includes recording their blood glucose levels and providing them with verbal health and nutrition information with accompanying written information (X et al., 2017). In the X RCT, the use of a smartphone app as an addition to the standard follow-up process for GDM has been tested and compared to the standard follow-up process at five different diabetes outpatient clinics in Norway (X et al., 2017). A total of 240 women were included in the study. The smartphone app analysed in the study supports the automatic transfer of blood glucose values from the measurement device to the

app and includes a graphic overview of blood glucose values over time. In addition, it provides tailored information about health and nutrition for women with GDM in Norwegian, Urdu and Somali (X et al., 2015). The aim of the RCT was to determine whether the use of the app contributed to better blood glucose values for the women with GDM, as measured by an oral glucose test at 3 months postpartum (X et al., 2017).

Aim of the study

The aim of this study was to explore the participants' experiences with using the app to control their blood glucose values and to receive health and nutrition information. It therefore provides insight into the usefulness of smartphone apps for managing medical conditions and identifies important factors for developing and implementing these types of apps, particularly for women with GDM.

Methods

The interpretative phenomenological analysis (IPA) inspired the research process. This methodology is suitable for exploring individuals' perspectives and experiences (Smith et al., 2009) and was therefore considered appropriate for exploring the experiences of women using the X app to manage GDM. IPA has previously been used to explore the experiences of women with GDM (Carolan, 2013; Evans and O'Brien, 2005).

Interviews

Semi-structured interview were used for data collection. The first author (X) and the second author (X) conducted the interviews. Two pilot interviews were conducted to determine the effectiveness of the interview guide. The interviews lasted for about 30 minutes and were conducted at the diabetes outpatient clinics, at health clinics or in the participants' homes between October 2016 and February 2017.

Selection of participants and recruitment

As we focussed exclusively on the experiences of using the X app, we included women from the intervention group only. Purposive sampling was used to select participants from all five diabetes outpatient clinics. In addition to having been in the intervention group that had access to the app, the women had to have completed all parts of the X RCT (including three questionnaires and an oral glucose tolerance test 3 months after birth). The women were

interviewed 3 to 10 months postpartum. Potential interviewees were contacted by phone and were given oral and written information about the study. They were recruited continuously through the research process, and recruitment continued until we had enough data to answer the research questions. Of the 22 women who were asked to participate in the interviews, 5 women declined. Two women were abroad, while the rest of the women did not have time to participate. Therefore, a total of 17 women were interviewed.

Analysis

The interviews were recorded and transcribed verbatim. The first author carried out the data analysis, while potential themes and subthemes were discussed with the research team. The software program NVivo (11) was used to identify and manage new themes. The analysis was guided by IPA (Smith et al., 2009) and included the following steps: (1) reading and rereading, (2) initial noting, (3) developing emergent themes, (4) searching for connections between emergent themes and clustering them into subthemes and (5) arranging the subthemes into superordinate themes related to the research questions.

Results

Characteristics of study participants and their use of the X app

The participants were either of ethnic Norwegian (n = 10) or immigrant backgrounds (here defined as having been born in another country and later moving to Norway). The women with immigrant backgrounds (n = 7) came from Poland, Bulgaria, Turkey, Pakistan, Palestine and Sweden. Two of the women had been diagnosed with GDM in a previous pregnancy. Of the women interviewed, some used the app daily for blood glucose management (n = 10), some used it for information only (n = 5) and two women did not download the app even though they were allocated in the RCT to using it. Table 1 describes the characteristics of the participants and their use of the app.

Table 1 about here

Experiences with the use of the app

We found that the women had different reactions to GDM and different experiences with the app. Five main themes related to the research questions were identified: Reaction to diagnosis, management of GDM, experience using the X app, the app's impact on the management of GDM and diet and use of the app in cooperation with health-care professionals (Table 2).

Table 2 about here

Reaction to diagnosis

The women had various reactions to receiving a diagnosis of GDM. Most described feelings of disappointment or sadness. Some were better prepared for the diagnosis because of personally perceived risk factors like being overweight, their ethnic background, age, having diabetes in their family or having diabetes in a previous pregnancy. The diagnosis was more difficult for those who did not perceive themselves as being at risk for GDM:

> *I know many people with diabetes, and I must say I was shocked … I think that it has something to do with my lifestyle and my weight and my health. I didn`t consider myself at risk of getting it* [*GDM*]. (Participant 12)

Some women blamed themselves for getting GDM and expressed guilt. Feeling overwhelmed was another emerging theme throughout the interviews. Most women did not know what the diagnosis implied, and there was a lot of information to process.

Self-management of GDM

Most of the women had to learn how to self-manage their GDM, such as measuring their blood glucose values and adjusting their diets and physical activity to regulate their blood glucose levels:

> *I tried different things and found out what I could eat and what I could not eat.* (Participant 16)

Over time, most women claimed to have 'found a balance' and learned what to eat to keep their blood glucose values down.

Several women received a large amount of nutrition-related information from those around them, which was met with some scepticism:

> Y*ou must not tell anybody that you have GDM because you will get so much advice.* (Participant 2)

Most women experienced managing their blood glucose to be a source of stress:

> *You think about the blood sugar values all the time, and if they increase, you get stressed*. (Participant 9)

There were differences among the women regarding what they could eat; while some women only had to limit their intake of sugar, others still struggled despite eating a very low amount of carbohydrates. The latter expressed more negative feelings related to the management of GDM.

Most women perceived the health of their baby as more important than their own risk of developing T2DM. While most described themselves as very motivated to eat healthy during pregnancy, a loss of motivation to eat healthy postpartum was a common theme. In fact, many of the women expressed feelings of freedom after their babies were born:

> *Once I had the freedom and no longer had the baby's health in my hands in the same way, it was easier to give in if I wanted to eat something.* (Participant 17)

Still, many women expressed that having to cope with GDM had a positive impact on their diet and weight management during pregnancy as they were 'forced' to eat healthy.

> *It was good for me, in a way, because you are forced to eat healthy.* (Participant 3)

Experiences with using the X app

The women had different experiences with the app, and they used it to different degrees (Table 1). As previously mentioned, some used it daily for blood glucose management, some used it for information only and some didn't use it at all.

Regarding the health and nutrition information in the app, most women found it to be easily accessible, as illustrated by the following statement:

> *You have the freedom to lie in your bed in the middle of the night and register* [*your blood glucose levels*]*, read more and scroll back.* (Participant 7)

Many also pointed out the benefit of having all the information in one place. Furthermore, women perceived the app as a reliable source of information that was consistent with the information provide by their health-care professionals. However, many of the women wanted more detailed, in-depth information.

> *Some of the dietary advice was a little too obvious – like soft drinks, I know I shouldn't be drinking that*. (Participant 4)

In addition, some women could not follow the dietary advice because they needed to eat even less carbohydrates to regulate their blood glucose values.

Many of the women felt that the most important features of the app were the overview of their blood glucose values and the real-time feedback. However, they experienced frustration, as there was not always agreement between the blood glucose limits in the app and the recommendations from their midwives:

> *It gave me an angry face before the midwife did, and then I got a little frightened. I think that was irritating.* (Participant 15)

The negative feelings related to the app also seemed to apply to the women who had trouble managing their blood glucose values. None of the three women who eventually had to use insulin used the app to manage their blood glucose values, and they seemed to experience the app as a burden:

> *I don't need another place where I can read what I should not eat.* (Participant 11)

In addition, many women experienced technical problems in using the app. Several had problems with the automatic transfer of the blood glucose values to the app, and many stopped using the app to register blood glucose values because of this:

> *It was supposed to transfer the blood glucose values automatically to my phone, but it never worked. I think that was a big disadvantage, because eventually I didn't bother to write it manually in the app.* (Participant 6)

Some women chose to register their blood glucose values manually in the app, but this was also a challenge as the app did not allow them to differentiate between fasting and after-meal levels. They also could not change a value if they had typed in a wrong number:

> *When I was trying to register a good blood glucose value and then it turned out bad because I had typed something wrong and I couldn't change it, it just killed me.* (Participant 13)

A few women tried their best to make the app work despite the technical challenges. This included calling a project member, searching for information about the blood glucose device online or continuing to register their blood glucose values manually. These women described themselves as very motivated to use the app and considered it as a useful tool.

Suggestions for improvement

Some of the women had suggestions for improvement, such as being able to add notes when registering blood glucose values, layout changes, more interactivity and pop-up messages and a better user manual. Some women also wanted more risk awareness–related information,

particularly related to possible effects on their babies, which they claimed to be the best motivator for eating healthy.

None of the women used the app to register physical activity. Many women had complications, like pelvic pains, which made it hard to be physical active, while other women were too busy with children and work to find the time to exercise. The women who were physically active preferred to track their physical activity on paper or in another app, as the X app only allowed them to register the amount of time they had exercised without any information about the type of activity:

> *It would have been more useful if you could register that you had been doing yoga or body pump or running… But it was just like: 'You have been exercising for 60 minutes'.* (Participant 13)

Impact on women's self-management of GDM and their diets

The analysis of the transcripts indicated that the app had an impact on the women's management of GDM and their diet in several ways. The app seemed to increase their confidence, and several women reported that they were pleased with their management of GDM:

> *Both the app and the help I´ve gotten at the hospital helped me to succeed as well as I did in the pregnancy, and I´m very happy with that*. (Participant 17)

Furthermore, some women reported that the app gave them a feeling of control:

> *I felt that to record* [*information*] *in the app was very important… In that way the app was very important because it gave me a feeling of control.* (Participant 2)

In addition, the real-time feedback seemed to function as a motivation to eat healthy and engage in physical activity for some women. A few women, however, admitted that they sometimes 'cheated' in order to get better values and feedback:

> *Sometimes I waited ten minutes so it* [*my blood glucose value*] *would be lower*, *because you kind of wanted to prove something*. (Participant 14)

It also seemed that the app increased self-awareness for some women. The overview of the blood glucose values helped them see how well they were managing their values over time, while the real-time feedback gave them an instant sense of self-awareness. Also after birth, some women reported taking choices based of their increased knowledge:

> *I'm no longer as strict as I was during my pregnancy, but I've learnt a lot and make more conscious choices.* (Participant 4)

However, a few women expressed that the feedback and the overview made them obsessed. These women tended to measure the blood glucose values more often than recommended and spent a lot of time using the app:

> *My husband said, 'That can't be good for you. You use it all the time'. So I worked very much for it to be normal*. (Participant 7)

These women did, however, seem to successfully achieve control over their blood glucose values. Despite being obsessed with the app in the beginning, they seemed to have positive experiences with it.

Cooperation with health-care professionals

The women reported differences in how their health-care professionals related to the app depending on where they received care. Most of the women's overall impressions, however, seemed to be that the health-care professionals had little knowledge about the app and that they were not able to help them when they had problems with the app:

> *I don't think they knew much … When I couldn't make it work, they just gave me a phone number, but I ended up going online and learning about the blood glucose measurement by myself and how to do everything.* (Participant 12)

The women also reported that their health-care professionals seemed to have little interest in the app and that they seemed more comfortable with looking at the blood glucose values on paper, which is the standard procedure in GDM treatment. Some women stopped using the app to register blood glucose values because their health-care professionals only looked at their book with the registered levels:

> *I had no interest in writing it two places, and I understood that no one was going to read or use my app … They always asked for my book, so I used that.* (Participant 11)

All the women who read the information in the app confirmed that the dietary advice and the information about GDM were consistent with the information they received at the hospital (except from blood glucose limit values in some cases). While the women considered their midwives to be the most reliable source of information, many pointed out that the information they received at the hospitals was hard to remember. There seemed to be a common

understanding among most of the women that the information in the app could function as a supplement and a reminder of the information they received at the diabetes outpatient clinics.

Discussion

The aim of this study was to explore how women with GDM who participated in the X RCT experienced controlling their blood glucose values and receiving health and nutrition information via the X app. The study has highlighted some of the challenges that women face when diagnosed with GDM in terms of accepting and learning to live with the diagnosis, as well as how the app was used for learning how to self-manage GDM. The self-management of blood glucose values with real-time feedback was perceived by many women a useful tool that led to feelings of control. The information in the app was considered trustworthy and served as a supplement to that provided by health-care professionals. However, the women who had trouble managing their blood glucose values expressed more negative feelings both related to GDM and the app, as the app provided them with negative feedback. In addition, technical problems negatively affected the women's experience with the app. Finally, a lack of support from their health-care professionals generated some frustration.

Some of the participants in this study had negative feelings following the diagnosis of GDM, as seen in other qualitative studies on women with GDM (Devsam et al., 2013; Evans and O'Brien, 2005). Pregnancy is commonly associated with certain expectations that do not include GDM (Evans and O'Brien, 2005). Similar to other studies (Devsam et al., 2013; Garnweidner et al., 2013), most of the women had little knowledge about the risk and consequences of GDM.

Pregnant women often seek out nutrition information, especially after being diagnosed with GDM (Garnweidner et al., 2013; Sayakhot and Carolan-Olah, 2016). Previous studies suggest that these women seek information from three primary sources: health-care professionals, the Internet and their social network (Carolan, 2013; Garnweidner et al., 2013; Swaicer et al., 2005). While midwives are considered the most reliable source of information, the Internet is more frequently utilised (Garnweidner et al., 2013). The women in this study also considered midwives to be the best source of information, but some of them pointed out that the limited time frame of consultations could make the information hard to process, which may explain the need for additional information from other sources.

The process of learning to self-manage GDM has been described in several studies (Carolan, 2013; Evans and O'Brien, 2005). Carolan (2013) described the process of learning to manage GDM as demanding and challenging, as well as strongly facilitated by social support, with the health of the baby serving as a main motivator. The women in this study expressed similar experiences. GDM has also been described as having a positive impact on women by motivating them to adopt healthier lifestyles (Evans and O'Brien, 2005). A study on women with a history of GDM found that while the women understand the association between GDM and 2TDM, they often didn't perceive themselves as at risk (Kim et al., 2007). This seemed to also apply to the women in our study, as most of the women returned to their regular diets and behaviours postpartum despite being aware of the connection between GDM and 2TMD.

Most of the women in this study found the X app to be a helpful addition to the information provided by their health-care professionals. Similarly, a pilot test of an app to monitor gestational weight gain found that it could help pregnant women to cope with the great amount of information provided by different sources (Knight-Agarwal et al., 2015). However, there were individual differences regarding how women in our study perceived the information in the app. This highlights the need for more tailored information. Individually tailored information is important to promote behavioural change, as individuals are more likely to change their behaviour if they perceive the information as personally relevant (Kreuter et al., 2000). mHealth has great potential for meeting this need as it can offer tailored information for different groups of people (Fiordelli et al., 2013).
Although the X app was tailored to women of different cultural backgrounds (X et al., 2015), the findings from this study suggest that other individual differences should also be taken into consideration. The fact that all but one woman in the current study spoke fluent Norwegian and had resided in Norway for several years may have contributed to the lack of differences between the women with immigrant background and the women who were ethnic Norwegians.

Not surprisingly, as the X app was only recently developed, most women experienced some technical challenges. While most were positive to the idea of using an app to manage GDM, they were sometimes discouraged by the technical issues. A cross-sectional survey on mHealth use among Latino patients with diabetes found that the lack of operability between the smartphone app and other devices could serve as a barrier to using the app (Arora et al., 2016). In the same study, the perceived lack of additional benefits was also an important

barrier (Arora et al., 2016). In our study, many women no longer seemed to see the benefits of using the app when the automatic transfer of the blood glucose values didn't work.

For many of the women in the current study, the self-management of blood glucose values, including the overview and real-time feedback, was the most important aspect of the app for increasing self-awareness and motivation. These elements triggered concrete behavioural responses and served as a *cue to action,* according to the Health Belief Model. This model suggests that in order to change behaviour, individuals must perceive that the benefits of the new behaviour outweigh potential barriers (Nutbeam et al., 2010). Previous studies have also found that the use of Behaviour Change Theories can be beneficial in the development of smartphone apps (Arnold et al., 2014; West et al., 2012; West et al., 2017). Therefore, elements from the Health Belief Model were used to develop the X app. While traditional public health interventions often focus on educating the patients to improve healthy behaviour, studies on mHealth interventions suggest that behaviour triggers may play a big role in apps' impact on behaviour changes (Fade, 2004; Pludvinski et al., 2015). A qualitative study on a smartphone app for T2DM also suggests that feedback serves as a motivation for behaviour change (Pludvinski et al., 2015).

Critics of mHealth technologies have argued that 'self-trackers' represent a particular group of people and that mHealth technologies may prompt an extreme form of *healthism* and individualism (Lupton, 2013; Sharon, 2016). Further, they emphasise that while smartphone apps can lead to a feeling of control, the opposite effect occurs if the data produced by these technologies suggest that their health is suffering or if the data conflict with the participants' interpretation of their health (Lupton, 2013; Sharon, 2017). This seems to apply to the current study, as the women experienced displeasure when the app gave them wrong feedback or showed increased blood glucose values, while the women who did not succeed in managing their blood glucose values stopped using the app to manage their blood glucose values. Another qualitative study on the opportunities and challenges of smartphone apps found that patients could be demotivated and might discontinue using the apps when the apps showed that they did not succeed in meeting a goal or provided them with negative feedback (Dennison et al., 2013).

Many women in the current study experienced a lack of support from their health-care professionals regarding their use of the X app. A qualitative study on a smartphone app for

T2DM found that it was most successful when it was coordinated with personalised health coaching (Pludvinski et al., 2015). Further, a narrative review on mHealth technologies in the prevention and management of T2DM found that mHealth technologies with added support from health professionals resulted in better outcomes for patients with T2DM (Muralidharan et al., 2017). The authors emphasised that in order to be successful, an mHealth platform should involve both health-care professionals and the user (Muralidharan et al., 2017). An RCT of a mobile diabetes diary app with or without telephone contact with a diabetes specialist nurse found no differences in HbA1c levels between the different groups but noted an increase in self-management skills and technique acquisition in the group with the telephone contact with health-care professionals (Holmen et al., 2014). However, the health-care professionals involved in the X RCT were asked to provide the participants of the intervention and the control group with standardised care without a specific focus on the app. A closer collaboration with health-care professional in the implementation of the app might have increased the benefits of the app for more study participants.

Limitations

The women who participated in this qualitative study agreed to participate and therefore may represent a self-selected group of women. The research design for the interviews only included women from the intervention group. Including women from both the intervention group and the control group would have allowed us to explore the differences between managing GDM with or without a smartphone app. Another limitation in this study was the time that passed between birth and the interviews, which could have made it hard for the women to remember their use of the X app.

Conclusion

This study has provided insight into women's experiences with and perceptions of using an app to self-manage GDM. The findings suggests that a smartphone app may have potential for assisting women with GDM in blood glucose management and increasing their confidence in self-management. However, it also highlights some of the potential challenges of using mHealth technologies. The findings indicate that a closer collaboration with health-care professionals is of great importance in the implementation of apps for women with GDM in the future. Because of the frustrations these technologies may produce, it is important that the use of these apps occurs in cooperation with midwives or other health-care professionals.

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