

Use of the smartphone application “Pregnant with Diabetes”

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ABSTRACT

INTRODUCTION: The aim of this article was to evaluate the awareness and use of the smartphone application (app) “Pregnant with Diabetes” locally, nationally and internationally.

METHODS: In 2013, a patient initiated collaboration with the staff at Centre for Pregnant Women with Diabetes, Rigshospitalet, to develop the app “Pregnant with Diabetes”. The app communicates clinically important antenatal health information to women with diabetes, based on recommendations from our centre. Women with pre-existing diabetes (Type 1 and Type 2 diabetes) completed an anonymous, structured questionnaire at their first antenatal visit in early pregnancy at our centre. National and international data on numbers of downloads were obtained from Google Play, from the App Store and from Google Analytics.

RESULTS: Among 139 pregnant women with diabetes (96 with Type 1 diabetes and 43 with Type 2 diabetes), 99% had a smartphone and 75% had downloaded the app, whereof 48% had obtained information from the app before their pregnancy. In July 2017, the app had been downloaded 4,465 times in Denmark and 27,361 times in a total of 183 countries. The topics most frequently visited were “diet and carbohydrates”, “blood glucose” and “possible complications”.

CONCLUSIONS: Easily accessible patient information made available via app technology reaches the patients and may contribute to improved pregnancy planning and outcome in women with pre-existing diabetes - locally, nationally and internationally.

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In women with diabetes, optimal glycaemic control before and during pregnancy is important to prevent an adverse pregnancy outcome, including congenital malformations and foetal overgrowth [1]. Patient education and involvement is crucial in order to improve diabetes self-management and glycaemic control prior to and during pregnancy [2]. A smartphone application (app) is an easily accessible tool that can communicate important health information. Several apps are already avail-

able for the non-pregnant population with diabetes, and they may have positive effects on glycaemic control [3, 4].

In 2013, a patient (HMJ) initiated collaboration with the staff at Centre for Pregnant Women with Diabetes, Rigshospitalet, to develop the smartphone app “Pregnant with Diabetes”. The primary target group for the app is pregnant women with pre-existing diabetes, but the app also includes information for women with gestational diabetes specifically, as well as for women with diabetes who are planning pregnancy. The aim of the app is to communicate clinically important antenatal health information to women with diabetes, and that enhanced knowledge at the patient level will lead to improved pregnancy outcomes. The app is an educational tool that includes evidence-based clinical recommendations from our centre [5]. The intention is to communicate such information in an easily understandable language tailored to the patients. Danish and English versions of the app have been available since 2014. In 2015, a Swedish version was launched and a version tailored for Australia was added in 2016 [6].

To our knowledge, the use of an informative app designed for pregnant women with diabetes has not previously been explored. The app technology easily crosses national borders, and the aim of the present study was to evaluate the awareness and use of the app locally, nationally and internationally.

METHODS

The app (**Table 1**) includes the following 13 topics of importance for motivating and executing self-care of diabetes treatment during pregnancy and in the pregnancy planning phase; “What is diabetes”, “Pregnancy planning”, “Possible complications”, “Blood glucose”, “Weight gain”, “Diet and carbohydrates”, “Physical activity”, “The foetus”, “Insulin dose”, “In need of assistance”, “Scans”, “Delivery” and “After birth”. Every topic can be selected from a wheel of illustrative icons on the front page of the app (**Figure 1**). The app is available free of charge at Google Play and App Store.

In the period from May 2015 to February 2017, a total of 274 pregnant women with pre-existing diabetes (Type 1 and Type 2 diabetes) were referred to the

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TABLE 1

The use of the smartphone app "Pregnant with Diabetes" in pregnant women with pre-existing diabetes: questions 1-6*. The values are n (%).

No.	Question	Type 1 diabetes (N = 96)	Type 2 diabetes (N = 43)	All women (N = 139)
1	Do you have a smartphone?	96 (100)	41 (95)	137 (99)
2	Are you aware of the app?	94 (98)	38 (88)	132 (95)
3	From where do you know about the app? ^{b,c}			
	Your local diabetes centre	39 (41)	18 (47)	57 (43)
	The Centre for Pregnant Women with Diabetes	27 (29)	13 (34)	40 (31)
	The Internet	12 (13)	4 (11)	16 (12)
	Facebook or friends	7 (7)	0 (0)	7 (5)
	Other	9 (10)	3 (8)	12 (9)
4	Have you downloaded the app?	76 (79)	28 (65)	104 (75)
5	When was the 1st time you used the app? ^d			
	Before pregnancy	38 (50)	12 (43)	50 (48)
6	How do you prefer to receive antenatal health information ^{b,e} ?			
	Via an app	32 (39)	19 (50)	51 (43)
	Via an app in combination with a homepage and/or a paper sheet	29 (35)	12 (32)	41 (34)
	Via a homepage and/or a paper sheet	21 (26)	7 (18)	28 (23)

a) Answers and data were available in 90-100% of the cases.

b) > 1 answer allowed.

c) % of those who know the app.

d) % of those who have downloaded the app.

e) Type 1: n = 82, Type 2: n = 38.

FIGURE 1

Front page and the main menu of the smartphone app: "Pregnant with Diabetes".



Centre for Pregnant Women with Diabetes, Rigshospitalet, Copenhagen, Denmark. At their first antenatal visit, the women were given an anonymous, structured questionnaire regarding the use and knowledge of the app. Women with gestational diabetes were not included.

The questionnaire was developed for the present study and included 13 questions in total. The questions covered awareness of and access to the app, use of the app before and during pregnancy, how the women preferred to receive antenatal health information (Table 1) and topics most frequently visited (Table 2). The women were also asked how many times they had used the app, and if the app made them feel more secure. Furthermore, they were asked about their diabetes type and glycated haemoglobin level (HbA_{1c}) at their first antenatal visit (questions 8-11). HbA_{1c} reflects the average blood glucose levels over the past three months, and thus HbA_{1c} at the first antenatal visit reflects blood glucose in the planning phase as well. Questions 12 and 13 were optional and allowed the respondents to provide proposals for improvement of and comments to the app and were not included in this paper. Questionnaires were obtained from 175 (64%) of the 274 women whereof 36 were excluded due to missing information on diabetes type (question 10), leaving available questionnaires from 139 (51%) women (96 with Type 1 diabetes and 43 with Type 2 diabetes). National and international data on the use of the app were obtained from Google Play, from the App Store and from Google Analytics in July 2017 [7]. Access to Google Play, the App Store and Google Analytics was administered by the app administrator (HMJ). The total number of national and international downloads of the app was collected in Google Play and in the App Store. Google Analytics was initially implemented in the app in order to track data regarding the use of the app. The following data were collected in July 2017 from Google Analytics: The countries with at least one download of the app, the frequency of visits to the different topics in the app in total, the average time used per access to the app (minutes) and if the app was used more than one time by the same user (repeated user).

Statistical analyses

The results are given as mean \pm standard deviation or median (range) for continuous variables and as number (%) for categorical variables. Results are presented for all included women as well as for women with Type 1 or Type 2 diabetes separately. Unanswered questions that were considered relevant for the respondent were classified as missing data. Statistical analyses were per-

formed using IBM SPSS Statistics 22 (SPSS, Chicago, IL, USA).

Trial registration: not relevant.

RESULTS

The vast majority of pregnant women with pre-existing diabetes owned a smartphone (99%) and were aware of the app (95%), mainly from their local diabetes centres (43%) or from our centre (31%) (Table 1). At the first antenatal visit, 75% of the women had downloaded the app (Table 1) and used it up to ten times with a median of two times (question 8). Of those who had downloaded the app, 48% had obtained information from the app before their pregnancy (Table 1).

Data on HbA_{1c} in early pregnancy was reported in 87% of the questionnaires (question 11). HbA_{1c} was $6.5 \pm 3.1\%$ (48 ± 10.8 mmol/mol) by those who had used the app in the planning phase (question 5) of their pregnancy compared with $6.7 \pm 3.4\%$ (50 ± 13.3 mmol/mol) by those first obtaining knowledge from the app in early pregnancy ($p = 0.47$) (question 5).

The topics most frequently visited (Table 2) were "Blood glucose", "The foetus" and "Insulin dose" among the total cohort of women with pre-existing diabetes and among women with Type 1 diabetes. For women with Type 2 diabetes, the most frequently visited topics were "Diet and carbohydrates", "Blood glucose" and "What is diabetes".

The majority of the women (70%) reported that the app made them feel more secure about their diabetes and pregnancy (question 9). Most women (77%) preferred to receive antenatal health information via an app, either unaccompanied or in combination with a paper sheet and/or a homepage (Table 1). Only 23% preferred a paper sheet and/or homepage.

In July 2017, the app had been downloaded 4,465 times in Denmark and 27,361 times in 183 different countries worldwide, mainly in developed countries but also in developing countries (Figure 2). A total of 55% of the knowledge seekers worldwide were repeated users with an average use of three minutes per access to the app. The topics most frequently visited worldwide were "Diet and carbohydrates", "Blood glucose" and "Possible complications". The three countries with the highest numbers of users were The United States of America, Denmark and Australia for iOS (Apple) smartphones and The United States of America, India and Denmark for Android smartphone.

DISCUSSION

In a local cohort of pregnant women with pre-existing diabetes we observed a frequent use of the app "Pregnant with Diabetes", with half of the users obtaining in-

formation from the app already when planning their pregnancy. The majority of the women preferred to receive the patient-tailored antenatal healthcare information via app technology rather than by paper sheets. Internationally, the app was downloaded by almost 22,000 individuals covering the majority of countries worldwide. The educational information in this app probably does reach the local, national and international community of pregnant women with diabetes much easier than a book or leaflet. Additionally, an app may be updated more easily, and the information specifying the topics most frequently visited in the app affords the authors with an opportunity to focus and update specific information.

The information included in the app was evidence-based at the highest possible level as judged by two experienced clinical scientists in the area of diabetes and pregnancy with both obstetric and endocrine experience [5]. During development of the app, it was decided to include educational information without other facilities, such as a feedback system between patients and their caregivers. It is, however, possible to combine the use of the app "Pregnant with Diabetes" with other apps, for example an app for carbohydrate counting and also apps for calculation of meal-time insulin dose based on the individual carbohydrate-to-insulin ratio.

Today, smartphones are widely used among women of childbearing age, and nearly all of the pregnant women in our population have a smartphone [8]. The app technology is also widely used in other countries such as the United States of America and India, where rates of smartphone ownership are similar across ethnic

 TABLE 2

The use of the different topics. Question 7: "Which topics have you used in the app?", included in the smartphone app "Pregnant with Diabetes" in pregnant women with pre-existing diabetes^a. The values are n (%).

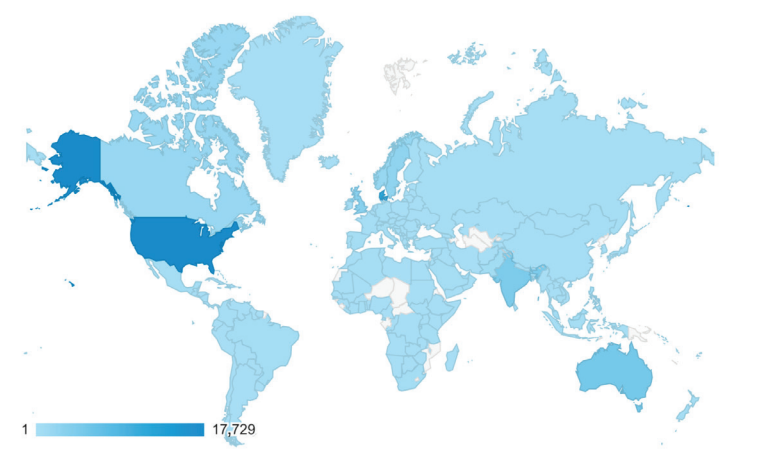
Topic title	Type 1 diabetes (N = 70)	Type 2 diabetes (N = 23)	All women (N = 93)
"What is diabetes?"	14 (20)	13 (56)	27 (29)
"Planning"	33 (47)	8 (35)	41 (44)
"Possible complications"	43 (61)	11 (48)	54 (58)
"Blood glucose"	50 (71)	17 (74)	67 (72)
"Weight gain"	41 (44)	12 (52)	53 (57)
"Diet and carbohydrates"	40 (57)	18 (78)	58 (62)
"Physical activity"	28 (40)	10 (43)	38 (41)
"The foetus"	49 (70)	10 (43)	59 (63)
"Insulin dose"	48 (69)	11 (48)	59 (63)
"In need of assistance"	19 (27)	9 (39)	28 (30)
"Scans"	41 (59)	9 (39)	50 (54)
"Delivery"	33 (47)	7 (30)	40 (43)
"After birth"	23 (33)	6 (26)	29 (31)

a) > 1 answer allowed.

b) % of those who have downloaded and used the app.


 FIGURE 2

Worldwide downloads of the app "Pregnant with Diabetes (August 2017)



groups and communities with different levels of income and access to healthcare [8, 9].

Several apps for patients with diabetes are available [10], but to our knowledge this study is the first to explore the awareness and use of an informative app, designed for pregnant women with diabetes and those planning their pregnancy. This study includes single centre questionnaire-based data in pregnant women with diabetes. To improve the applicability (external validity), data on national and international downloads of the app were also included. Women followed at our centre, where the app was developed, may be more aware of the app than women visiting other centres, and our centre may therefore have a higher number of users of the app than other diabetes centres, which may bias our findings. Nevertheless, our results show that the majority of the women knew the app from their local diabetes centre. It is a limitation that only 51% of the women referred to our centre in the study period completed the questionnaire, which may also bias our findings. However, the missing dataset was related mainly to days when the nurses were busy and had to prioritise their clinical work over the collection of research questions, suggesting that the dataset may be considered to be representative of the whole population.

The large number of downloads may represent the use of the app by both women with diabetes and by healthcare professionals or relatives. The use of the app by healthcare professionals, in Denmark and internationally, may be important to upgrade their own knowledge about diabetes and pregnancy, but also to guide the patients in selecting appropriate apps with evidence-based knowledge within this field [11, 12].

The information in the app reached half of the women in the pregnancy planning phase and the majority were repeated users, which documents a clinically relevant awareness and use of the app. The app contributes knowledge about the importance of good glycaemic control and folic acid intake prior to pregnancy, which may lead to a reduced prevalence of malformations in women with pre-existing diabetes. Data from this study point in the direction of a lower HbA_{1c} in early pregnancy in those who used the app in the pregnancy planning phase. Knowledge from the app may have a positive influence on the obtained glycaemic control in early pregnancy, but the women seeking the information may also have a better compliance in general and be able to obtain better glycaemic control than the less privileged part of our patient population. Future studies including a qualitative assessment of the women's experiences from their use of the app are needed to further elucidate whether the app contributes significantly to an improved glycaemic control and pregnancy outcome in women with pre-existing diabetes.

The present patient population comes from a society with a high level of daily internet use and computer skills, and the women had generally obtained good glycaemic control. HbA_{1c} was self-reported based on measurement performed the same day, and at a similar level as previously reported in a similar patient population from our centre [13]. The results are probably applicable to other societies, including Third World countries. App technology may have the potential to provide information and reach otherwise inaccessible women in rural areas and third world countries [8]. Worldwide, use of smartphones is increasing, and on average half of the world's population now use a smartphone [14]; these figures are probably even higher among young women of childbearing age.

CONCLUSIONS

The app "Pregnant with Diabetes" is widely known and used, and antenatal health information in an app is preferred to other media by pregnant women with pre-existing diabetes. Information via app technology has the potential to reach the women immediately, even in rural areas and developing countries. Improved knowledge obtained from the app may contribute to improved pregnancy planning and outcome - locally, nationally and internationally.

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