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The use of menstruation and fertility app trackers: A scoping review of the evidence

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Abstract

Introduction: There has been a phenomenal worldwide increase in the development and use of mobile health applications (mHealth apps) that monitor menstruation and fertility. Critics argue that many of the apps are inaccurate and lack evidence from either clinical trials or user experience. The aim of this scoping review is to provide an overview of the research literature on mHealth apps that track menstruation and fertility.

Method: This project followed the PRISMA Extension for Scoping Reviews. The ACM, CINAHL, Google Scholar, PubMed, and Scopus databases were searched for material published between 1st January 2010 and 30th April 2019. Data summary and synthesis were used to chart and analyse the data.

Results: In total 654 records were reviewed. Subsequently, 135 duplicate records and 501 records that did not meet the inclusion criteria were removed. Eighteen (n=18) records from 13 countries form this review. The papers reviewed cover a variety of disciplinary and methodological frameworks. Three main themes were identified: fertility and reproductive health tracking; pregnancy planning; and, pregnancy prevention.

Discussion & conclusions: Motivations for fertility app use are varied, overlap and change over time although women want apps that are accurate and evidence-based regardless of whether they are tracking their fertility, planning a pregnancy or using the app as a form of contraception. There is a lack of critical debate and engagement in the development, evaluation, usage, and regulation of fertility and menstruation apps. The paucity of evidence-based research and absence of fertility, health professionals and users in studies is raised.

Keywords: Mobile apps, pregnancy, fertility, menstruation, self-tracking.

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KEY MESSAGES

- Although the use of fertility apps is growing, evidence-based research on the development and use of menstruation and fertility apps is limited.
- Women use fertility apps for a number of purposes that can change over time or overlap but regardless of how apps are used, women value apps that are accurate and based on scientific evidence.
- With some notable exceptions, app developers seldom involve health professionals or users in the design, development or deployment of menstruation and fertility apps.
- There is limited regulation of menstruation and fertility apps.

INTRODUCTION

The use of personal digital health informatics, including self-tracking, is becoming increasingly important to the way in which people manage their own health. It has even been argued that apps are changing the way that medicine is practiced.[1] There has been a significant increase in the development of mobile health applications (mHealth apps) including those that monitor menstruation and fertility.[2] Self-tracking of menstruation and fertility is not new and the development of apps is the latest in a long line of approaches.[2,3] Self-tracking is thought to promote personal choice and self-knowledge[1] through their affordability,[3] privacy, and ubiquity.[4] Consequently, user-app-interaction can take place at any time or place. Fertility Awareness Based Methods, including digital ones, are also seen as an increasingly viable alternative for women who reject hormonal methods of contraception.[5,6] Worldwide, the use of 'period tracking' apps has been increasing with at least 200 million downloads by 2016.[7]

Despite their growing popularity, two major concerns have been raised over menstruation and fertility apps. Firstly, how apps have been marketed, including the use of social media influencers[8] and, secondly, questions surrounding their evidence-base and efficacy, particularly in relation to the risk of unintended pregnancy.[9-11] For these reasons it is important to review what is known about the use of menstruation and fertility tracking apps.

METHODS

A scoping review strategy was selected to provide an overview of this expanding and complex subject. The aims of this project fit the scoping review method[12] and followed the PRISMA Extension for Scoping Reviews (PRISMA-ScR).[13]

Selection criteria

This study sought to review apps designed to track women's menstruation or fertility with a specific focus on the evidence. In this review each article was subject to the inclusion and exclusion criteria (Table 1).

Table 1 Inclusion and exclusion criteria

Inclusion	Exclusion
Apps	Animals/non-human
Basal body temperature	Baby information
Birth control	Book chapters
Commercial technologies	Editorials
Commercial technologies	Editorials
Conference proceedings	Foetal information
Contraception	Health and fitness
Contraceptive efficacy	Implant
Dysmenorrhea	Letters to the editors
e-Health	Master's and PhD theses
Family planning methods	Modelling
Female	Motherhood
Fertility	Newsletters
Fertility awareness	Parenting
Human	Preconception care
Menopause	Pregnancy
Menstrual Apps	Pregnancy rate
Menstrual cycle	Pregnancy risk factors
Menstrual tracking	Purpose built technologies
Menstruation	Reports
Mobile application (apps)	Reviews
Mobile Health (mHealth) Apps	Security/Privacy
Natural Family Planning	Sexual health
Ovulation detection	Simulation
Paid and free apps	Smart Fabric/textiles

Pearl Index	STIs
Period	Theoretical papers
Purpose built technologies	Website
Quantified Self (QS)	
Self-tracking	
Smartphone access	
Study designs: (RCT, Exploratory, Cohort, Prospective, Feasibility)	
Wearables	
Women's health	

Search strategy

A desktop search was conducted of the following databases: ACM, CINAL, Google Scholar, PubMed, and Scopus for material published between 1st January 2010 and 30th April 2019. Limiters were 'English' and 'humans'. However, each database required tailored strategies in order to access the appropriate material and there was some variation in search terms and/or limitations (see Table 2). Consequently, some databases involved several searches to extract the full range of material. The references of each paper selected for inclusion were also searched manually for additional citations. The search was conducted in May 2019.

Table 2 Databases searched, search terms used, reasons for adaptions

Database	Search term used	Adaptions/Notes
ACM	Searched for *(+Fertility +awareness-based +planning +methods +ovulation +menstrual +cycle +mobile +applications +self +tracking +mhealth +ovulation +infertility +menstrual +cycle +mobile +applications +self +tracking +menses +pregnancy + menstrual-calendar diary +birth + self-tracking surveillance fertility +control +contraception +menstruation + self-tracking menstruation fertility)*	2010 Excluded: soil, fertiliser
CINHAL	*self-tracking AND fertility awareness based methods AND (mobile apps or mobile applications or apps) AND (mhealth or mobile health or m-health or mobile app or mobile application) AND fertility awareness AND mobile apps AND fertility AND (menstruation or menstrual cycle or menarche) AND ovulation OR (mobile applications or apps or mobile apps) AND ovulation*	
PubMed	*mhealth AND menstruation OR ovulation OR reproductive health OR fertility-awareness smart phone applications OR fertility-*	

	awareness cell phone applications OR ((fertility-awareness) AND menstru) AND mobile apps OR menstru* AND self tracking OR mhealth AND reproductive health*	
Scopus	*fertility-awareness applications AND Fertility monitoring applications OR Tracking women's periods OR mhealth AND menstru* OR fertili* OR ovulation OR menstru* AND mhealth AND OR reproductive health OR period AND tracking*	*TITLE-ABS-KEY(*fertility *AND* monitoring *AND* applications*) Adjusted criteria: AND (EXCLUDE (SUBJ AREA,*"AGRI"*)) AND (EXCLUDE (SUBJ AREA,*"EART"*)) AND (EXCLUDE (SUBJ AREA,*"ENVI"*)) AND (LIMIT-TO (LANGUAGE,* "English"*)) AND (LIMIT-TO (EXACT KEYWORD,* "Humans"
Google scholar	*fertility OR menstru* AND self-tracking OR mobile apps self-tracking OR mobile apps and menstruation or ovulation OR Fertility awareness-based mobile app for contraception OR Fertility awareness-based mobile apps OR Fertility mobile apps OR Fertility monitoring mobile apps*	

Titles of papers and abstracts were initially screened for suitability and, if necessary, the full paper was reviewed. Abstracts and full texts were retrieved to determine if they met the inclusion criteria. The reviewers, HM, SE and DB assessed all records from each database using data extraction forms. Any discrepancies were discussed by HM, DB and SE before a final decision was made.

Quality summary

The papers selected for review are methodologically very diverse. The purpose of this scoping review is to provide an overview of the existing evidence on menstruation and fertility tracking apps, in spite of methodological quality or risk of bias and without excluding papers on this basis. Indeed, this is a key difference between scoping reviews and systematic reviews.[13] In Table 3 we include a brief quality summary of each paper indicating main limitations and potential indications of bias (including commercial interests) for information. We have also used the Mixed Methods Assessment Tool (MMAT) checklist to enable comparison of methodological quality between different papers.[14] The reviewers HM and DB assessed all papers using the MMAT checklist. SE reviewed the papers where there was a discrepancy in quality assessment scoring in order to agree a final score for each paper.

Charting the data: Summary and synthesis

Two approaches were used to chart the data: summary and synthesis. Firstly, each paper was summarised by extracting data on research aims, participants, study design, method/assessment

and role of technology (see Table 3). Secondly, using QSR NVivo 12 for Mac, a data analysis software package, thematic data analysis[15] was carried out to determine descriptive categories (according to focus) and themes (according to specific issues) to produce a synthesis of the use of menstruation and fertility tracking apps. A line-by-line coding of the findings/results and discussion/conclusion sections of each paper was carried out by SE and HM who discussed and compared initial codes, categories and themes.

RESULTS

The database search identified 654 records. Following the removal of 135 duplicate records, the reviewers (HM, SE and DB) independently assessed 519 records for inclusion. Five hundred (n=500) records did not meet the inclusion criteria. Nineteen papers were initially identified for inclusion, but one was rejected since it reported interim data from a study which was then published in full two months later.[16] Eighteen (n=18) records met the criteria for inclusion and are examined in this scoping review (see Figure 1).

INSERT FIGURE 1: Process of the database search

Of the 18 papers selected for review, fifteen were published in peer reviewed journals and the remainder (n=3) as peer-reviewed conference proceedings. The majority of studies were conducted in the USA (n=7) and the remainder in Germany (n=4), Sweden (n=3), Egypt (n=1), Ghana (n=1), India (n=1), Jordan (n=1), Kenya (n=1), Nigeria (n=1), Portugal (n=1), Rwanda (n=1), South Korea (n=1) and the United Kingdom (n=1). Three papers report data from their respective studies on the 'NaturalCycles' app.[17-19] Similarly, two papers report their individual studies on the 'Dot' app.[16,20] Summaries of all the selected papers are given in Table 3.

Table 3. Summary of papers (n=18) included in scoping review

Following analysis of the selected papers, the results are organised in relation to the three different functions that menstrual and fertility app trackers serve: fertility and reproductive health tracking, pregnancy planning and, pregnancy prevention.

Fertility and reproductive health tracking

One third of the papers in this review address fertility and reproductive health tracking.[21-26] These papers are very diverse, but they all address the opportunities afforded by apps that support women to track their reproductive health.

Three papers focus specifically on women's motivations for tracking. In the first of these, Gambier-Ross, McLernon & Morgan[21] argue that although there is increased use of digital health information, and some health professionals are recommending health apps to patients, we do not know nearly enough about how people interact with and use their own digital health data. Their survey data highlight four main motivations for the use of fertility tracking apps: (1) observing cycle, (2) to conceive, (3) to inform fertility treatment and, (4) as a contraception. 72% of app users were observing their cycle only and follow-up interviews indicated that menstrual cycle prediction was especially important for the majority of interviewees.

Epstein, Lee, and Kang[22] also explored how and why women track their menstrual cycles and found that women self-track for five main reasons: (1) to be aware of their body, (2) to understand their body in differences phases of the menstrual cycle, (3) to be prepared, (4) to become pregnant and, (5) to inform conversations with healthcare providers. They note that women's motivations and the means they use to track change over time, suggesting that apps should be designed to accommodate this but that '*existing apps also generally fail to consider life stages that women experience, including young adulthood, pregnancy, and menopause'* (p.6876).

The lab-based study conducted by Bretschneider et al.[23] – based on the development of the app NetMoms Cycle Calendar – suggests that women who self-track can be categorised as either 'trying to conceive' or 'not trying to conceive' but that the motivations of the latter group were complex. This included women who were using apps as contraception, for medical reasons, to learn about their cycle, or to understand their body. The study explored the functionality of menstruation trackers and suggest that if apps enable women to track too many symptoms (e.g. date of menstruation, basal body temperature, cervical mucus, mood, and so on) then users could experience 'tracker fatigue'. Although this could be said of FABM in general, the respective authors argue that this could negatively influence accuracy since all

apps rely on women inputting their data accurately, consistently and regularly. Accuracy is especially important when women are relying on the predictive potential of their digital data (for example, to prevent pregnancy) but this review highlights that women self-track for a variety of reasons, that their motivations for tracking change over time, and that accuracy can be important even when apps are being used observationally[22].

The paper by Haile et al.[24] focuses on the CycleBeads app, which incorporates a digital algorithm based on the Standard Days Method (SDM), using first date of menstruation only. The app enables women to track their cycle, prevent or plan pregnancy. The paper examined the social marketing campaigns of the CycleBeads app in seven developing countries. This is the only study that draws on data from low- or middle-income countries and highlights that app use differed significantly by country and age of user. The majority of app users were aged between 20-29 years of age, 39.9% of users were using the app to prevent pregnancy, 38.5% to plan a pregnancy, and 21.6% were tracking their cycles. A third of the women who were using the app to track their cycles were not using any form of contraception in the three months prior to using the app. The authors conclude by arguing that the CycleBeads app can be easily distributed at low cost, has the potential to expand access to FABM, and can address multiple reproductive intentions.

Two studies focus on the potential of apps to improve women's reproductive health and wellbeing[23,24]. The paper by Blödt et al. [25] evaluated the effectiveness of an app-based self-acupressure intervention – AKUD – to alleviate menstrual pain. Lee et al.[26] focused on women's experiences of the menopause in order to develop guidelines for an mHealth app designed to support women's wellbeing.

This review indicates that women self-track for a variety of reasons and that – over time – motivations for tracking can change or can overlap. The studies highlight the significance of personal digital health information in developing knowledge and understanding of the body, as well as its use in informing treatment or for predictive purposes. The next two sections of the paper focus on the latter and on the use of apps to either plan or prevent pregnancy.

Pregnancy planning

Four papers focused on apps that could be used to support pregnancy planning.[27-30] Two of these address specific mHealth apps,[27,31] whereas the others seek to evaluate apps that either support pregnancy planning or support both pregnancy planning and prevention.

The study by Sodha, Suzuki and Igari[27] focused on the Luna Luna app, which is part of a commercial women's health service in Japan. The app requires that women only enter their

first day of menstruation and it then predicts ovulation dates and fertility. Using the data of 7,043 women, this study explored how the app's data set could be used to improve the accuracy of ovulation date prediction. The authors argue it compares favourably to more traditional calendar methods that do not make use of such large aggregate data. The authors highlight the importance of user consistency in relation to how women record their data, but the paper focuses, in particular, on the potential of large data sets to improve accuracy of prediction. The authors conclude that the Luna Luna app is an especially good option for couples in the early stages of pregnancy planning since it requires data only on the first day of menstruation.

Of the three papers that evaluate a range of apps, the study by Freis et al.[28] is the only one focused specifically on the evaluation of apps marketed to support conception. Twelve apps were scored including calendar-based, calculothermal and symptothermal apps. The authors conclude that apps which base fertility predictions on data from previous cycles only are unsuitable. They identified apps that would be suitable for good-quality prospective studies but did not comment on the efficacy of the apps themselves. They highlight the importance of precision in being able to determine the fertile window and the significance of this for the sexual behaviour of couples trying to conceive.

Setton, Tierney & Tsai[29] evaluated the top free 33 fertility apps downloadable to mobile phones from free web sites and apps, replicating the likely behaviour of the general public when downloading fertility apps to use. For the purposes of analysis, a 28-day cycle length with four days of menstruation was used. The predicted dates of ovulation were compared with an assumed actual date of ovulation. Only three apps (9%) predicted the precise fertile window or did not give false negatives (i.e. there were no fertile days classed as infertile).

The evaluation by Moglia et al.[30] assessed 108 free menstrual cycle tracking apps, using a modified version of the APPLICATIONS Scoring System.[34] Only 20 (19%) of the apps were found to be accurate; accuracy was based on the ability to predict the next menstrual cycle based on averages of past cycles and not on a default cycle length, allowing input of at least three full menstrual cycles. This study concluded that most freely available menstrual cycle tracking apps are '*inaccurate, containing misleading health information, or do not function*' (p.1157). We report this study here because 80% of the apps contained information that supported conception and 50% for contraception.

There is limited research on apps that support women or couples to have a baby. The ability to accurately predict the fertile window is important but the limited research that exists seems to indicate that many of the most popular apps are not accurate even though they might

contain information that supports pregnancy planning or are marketed specifically for this purpose.

Pregnancy prevention

More than half of the papers in the review address the issue of pregnancy prevention[16-20] although some of these apps address both prevention and planning and these have been discussed above[24, 29-30].

Six papers focus on apps that can be used to prevent pregnancy. Three of these are focused on the paid-for app NaturalCycles.[17-19] NaturalCycles has CE certification and FDA approval as a contraceptive. This app requires women to enter basal body temperatures and date of menstruation and, then, using a proprietary algorithm, calculates ovulation and fertility. Women are also encouraged to purchase luteinising hormone tests that predict ovulation. Drawing on two retrospective studies [17,18] and one prospective observational study,[19] these studies argue that the app is effective at identifying ovulation day and fertile window although there are differences depending on perfect- and typical-use. There has been discussion of NaturalCycles within the press, particularly following complaints made by women who became pregnant while using the app. However, the Swedish Medical Products agency concluded in 2018 that the pregnancies were in line with the product's failure rate but that the company should make clearer in their instructions and advertising the risk of unwanted pregnancies. In the UK, a complaint was also upheld by the Advertising Standards Authority with respect to the way that the company marketed NaturalCyles on Facebook in 2017.[9]

Two further papers are based on research of the Dot app which estimates fertile days only using date of menstruation.[16,21] Using modern Bayesian statistical methods and an analysis of three large data sets, the app uses Dynamic Optimal Timing (DOT) to flag the days with the highest estimated probabilities of pregnancy. Li et al. [21] describe several simulation studies using this method to estimate its efficacy in preventing pregnancy. Jennings et al.[16] presents the findings from a prospective 13-cycle contraceptive effectiveness trial. At the time of writing, the Dot app has not received either European certification or FDA approval and some concerns have been expressed within the press about the marketing of the app to prevent pregnancies.[35]

Koch et al.[31] presented the results of a retrospective efficacy study of the free DaysyView app. The DaysyView app was designed to improve the usability and pregnancy rates of a companion fertility monitor (a biosensor-embedded device used to measure basal body temperature) called 'Daysy'. Daysy is classified (in Europe) as a class I medical device

used to ‘facilitate conception’ and based on the principle that the use of apps can increase a person’s focus on their health behaviour(s). However, this particular paper focuses on the efficacy of Daysy and DaysyView as a form of female contraception. The study indicates that the combination of the fertility monitor (Daysy) with the DaysyView app leads to higher user engagement and, therefore, higher overall usability. A commentary published by Polis[10] in the journal *Reproductive Health* has, however, criticised the findings of this study arguing that the analysis ‘was flawed in multiple ways’.

The two remaining papers that focus specifically on pregnancy prevention include the paper by Starling[32], which reports on a user survey exploring women’s preferences in fertility apps and the paper by Duane[33] which evaluated 40 fertility awareness-based method apps specifically marketed to avoid pregnancy using an established rating system.[36] Starling et al.[32], conclude that since there is evidence of increasing interest and demand for fertility apps that prevent pregnancy, there should be enhanced collaboration between app developers, women’s health experts, and consumer groups to ensure that women are able to make informed choices about fertility apps. Duane et al.[33] concluded that the majority of fertility apps marketed to avoid pregnancy are not designed for this, nor do they use evidence based FABM.

There is considerable interest in the use of fertility apps to prevent pregnancy and a number of studies indicate that some apps are effective. However, there is some evidence to suggest that not all apps marketed to prevent pregnancy have been designed for this purpose and that women may be using a range of apps for pregnancy prevention that are not intended to be used in this way.

DISCUSSION & CONCLUSIONS

This scoping review explored what is known about the use of menstruation and fertility tracking apps. The number of such apps is large, they are growing, and they are increasingly popular. There is enormous variation in the types of apps[37] available ranging from very simple diaries through to apps that use complex, sometimes proprietary, algorithms to determine ovulation and fertility windows. A survey of 1,000 women indicates that nearly 80% of women intend to use a fertility tracker app in the future.[32]

The review has a number of limitations that may reduce its usefulness. For example, given our resources, it was only possible to include studies published in the English language. Our particular search terms and other delimiters may also have inadvertently excluded other materials that may otherwise have been included. The disciplinary and methodological

heterogeneity of papers means that comparing the different studies is complex and it is challenging to apply quality assessment criteria to studies that are so varied.

This review highlighted how women are motivated to use menstruation and fertility tracking apps for a range of reasons but that their motivations and goals shift over time and can overlap. Previous research highlighted the complexities of both defining pregnancy intention and women's experiences of reproduction.[38] Existing apps do not necessarily take into account the way in which women use such apps and HCI researchers highlight the importance of involving users in their design and development.[39,40] This is especially important because the user is considered to be the single greatest 'risk factor' in the accuracy of apps and so particularly significant if women are seeking to prevent, or plan, a pregnancy.[36]

The evidence suggests that women value apps that are accurate and based on scientific evidence regardless of whether they are relying on the app to predict their fertile window or not[21]. There is limited research on apps that specifically support pregnancy planning but the evidence that does exist suggests that popular apps which contain information on planning a pregnancy are not always accurate, which could be very misleading for women and couples that are trying for a baby.[29]

The review highlights a growing evidence base on apps marketed to prevent pregnancy with evidence suggesting that some apps are useful for women who do not want to rely on hormonal methods of contraception or do not want to use condoms.[16-19,31] However, not all apps accurately predict the fertile window and women may be using apps for pregnancy prevention that have not been designed for this purpose.[33] Given this issue and the fact that fertility apps are used fluidly over time, this poses the potential risk of unintended pregnancy.

While there are many apps available for download there is little discussion surrounding the regulation of fertility and menstruation apps. Guidance is available for both app developers and individuals seeking to receive approval via The Food and Drug Administration (FDA) [41,42] for Mobile Medical Application (MMA). The FDA have approved many different types of MMAs for use across different health disciplines [41,42] but, as noted earlier, NaturalCycles [17-19] is the only app to have been granted approval as a contraceptive[43,44]] and the DaysyView app supports the class I medical device Daysy.[31] The recently published Joint BASHH/FSRH Standard for Online and Remote Providers of Sexual and Reproductive Health Services may be useful going forward.[45]

The limited evidence-base that exists within this field means there is considerable scope for future research. As demonstrated across the various studies, there is a need for further prospective independent research free from commercial interests and risk. Consequently, it is

important that future research involve users that reflect ethnic, cultural and geographical diversity, as well as differences across the life course. The role of menstruation and fertility tracker apps in developing countries is also significantly under-researched. The involvement of fertility specialists and other health professionals should also be an important aspect of future research and development in this field.

ADDITIONAL EDUCATIONAL RESOURCES

- Marston, H.R. & Hall, A.K. (2015). Gamification: Application for Health and Health Information Technology Engagement. In D. Novak, B. Tulu, & H. Brendryen (Eds.) Handbook of Research on Holistic Perspectives in Gamification for Clinical Practice (pp.78-104). Hershey, PA: Medical Information Science Reference. DOI: 10.4018/978-1-4666-9522-1.ch005.
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Author Disclosure Statement

There are no competing interests.

Author Contributions

SE and HM drafted the paper and revisions, All authors proofread. All authors conducted the MMAT checklist to assess the quality of papers. HM and DB decided on search criteria. All authors agreed upon in/exclusion criteria. RH conducted database searches, HM DB and SE conducted decision making of papers after database searched.

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