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Women's perspectives on smartphone apps for fertility tracking and predicting conception: a mixed methods study

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ABSTRACT

Background: Women use fertility tracking apps (FTAs) for conception purposes, but user perspectives on FTA use for conception are largely unknown. In collaboration with SPD Clearblue, this study explored: how women trying to conceive use FTAs; women's knowledge of their conception chances; and women's feelings towards a potential natural conception prediction app (NCPA).

Methods: A mixed methods design was used (online survey and phone interviews). Participants were women 18–40 years old actively trying to conceive.

Results: The survey received 154 responses and 24 interviews were conducted. Thematic analysis of interviews found that women consider several factors before trying to conceive (ex. age, financial and job security, stability of relationship, etc.) and may adopt lifestyle and behaviour changes when trying (ex. increasing exercise, smoking cessation, diet changes, etc.). Survey results indicated that nearly all respondents were aware of FTAs ($n = 146$, 94.8%), however, several other fertility and conception information sources were also used (ex. health care providers, online sources, family and friends, etc.). Nearly all respondents reported they would use an NCPA ($n = 153$, 99.4%). During interviews women had positive feelings towards such an app due to it offering new and individualised information, but worried the app could provide upsetting information.

Conclusion: This research elaborates on women's uses of and interest in FTAs. Stakeholders should use this research to reflect on current conception experiences and possibilities for improvement through development of an NCPA. Future research should seek opinions from a more diverse sample of women to inform the development of an inclusive NCPA.

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Introduction

Use of smartphone apps that provide personalised health information is common and rising [1,2]. Among women, this interest includes fertility tracking apps (FTAs) [3], which exist to help understand or track menstruation or fertility. Two popular FTAs, *Flo* and *Clue*, have collectively been downloaded more than 60 million times from the Google Play Store [4,5]. FTAs allow women to track their period days, symptoms, and other events (ex. mood, pain, and intercourse). They may also link to peripheral devices such as ovulation tests (ex. *Clearblue Connected*), thermometers (*Femometer*), and activity trackers like *FitBit (Flo)*.



Researchers have investigated different reasons for FTA use including contraception [6,7], to gain information about pregnancy and early motherhood [8], to confer fertility knowledge [9], and to become pregnant [10,11]. Although FTAs are meant to help women understand fertility, many are inaccurate. Evaluation of 108 FTAs found only 20 provided accurate information about conception and contraceptives [12]. Another study found that less than 10% of FTAs could accurately predict a woman's ovulation [13].


Importantly, current FTAs only provide women with their predicted ovulation, their optimal time to try to conceive, and do not provide conception chances. An app that could use a couple's personal characteristics to output their

predicted conception chance might provide valuable information that could enable lifestyle changes and support referral for fertility care.

Existing fertility prediction models can predict conception chances at different time-points such as when starting IVF [14] and diagnosed with unexplained infertility [15], but are limited to specific infertile groups. Such models are mathematical equations that use characteristics, such as age, length of time trying to conceive, and pregnancy history, to predict a personalised conception chance. These models are often converted into online calculators, which allows the user to easily enter their characteristics and obtain their predicted conception chance. Other studies have aimed to determine when a couple should start trying to conceive to achieve a preferred family size [16], and at what age women are biologically unable to have children [17]. These latter models are applicable to most couples, but do not provide personalised conception chances and are not currently available as smartphone apps.

Whether women want to know their individualised natural conception chances is unknown. Review of the literature found no user perspectives on FTAs for predicting conception. A lack of evidence-based research and user perspectives has been highlighted by a recent review of FTA research [18]. This study aims to explore women's current use of FTAs, their knowledge of conception, and the

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 Supplemental data for this article can be accessed [here](#).

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need for and acceptability of a potential natural conception prediction app (NCPA) proposed by data scientists and industry partners within the broader research group.

Methods

A sequential explanatory mixed methods design was used. A quantitative online survey was distributed, followed by qualitative one-to-one interviews with a purposively sampled subset of survey respondents to further explore survey findings and investigate other fertility related topics. Ethical approval was granted by University of Aberdeen's College Ethics Review Board (CERB/2019/4/1760).

Inclusion criteria

Participants were women actively trying to conceive between 18 and 40 years old. For logistical and convenience purposes, interview participants had to live in the UK. Inclusion criteria was self-reported in the survey and confirmed during interviews.

Recruitment

Recruitment involved self-selection among women who had volunteered for a separate study being conducted by SPD Development Company Ltd. (Clearblue brand of pregnancy and ovulation tests – hereafter referred to as SPD Clearblue). See [Figure 1](#) for a visual depiction of the sampling strategy. SPD Clearblue's study collected urine samples for the evaluation of SPD Clearblue products. Volunteers were recruited by SPD Clearblue using online posts on social media and other websites. Women interested in participating in SPD Clearblue's study completed an online volunteer form and were subsequently contacted by SPD Clearblue to confirm eligibility. SPD Clearblue's

study included women 18–34 who had been trying to conceive for less than 6 months and women 35–40 who had been trying for less than three months. Many women eligible for the SPD Clearblue study were excluded due to a limit on the number of participants the study could include. Women who volunteered for SPD Clearblue's study (including those not eligible for that study) were invited through email by SPD Clearblue to participate in the current study. New volunteers, and volunteers from before the current study began, were invited if they met the inclusion criteria for the current study. To avoid biasing results of either study based on participation in the other, only women who were not participating in SPD Clearblue's study were invited to the current study. Sampling from SPD Clearblue's volunteer pool allowed for faster data collection as invitations were sent directly to the target audience.

Email invitations included the participant information sheet ([Supplementary Appendix 1](#)) and a survey link. In the survey, respondents could volunteer for an optional follow-up interview. Interview volunteers were contacted sequentially until data saturation was reached in two age-stratified groups (18–30, and 31–40). Age-stratification was done in recognition that women below and above age 30 may experience fertility differently [15]. Following qualitative research convention, the intention was to conduct 20–30 interviews [19].

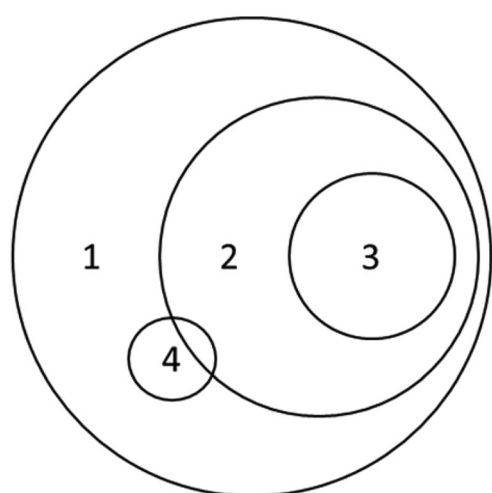
Survey

The survey ([Supplementary Appendix 2](#)) was created and distributed online using *SurveyMonkey* to increase response rates and diversify the sample by allowing respondents from various locations to answer at their convenience [20]. Ten colleagues reviewed a pilot survey resulting in minor text and logic changes. The survey was active from 28 May 2019 to 05 July 2019. All questions had fixed answer categories; some had 'other-specify' options. Completion was expected to take five minutes. Responses were anonymous unless the participant volunteered for an interview. A consent statement was presented before the questionnaire and informed consent was assumed through submission of the survey.

Results were analysed using IBM SPSS Statistics V25. 'Other-specify' responses were coded by DB. Responses were summarised using frequencies and percentages. Continuity-corrected chi-squared tests were conducted to test for associations between age-groups and interview participants versus non-participants; if assumptions were not met, Fisher's exact test was performed. A Mantel-Haenszel chi-squared test was used to test for trend in education status by age group and by interview participation. This was repeated for length of time trying to conceive.

Interviews

Semi-structured interviews were conducted to further explore women's conception thoughts and experiences. Interviews were conducted by phone and were expected to last 20–60 min. All interviews were administered by DB, with an initial subset supervised by HMM. There was no prior relationship between the research team and any of



1. All SPD Clearblue study volunteers
2. Volunteers eligible for SPD Clearblue study
3. Volunteers included in SPD Clearblue study
4. Volunteers Included in the current study

* Diagram not to scale

Figure 1. Venn diagram of sampling strategy. Venn diagram depicting the sampling strategy for the SPD Clearblue study and current study.

the interview participants. An indicative topic guide was developed to provide structure to interviews (Supplementary Appendix 3). Phone interviews allowed for participation across the UK and were used to reduce interviewer effects and participant discomfort [21]. Participants were provided consent forms (Supplementary Appendix 4) to read before their interviews, and audio recorded consent was collected during the interviews. At the end of the interviews, participants were offered a free pregnancy or ovulation test as a gift for their participation. They were unaware of this gift until their interview was complete.

Half of the interview recordings were transcribed verbatim to text by DB; the remaining half were transcribed using NVivo Transcription then verified by DB. Thematic analysis, which provides a flexible approach, can be modified to provide a rich and detailed account of data [22], and is useful for 'examining the perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights' [23], was applied systematically to all qualitative data. This involved transcripts initially being coded into a priori themes, which were identified through literature review and the researchers' previous experiences, alongside emerging themes, to address the research objectives (Supplementary Appendix 3). Transcripts were open coded by DB using NVivo 12 with a subset also coded by HMM to ensure the quality and consistency of the analysis, promoting transparency, reflexivity and dialogue [24].

Results

Participation

1360 invitations were sent yielding 175 survey responses (12.9% response rate) (see Figure 2). Incomplete responses and those not meeting inclusion criteria were removed, leaving 154 responses for quantitative analysis (11.3% adjusted response rate). Of these, 112 (72.7%) respondents volunteered to be interviewed and lived in the UK. Interview invitations were sent to the first 37 volunteers resulting in 24 interviews; 11 with women aged 18–30, and 13 with women 31–40. Interview length ranged from 11 to 46 min.

Sample demographics

Survey

Of the 154 valid survey respondents, 67(43.5%) were aged 18–30, and 87(56.5%) were 31–40. See Table 1 for full demographic details. There was no statistically significant difference in the proportion of white and non-white respondents between age-groups ($p=0.62$). No significant trends were found for level of education ($p=0.24$), or length of time trying to conceive ($p=0.62$) by age-group. Responses were received from all UK regions and from three non-UK respondents (Ireland, USA, and South Africa).

Interviews

See Table 2 for characteristics of interview participants. The mean age was 31(SD = 4). Chi-squared tests to compare interview participants and non-participants found no significant differences in age-group proportions ($p=0.98$),

white and non-white participant proportions ($p=0.48$), highest level of education ($p=0.24$), or length of time trying to conceive ($p=0.67$). Two UK regions lacked representation by interview participants: East England and Wales. One participant did not accept a gift after her interview.

Key findings

This research used sequential explanatory mixed methods, therefore survey and interview findings are separated with synthesis presented in the discussion.

Survey

All 154 (100%) survey respondents owned smartphones, and 146 (94.8%) were aware of FTAs (see Table 3). Most women ($n=97$, 66.4%) were aware of two or more FTAs. One woman was not aware of any specific FTAs but was aware of the concept. Most women who were aware of FTAs were also FTA users ($n=127$, 87%). Nearly two-thirds of women who used FTAs only used one ($n=82$, 64.6%). There was no significant association between age and FTA-awareness ($p=0.30$), and age and FTA-use ($p=0.48$). Nearly all respondents ($n=153$, 99.4%) reported they would use an NCPA. The one respondent who said she would not use an NCPA did not volunteer for an interview.

Interviews

Themes identified were:

- What women trying to conceive know and do in relation to their fertility;
- Sources of information and digital tools, and;
- Feelings towards an NCPA.

No notable differences between age-groups were evident during analysis, therefore all interview findings are presented together in the sections below.

What women trying to conceive know and do in relation to their fertility

When women decide to try to conceive, they consider many factors (see Table 4). Rebecca said 'We got married the year before and we had kind of everything in place. Our jobs were secure. We had a house [...] we just felt like that was the right time.' At the point when women decide to begin trying, their knowledge of fertility and conception chances appears limited. Women expected pregnancy to occur within 6 months or a year of beginning to actively try for conception. Those who expected conception within 6 months spoke about their previous pregnancies conceiving quickly, or feeling misinformed about conception chances; 'It's not taught to you, [...] throughout your earlier years you try not to get pregnant, so you think that it can happen just from that one time' (Amy). Women who had previously been pregnant or experienced reproductive health issues usually felt they had a stronger understanding of their fertility. 'I've already got a child [...] so I know that I'm capable of getting pregnant' (Melissa).

When trying to conceive, women may adopt several lifestyle and behaviour changes. Ashley listed 'stopped taking

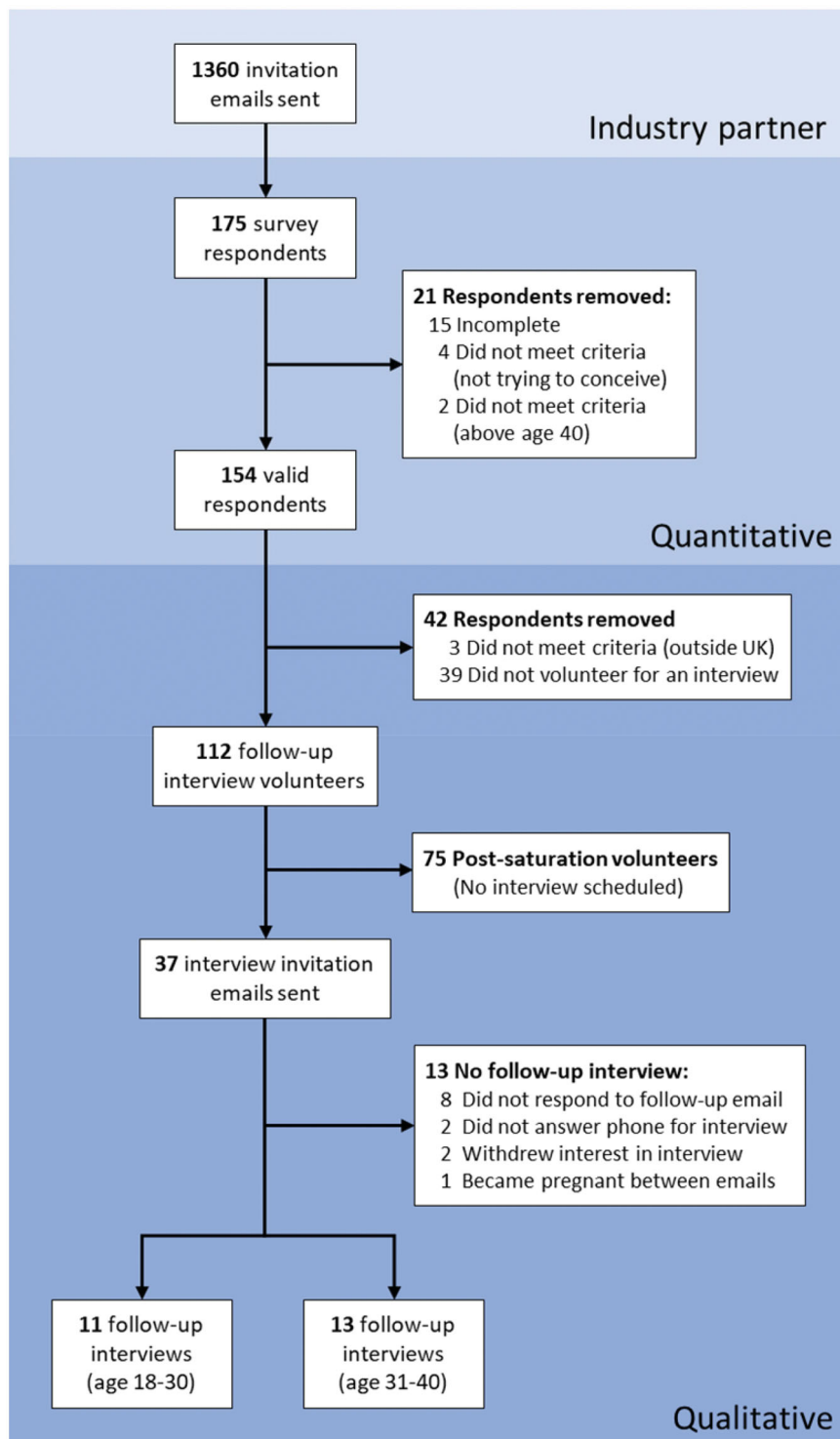


Figure 2. Participant recruitment flow-chart. Flow-chart depicting the number of invitation emails sent by the industry partner (SPD Clearblue), the number of survey respondents, and the number of follow-up interviews conducted.

contraception [...] just generally started um bit more of a healthy lifestyle really, not eating so much rubbish, been taking some prenatal vitamins.' Women report making these changes to prepare for a healthy pregnancy and in the hopes that this would help in conceiving faster. Moreover, some women mentioned their husbands would adopt similar lifestyle and behaviour changes. Table 5 provides a list of changes women discussed.

Sources of information and digital tools

Women used several sources to find information about conception chances (see Table 6). Nearly all the women

interviewed used FTAs and the majority also consulted online sources, health care providers, and family and friends. Regarding online sources, Melody said, 'you just google stuff and you come across random webpages'. Less frequently used were other digital tools and books.

Overall, women felt that seeking information, regardless of the specific source, could be both positive and negative. Positive aspects included allowing them to learn more about themselves and the experiences of others, and providing feelings of control, community, and reassurance; 'It kind of shows me that I'm doing the right thing, like I'm not doing anything wrong, I'm just not being lucky,' (Melissa). Negative aspects were that information seeking felt

embarrassing, overwhelming, upsetting, and obsessive; 'You just get more and more obsessed with the situation and obsessed with an answer [...], obsessed with finding out knowledge where there isn't any' (Rebecca). Moreover, women expressed that information could be hard to find, unreliable, and unavailable. One woman also felt taken

advantage of by companies profiting from women's desperation to conceive.

Among women not using FTAs, barriers were lack of awareness and the expectation that FTAs were redundant to generic calendars or ovulation predicting websites. Facilitators to using apps and online sources were convenience and privacy; 'I didn't really want to ask anybody [...] I thought it would be easier just to look online' (Anna). FTAs and digital tools were used for period and symptom tracking, and predicting and determining ovulation and pregnancy. Women who used multiple FTAs did so because they found different apps offered different functions and predictions.

Some women also used FTAs and online sources to engage with forums and/or read articles; 'I really like [that] it has articles and I wish there were more articles that were relevant to me' (Meera). Women felt non-FTA sources also lacked personally relevant information. 'I don't think it goes into specifics, sort of very generalised so I suppose that's the downside' said Emma, speaking generally about all her information sources.

Feelings towards and NCPA

Women generally had positive feelings towards the idea of an NCPA due to it offering individualised and new information; 'I'd love try something new if it's going to help predict conception' (Corinne). Women thought knowing these chances could reduce stressful feelings towards conception by providing hope and clearer future expectations. However, some women worried that it could be upsetting to receive low chances of conception, or to have high chances then continue not achieving pregnancy. Furthermore, one woman felt an NCPA would 'become really prescriptive' (Zoe) and another thought the information would be too broad unless prediction was ovulation specific.

When asked how they might use an NCPA, women discussed learning how they could increase conception chances, assuming the app would consider modifiable variables

Table 1. Demographics of quantitative survey respondents by age-group and in total, reported as frequencies and percentages.

Demographic	Age 18–30	Age 31–40	Total
Total	67 (100)	87 (100)	154 (100)
Age-group (years), n(%)			
18–25	20 (29.9)	–	20 (13.0)
26–30	47 (70.1)	–	47 (30.5)
31–35	–	62 (71.3)	62 (40.3)
36–40	–	25 (28.7)	25 (16.2)
Ethnicity, n(%)			
White	61 (91.0)	75 (86.2)	136 (88.3)
Asian	1 (1.5)	4 (4.6)	5 (3.2)
Black	3 (4.5)	6 (6.9)	9 (5.8)
Mixed	2 (3.0)	1 (1.1)	3 (1.9)
Prefer not to say	0 (0.0)	1 (1.1)	1 (0.6)
Highest level of education, n(%)			
Less than secondary	0 (0)	0 (0)	0 (0)
Secondary	29 (43.3)	30 (34.5)	59 (38.3)
Further Education	17 (25.4)	29 (33.3)	46 (29.9)
Undergraduate	13 (19.4)	20 (23.0)	33 (21.4)
Postgraduate	8 (11.9)	8 (9.2)	16 (10.4)
Primary address in the UK, n(%)			
East	3 (4.5)	3 (3.4)	6 (3.9)
East Midlands	2 (3.0)	3 (3.4)	5 (3.2)
London	3 (4.5)	16 (18.4)	19 (12.3)
North East	10 (14.9)	4 (4.6)	14 (9.1)
North West	4 (6.0)	8 (9.2)	12 (7.8)
Northern Ireland	2 (3.0)	1 (1.1)	3 (1.9)
Scotland	7 (10.4)	9 (10.3)	16 (10.4)
South East	8 (11.9)	20 (23.0)	28 (18.2)
South West	6 (9.0)	4 (4.6)	10 (6.5)
Wales	4 (6.0)	5 (5.7)	9 (5.8)
West Midlands	7 (10.4)	10 (11.5)	17 (11.0)
Yorkshire and the Humber	9 (13.4)	3 (3.4)	12 (7.8)
Not in the UK	2 (3.0)	1 (1.1)	3 (1.9)
Length of time trying to conceive, n(%)			
<3 months	13 (19.4)	8 (9.2)	21 (13.6)
3–6 months	18 (26.9)	17 (19.5)	35 (22.7)
6–12 months	14 (20.9)	19 (21.8)	33 (21.4)
1–2 years	12 (17.9)	33 (37.9)	45 (29.2)
2–3 years	7 (10.4)	4 (4.6)	11 (7.1)
>3 years	3 (4.5)	6 (6.9)	9 (5.8)

Table 2. Characteristics of interview participants.

Pseudonym ^a	Age	Highest education level	Ethnicity	Fertility app user	Length of time trying to conceive	First attempt at pregnancy
Alyssa	24	Further Ed	White	Y	2 months	Y
Charlotte	25	Further Ed	White	Y	5 months	N
Corrine	25	Further Ed	White	Y	2 years 6 months	Y
Leslie	26	Further Ed	White	Y	1 month	Y
Melody	26	Further Ed	White	N	2 years	N
Taylor	27	Further Ed	White	Y	5 months	N
Zoe	28	Postgrad	White	N	1 month	Y
Melissa	28	Undergrad	White	Y	1 year 4 months	N
Holly	28	Further Ed	White	Y	1 year 6 months	N
Anna	29	Secondary	White	Y	2 years 1 month	Y
Julie	29	Further Ed	White	Y	3 months	Y
Ashley	31	Further Ed	White	Y	10 months	Y
Amy	31	Secondary	White	Y	4 months	Y
Emily	31	Undergrad	White	Y	6 months	Y
Meera	32	Postgrad	Asian	Y	4 months	Y
Avery	32	Further Ed	White	Y	7 months	N
Valerie	32	Further Ed	White	Y	2 years 10 months	N
Louisa	35	Further Ed	White	Y	1 year 7 months	Y
Rebecca	35	Undergrad	White	Y	3 years 6 months	Y
Naomi	35	Postgrad	White	Y	11 months	N
Emma	36	Postgrad	White	N	1 year 6 months	Y
Lydia	36	Further Ed	White	Y	2 years 2 months	N
Lisa	38	Undergrad	White	Y	1 year 6 months	N
Victoria	39	Further Ed	White	Y	3 months	Y

^aAll participants were given unique study ID numbers which have been replaced with pseudonyms for this publication to protect their identities.

Table 3. Summary of survey responses by age-group and in total, reported as frequencies and percentage with *p*-values from chi-squared tests comparing age groups.

Question/answer	Age 18–30	Age 31–40	<i>p</i> -Value	Total
Do you have a smartphone? <i>n</i> (%)				
Yes	67 (100)	87 (100)	–	154 (100)
No	0 (0)	0 (0)		0 (0)
Are you aware of any smartphone apps for fertility monitoring or period tracking? <i>N</i> (%)				
Yes	62 (92.5)	84 (96.6)	0.30*	146 (94.8)
No	5 (7.5)	3 (3.4)		8 (5.2)
Number of specific apps the respondent is aware of ^a <i>n</i> (%)				
0–1	26 (41.9)	23 (27.4)	0.10**	49 (33.6)
2–8	36 (58.1)	61 (72.6)		97 (66.4)
Do you currently use any fertility apps? ^a <i>n</i> (%)				
Yes	52 (83.9)	75 (89.3)	0.48**	127 (87.0)
No	10 (16.1)	9 (10.7)		13 (13.0)
Number of apps the respondent uses ^b <i>n</i> (%)				
1	31 (59.6)	51 (68.0)	0.43**	82 (64.6)
2–4	21 (40.4)	24 (32.0)		45 (35.4)
Would you use a smartphone app that could predict your personalised chance of natural conception in real-time? <i>n</i> (%)				
Yes	66 (98.5)	87 (100)	–	153 (99.4)
No	1 (1.5)	0 (0.0)		1 (0.6)

^aDetermined for respondents who answered 'Yes' to the question 'Are you aware of any smartphone apps for fertility monitoring or period tracking?' (Total = 146 respondents).

^bDetermined for respondents who answered 'Yes' to the question 'Do you currently use any fertility apps?' (Total = 127 respondents).

*Fisher's Exact test.

**Continuity-corrected chi-squared test.

Table 4. Factors that may affect a woman's decision to begin trying to conceive.

Age (their own, their partner's, and if applicable their children's)
Financial and job security
Appropriateness of their home for children
Stability of their relationship
Strength of desire to have a baby
Encouragement from friends and family
Whether their social cohort is having children
Emotional preparedness

Table 5. Lifestyle and behaviour changes of women trying to conceive.

Stopping contraceptive use
Period and ovulation tracking
Diet changes (including changing alcohol and coffee intake)
Exercising more
Weight loss
Smoking cessation
Taking vitamins or supplements (ex. prenatal multivitamins and folic acid)
Alternative medicine (ex. Chinese medicine, acupuncture, and massage)

(ex. diet). Emma said she would use the app 'to see if there's anything else that I could or couldn't be doing that might sort of increase chances.' Additionally, women discussed planning for the future, deciding when to seek medical help, and tracking changes in conception chances over time. One woman also mentioned using the app for contraceptive purposes.

Women expected an NCPA to be similar to current FTAs; it should track their cycle and symptoms, predict ovulation, and provide fertility information in addition to predicting conception chances. Women also expected insights into the calculations; 'it would be interesting to know like the data behind it, to understand how you get to that' (Avery). Other preferences were that the app should be considerate to the impact of other health experiences, be inclusive of the male partner, be free, and have a community forum and built-in shop for fertility products.

Table 6. Fertility information sources used by interview participants.

Source	Examples
Health care providers	<ul style="list-style-type: none"> • General practitioners • Nurses • Fertility specialists
Online sources	<ul style="list-style-type: none"> • Google • NHS website • Fertility forums (ex. Baby Centre and NetMum) • Social media sites (ex. YouTube and Instagram) • Blogs • Online ovulation calendars • Scientific studies published online • Company websites (ex. Tampax and Clearblue) • Tommy's • WebMD
Family and friends	<ul style="list-style-type: none"> • Parents • Siblings • Aunts • Friends
FTAs	<ul style="list-style-type: none"> • Ovia • Glow • Flo • Maya • Ava
Other digital tools	<ul style="list-style-type: none"> • FitBit • Ava Bracelet • Pregnancy and ovulation tests • Basal body temperature thermometers • Podcasts
Books	<ul style="list-style-type: none"> • <i>It Starts With The Egg</i> [25] • <i>Taking Charge of Your Fertility</i> [26] • <i>What To Expect When You're Expecting</i> [27]

Discussion

This paper provides insights to how women trying to conceive use FTAs, their knowledge of natural conception chances, and their feelings towards a potential NCPA. Invitations to participate in the survey yielded 154 valid responses (11.3% response rate). This response rate may be due to the invitations being unsolicited, there being no pre-notification or follow-up, and no indicated incentive for completion [28]. However, 72.7% of respondents volunteered for follow-up interviews, indicating an eagerness to share experiences and perspectives.

Unsurprisingly, survey results indicated that nearly all respondents were aware of and used FTAs. The novel results of this study come from the qualitative findings, which relied on a rich supply of user perspectives from established FTA users alongside the views of non-FTA users. These perspectives were synthesised in this study to inform future NCPA development.

In addition to FTAs, interviews found that women seek information from health care providers, online sources, friends and family, other digital technologies, and books. Previous research on how women use digital technology for health generally identified the same sources and found that health apps were used by 57% of study participants [29]. Similarities in information sources indicate consistency in women's information seeking, but differences in app-user proportions may indicate that women are more likely to use health apps when trying to conceive.

Seeking information may result from women having limited knowledge of fertility and conception chances. A previous study of university students in the UK found that participants could identify infertility risk factors, but had difficulty identifying fertility myths and healthy habits which do not benefit fertility [30]. This study and the current research both demonstrate lack of fertility awareness in the UK.

Nearly all women surveyed reported that they would use an NCPA. Previous research found that women were dissatisfied with available FTA options [10]. By providing new and personalised information, an NCPA may satisfy the unmet needs of some users.

Implication of findings

The results of this study show there is a sub-group of women who are interested in using FTAs for conception. Health service providers, fertility app developers, and prediction model developers should use the qualitative findings to reflect on the current experiences of women trying to conceive and inform the collaborative development of an NCPA. Women want to calculate their personalised natural conception chances to gain new insights into their fertility. However, as app-based technology, women expect additional features such as symptom tracking, ovulation prediction, and community forums. An NCPA could reduce feelings of stress towards conception, increase feelings of hope, and help women decide when to seek medical help. Moreover, if the app considered modifiable factors (ex. diet) it would provide women with an understanding how these factors affect conception chances. However, it could be upsetting if the app indicated low conception chances or discouraging for couples whose predicted chances were high but were struggling to conceive. Stakeholders should consider these user perspectives to collaboratively create an app that meets women's needs and offers a positive user experience.

Strengths and limitations

This research used a mixed methods approach, which allowed the strengths of quantitative and qualitative research to be applied together while minimising their relative weaknesses [31]. This also allowed for a more

thorough understanding of the experiences and thoughts of women trying to conceive. Moreover, this research fills a gap in knowledge by providing user perspectives on FTAs for conception, and may allow women to inform the development of a future NCPA.

Limitations include the recruitment strategy, which relied on SPD Clearblue to initiate contact with participants. There was also potential for bias via recruitment using an industry partner that markets reproductive diagnostics, self-selection among participants, and participants' previous experiences with SPD Clearblue. These limitations pose a serious risk of bias given that women recruited to this study were likely predisposed to feel positively towards FTAs and digital health tools. This reduces the extent to which the reported high interest in an NCPA can be generalised to women outside the SPD Clearblue volunteer pool. Additionally, this research used self-reported data, allowing for falsification, and relied on memory and hypothetical expectations during interviews. Lastly, this study's sample lacked ethnic and geographic diversity, and did not consider the perspectives of women below 18 or above 40, which further reduces generalisability.

Directions for future research

This research demonstrates that women are interested in using an app to calculate their conception chances. Future research should seek opinions from a more diverse sample of women, and could investigate uses of an NCPA for contraceptive or other purposes. Broader perspectives will allow for development of a more inclusive app. Moreover, prediction model and FTA developers, as well as potential users and clinicians, should collaborate to determine capacity to produce an NCPA, with consideration given to the expectations identified. Lastly, future research should investigate the opinions of clinicians towards using an NCPA to individualise fertility clinic referrals.

Conclusion

This research emphasises women's interest in using FTAs to support conception and can be used to facilitate the design of future apps that deliver reproductive health information. Women consider several factors before trying to conceive and may adopt lifestyle and behaviour changes when trying to conceive. At this point however, women appear to lack knowledge about fertility and conception chances. Most women are aware of FTAs and many are FTA-users, but several other sources were also used for information seeking. Women found information seeking positive and negative; these mixed feelings were maintained when discussing a potential NCPA. However, nearly all respondents reported they would use an NCPA, emphasising the importance women place on personalised fertility information. Stakeholders should work collaboratively towards development of an NCPA with the intention of improving the quality and accessibility of fertility information available for women.

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Author contributions

This study was designed by DB, HMM, and DJM in collaboration with the industry partner SPD Development Company Ltd. (Clearblue). Participant recruitment was led by the industry partner. Data collection was conducted by DB. Analysis was done by DB with statistical analysis support from DJM and qualitative analysis support from HMM including transcript coding work. DB led the writing with contributions and comments provided by HMM and DJM who also approved the final version.

Disclosure statement

An NCPA is planned for development by researchers at the University of Aberdeen in collaboration with SPD Development Company Ltd. (Clearblue). This study will serve as a proof of concept for the development of this technology.

Reflexivity and potential for bias

It should be acknowledged that DB is currently using contraception that affects her menstrual cycle. She does not have any children and has never tried to conceive. She does not currently use any fertility apps although she previously used Clue to track her cycle and symptoms. Although experienced in conducting interviews, and in survey development and collection methods, this is the first research she has conducted using a mixed-methods design, and in the fields of digital health and fertility tracking.

HMM uses no hormonal contraception, has no children, and has never tried to conceive. She has been a quantified self since her teens and early adopter of self-tracking apps and technologies. She is a specialist in the field of digital health and has previously conducted research into fertility tracking.

DJM has no children and has been conducting and leading research in the discipline of reproductive medicine for 10 years. He has led the development of prediction models that can inform couples of their chance of live birth before and during IVF treatment. These have subsequently been converted into freely available online tools which are used by patients and clinicians.

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