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Navigating Fertility: A Critical Review of Fertility Smartphone Apps in Modern Healthcare

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Abstract

Background: Smartphone health applications help users access and store fertility and menstrual health information. Previous research on these apps has underscored user preference for simplicity. There lacks comprehensive evaluation of these tools from usability to privacy. Many apps are not concordant with evidence-based fertility awareness methods. We aim to bridge the existing gaps in fertility app functionality and content through a comprehensive assessment.

Methods: Initial Apple app store search with specific terms yielded 606 apps. Exclusion criteria included apps that cost money, non-English, not-relevant, and duplicates. Two medical students (S.M., S.H.) and a second-year obstetrics and gynecology resident (R.V.) independently reviewed 25 apps. Average sums of each category calculated, reflecting overall app quality, with a maximum score of 34.

Results: 48% of apps were moderately adequate, 52% were adequate, and no apps were poor. The highest scoring app was 30.26. Only one app used substantially accurate literature and met all educational objectives. 56% of apps required in-app purchases, while 48% were compatible across Android and Apple platforms. 92% had implemented educational imagery. Notably, 20% of apps had no clear privacy statement. 24% of apps were well-organized, and 88% did not have any factual errors. Only one app had poor design compromising its usability.

Conclusion: Fertility apps lack crucial user features, high-quality consumer education, or promote unsubstantiated facts leading to misinformed patients, practitioners. Strict guidelines, possibly peer review, needs to be implemented prior to app availability. Further research needs to examine additional apps exclusively for Android users. It would be beneficial to study consumer needs to find apps better suited for them. By doing so, health care providers may provide their patients with beneficial tools to make informed decisions regarding their reproductive health.

Introduction

The advent of health tracking smartphone applications (apps) has revolutionized access to personal health data, offering users a convenient way to manage their health information from anywhere [1,2]. Among these, fertility applications have gained significant traction, providing a simple interface for women worldwide to track their menstrual cycles, most importantly ovulation [3]. These tools not only record the onset and duration of menstrual cycles, but also predict future menstruation, identify peak fertility windows, and track vital health indicators such as basal body temperature and mood variations. Many patients report possessing limited knowledge about fertility; however, patient personal interest in learning about their own menstrual cycles and reproductive capacity has increased [4,5,6]. In fact, the basis of fertility apps remains accurate tracking of the menstrual cycles and associated symptomatology.

Despite the convenience and popularity of fertility apps, concerns have risen regarding the accuracy of these tools and the security of sensitive personal information [2,7]. Moreover, the design and user experience of many widely used apps have been called into question, potentially impacting their effectiveness [2]. Among available apps, the most common method for menstrual monitoring remains the calendar-based approach, emphasizing the need for well-designed tracking systems [8].

Users typically select a fertility app based on several criteria including: user-friendliness, the extent of medical knowledge provided, cost, and data privacy [1,9]. Users have experienced dissatisfaction when they encounter difficulties in navigation or functionality [1,7]. Furthermore, there is a marked propensity for users to engage more thoroughly with their menstrual health and to feel more confident in their ability to navigate health decisions when the app aligns well with their individual needs [1,6,9].

Given the wide range of available apps, it is essential for healthcare professionals and consumers alike to be equipped with the knowledge to discern the most suitable options. Previous research has underscored a user preference for simplicity in health tracking applications, yet there is a notable lack of comprehensive evaluations of these apps according to how effectively they cater to varied consumer preferences [10]. Additionally, a large majority of apps are not concordant with evidence-based fertility awareness-based methods [10,11].

Our study aims to bridge the existing gaps in fertility app functionality by conducting a comprehensive assessment of various apps available on the Apple app store. We will grade these apps based

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on their effectiveness in meeting a wide range of user needs. This comprehensive assessment will provide invaluable information for clinicians and consumers alike, enabling them to make informed decisions regarding the selection of fertility apps. Ultimately, this research seeks to improve user experience and satisfaction by recommending apps that are not only effective and accurate, but also align with the users' expectations for privacy, ease of use, and comprehensive functionality.

Materials and Methods

We used the Apple app store (Apple Inc) to search for publicly available mobile apps related to fertility from April 2013 to September 2023 using the following search terms "fertility", "fertility tracker", "menstruation", and "menstruation tracker". We excluded apps based on the price, non-English, not-relevant, and duplicate apps. During this process we aimed to gather and evaluate apps that were not only relevant, but also affordable, accessible, and accurate. Specific reasons for exclusion of apps also included: could not be found in the app store after initial search, app used to find specialist and resources, IVF treatment support network/treatment calendar, required external blood work/urine testing/external device, patient portal. Selection bias noted as the study was limited to fertility apps on the Apple app store (Figure 1).

Interestingly, we used Chyjek et al.'s quantified grading rubric, though the study evaluated pregnancy wheel applications(Table 1) [12].

We primarily modeled our study after Masaud et al.'s review of patient educational apps and utilized their quantified grading rubric (Table 2)[13].

We combined both rubrics to formulate a comprehensive guide to grade and evaluate the target apps. Chyjek et al.'s established criteria included price, paid subscription, literature used, in-app purchase, connectivity, advertisements, text search field, interdevice

Table 1: Rubric used to evaluate apps generated by Chyjek et al. [12].

Component	Score	Description
Price		0=price, 1=free
Paid subscription		0=required, 1=not required
Literature used		0=yes, 1=no
In-app purchase		0=yes, 1=no
Connectivity		0=Internet required, 1=Internet not required
Advertisements		0=yes, 1=no
Text search field		0=yes, 1=no
Interdevice compatibility		0=iPhone or iPad, 1=Android phone, Android, iPhone/iPad
Images or figures		0-absent 1=present
Videos		0-absent 1=present
Privacy and Security		1= no privacy policy, does not declare data use or purpose, does not allow users to opt out, does not explain security systems used, does not claim to collect 2=meeting half of the criteria above 3=meeting all of the criteria above
Total		14

Table 2: Rubric used to evaluate apps generated by Masaud et al. [13].

Educational Objectives	1=app does not fulfill educational objectives 2=app minimally fills educational objectives 3=app mostly fulfills educational objectives 4=app completely fulfills
Content	1= app has major gaps in information 2=app has gaps in information and content is disorganized 3=app has minor gaps and is disorganized 4=app has no gaps and is organized
Accuracy	1=app presents factually incorrect information 2=app has minor errors that do not detract from the educational objectives 3=app has no factual errors, does not provide resources 4=app provides evidence based information
Design	1=Design of app is difficult to use 2=App has issues with design 3=App has design, mode of navigation 4=App is easy to use and well designed, enhances user experience
Conflict of Interest	1=app has obvious COI 2=app was made with some COI, however it presents information in an unbiased manner 3=app is created with some monetary incentive, relatively unbiased, factually correct information 4= app was created with no COI or monetary incentive
Total	20

Figure 1: Flowchart explaining process of identifying appropriate apps.

compatibility, images/figures, videos, special features, privacy and security (scale of 0 to 1, last category scale of 0 to 3) [12]. 0 points were awarded if the criterion was present and 1 were awarded if the criterion was not present. Of note, for the category of privacy and security the scale used was from 1 to 3 points. 1 point was given if there was no privacy policy, no data use was declared, does not allow
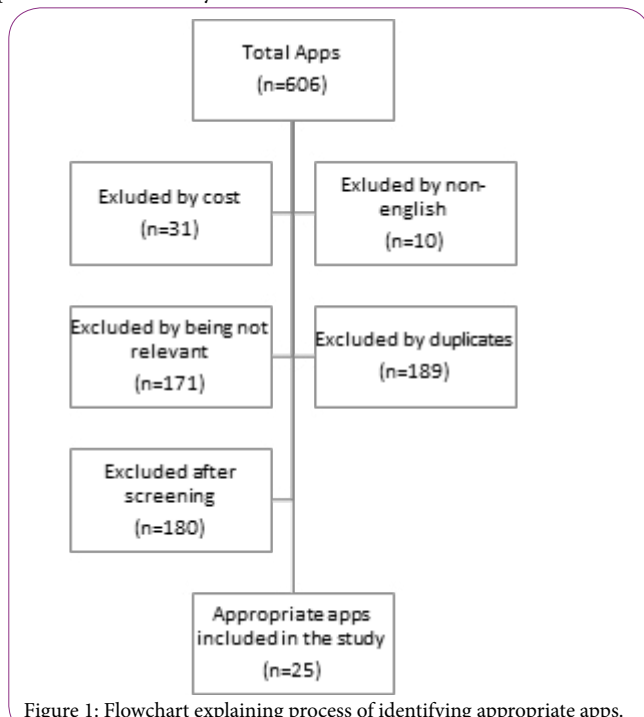
users to opt out, does not explain security systems used, and does not complain to collect. 2 points were given if the half of the criterion above were met, and 3 points were given if all of the above criteria were met [12].

The established criteria from Masaud et al. included educational objectives, content, accuracy, design, and conflict of interest (scale of 0 to 4)][13]. Per Masaud et al.'s rubric, each app earned a minimum of 1 point and maximum of 4 points per criterion listed before[13]. 1 point was given if the app does not fulfill the listed criterion, 2 points for minimally fulfilling the criterion, 3 points for mostly fulfilling the criterion, and 4 points if the criterion was completely fulfilled[13].

Two medical students (S.M. and S.H.) both at the clinical stage of medical education (third year and fourth year of medical education) and a second-year obstetrics and gynecology resident (R.V.) independently reviewed the apps using the given rubric and reviewed the apps using the rubrics mentioned prior (Table 1, and Table 2). A protocol did not exist for this systematic review.

The mean of the student's score and resident's score were calculated for each category listed prior. The sum of the averages for each category were considered the final score for the app which reflects upon overall quality. The maximum score as a result of combining both rubrics is 34 (Table 1, Table 2, Table 2.1, Table 3, and Table 4).

Table 2.1 Rubric used to evaluate apps generated by Masaud et al. with cumulative ranges from grading [13]

Category	Cumulative Ranges
Educational Objectives	1-1.99=app does not fulfill educational objectives 2.00-2.99=app minimally fills educational objectives 3.00-3.99=app mostly fulfills educational objectives 4+=app completely fulfills
Content	1-1.99= app has major gaps in information 2.00-2.99=app has gaps in information and content is disorganized 3.00-3.99=app has minor gaps and is disorganized 4+=app has no gaps and is organized
Accuracy	1-1.99=app presents factually incorrect information 2.00-2.99=app has minor errors that do not detract from the educational objectives 3.00-3.99=app has no factual errors, does not provide resources 4+=app provides evidence based information
Design	1-1.99=Design of app is difficult to use 2-2.99=App has issues with design 3-3.99=App has design, mode of navigation 4+=App is easy to use and well designed, enhances user experience
Conflict of Interest	1-1.99=app has obvious COI 2-2.99=app was made with some COI, however it presents information in an unbiased manner 3-3.99=app is created with some monetary incentive, relatively unbiased, factually correct information 4+= app was created with no COI or monetary incentive

Results

Our total search resulted in a total of 606 apps; however, after careful evaluation by utilization of the inclusion and exclusion criteria, 25 apps were eligible for review. At present time,

all 25 apps are available on the Apple app store. All 25 apps utilized in this study are free of charge [table 3 and table 4]. Again, selection bias present as all apps evaluated were from the App store.

The maximum total score to achieve was 34. However, the actual range of scores was 13 to 30.26. Cumulative scores between 0 to 11.99 were considered poor, 12.00 to 23.99 were considered moderately adequate, and 24.00 to 34.00 were considered adequate apps per Masaud et al. [13]. 0% (0/25) apps were considered poor, 48% (12/25) apps were considered moderately adequate, and 52% (13/25) were considered adequate based on the extensive criteria generated by Masaud et al. and Chyjek et al. [Table 3 and Table 4][11,12].

Regarding technicalities of the apps: about 76% (19/25) did not require a paid subscription, while for 12% (3/25) of the apps access to special features required a paid subscription, and the remaining 12% (3/25) required a paid, monthly subscription.

Surprisingly, only one of the apps used substantial, accurate literature. 100% of the apps either did not specifically state they used literature or there was discrepancy of the quality of the literature used amongst the reviewers.

56% (14/25) of apps required in-app purchases, while 36% (9/25) did not require in-app purchases. For the rest of apps, there was discrepancy amongst the reviewers about the presence/requirement of in-app purchases.

48% (12/25) required functioning internet while 36% (9/25) did not. For the remaining apps, it was unclear how connectivity-related issues were addressed.

24% (6/25) of the apps had advertisements present on the apps, while 40% (10/25) did not. Amongst the rest of the remaining apps, at time of reviewer engagement, advertisements were either present or absent depending on the timing of app use, leading to score discrepancy.

Furthermore, two apps had a specific text search field feature, while 80% (20/25) did not have this feature. Amongst the remaining apps, some reviewers were able to identify the text search field feature.

Regarding inter-device compatibility, meaning app compatibility across both Apple and Android products, 36% (9/25) of apps were only compatible with Apple products, while 48% (12/25) were compatible with both products. For remaining apps, it was unclear whether the apps were compatible across both platforms to the reviewers.

Regarding the presence of images and videos, 92% (23/25) of apps did have educational imagery and 12% (3/25) of apps had educational videos.

Special features that were unique to each app were present for 36% (9/25), absent for 36% (9/25), and for the remaining there was discrepancy between the reviewers.

Regarding privacy and security, 32% (8/25) apps had a privacy policy, declared data use or purpose, did allow users to opt out, did explain the type of individual security systems used, and did not claim to collect personal data for dissemination. Another 32% (8/25) of apps had met about 75% of the criteria stated above. 16% (4/25) of the apps had about 25% of the criteria mentioned above. 20% (5/25) of the apps had no clear mention of the statements mentioned prior.

Table 3: Grading of applications meeting inclusion criteria

	Price	Paid subscription	Literature Used	In-app purchase	Connectivity	Advertisements	Text search field	Interdevice
Clue Period Tracker & Calendar	1	0.67	1	0	0.67	0	1	0.67
Cycles: Period & Cycle Tracker	1	0.67	0.67	0.67	1	0.67	1	0
drip	1	0.67	1	1	1	1	1	1
Eveline Ovulation Cycle Track	1	1	1	0	0	1	1	1
FEMM Period Ovulation Tracker	1	1	0.67	1	0	0.67	1	1
Fertility Friend FF App	1	1	0.67	0	1	0.67	1	1
Fertility Tracker- Sprout	1	1	1	1	1	0.67	1	0.67
Flo Period & Pregnancy Tracker	1	0	0.67	0	0	1	0	1
Glow: AI Ovulation Tracker App	1	1	1	0	0.67	0.67	0.67	0.67
Groove - Period & Fertility Tracker	1	1	1	0	1	1	1	0
iCycleBeads Lite	1	1	1	0.67	1	1	1	0
iPink Period Tracker	1	1	1	1	1	0	1	0
Kindara: Fertility Tracker	1	1	1	0	1	1	1	1
Modern Fertility Cycle Tracker	1	1	0.67	0	0.67	0.67	0.67	0
MyFLO Period Tracker	1	1	1	0	0	0	1	1
Obie: Fertility, cycle tracker	1	1	0.67	1	0	1	0	0
Orchyd: Period Tracker & OBGYN	1	1	1	0	0.67	0.67	1	1
Ovia: Fertility, Cycle, Health	1	1	0.67	1	0	0.67	0.67	1
Ovulation Calculator Fertility Tracker & Calendar	1	1	1	1	0	1	1	0.67
Ovulation Calculator, Calendar	1	0	0	1	1	0	1	0
PeakDay Fertility Tracker	1	1	1	0	0	1	1	1
Period & Ovulation Calculator	1	1	1	0	0	0	1	0
Period Tracker and Calendar	1	1	1	0	0	0	1	0
Period Tracker by GP Apps	1	1	1	1	0	0	1	1
Read Your Body	1	0	1	0	0	1	1	1

Only one app had completely met all educational objectives. 28% (7/25) of the apps mostly fulfilled educational objectives. 28% (9/25) of the apps minimally fulfilled educational objectives, while 28% (8/25) did not fulfill those same objectives.

20% (5/25) of the apps had major gaps in information, 28% (7/25) had minor gaps in information and were disorganized. 28% (7/25) of apps had minor gaps in information and were minorly disorganized. 24% (6/25) of apps had no gaps and the apps were well organized.

88% (22/25) of the apps did not have factual errors, but did not provide resources used. 12% (3/25) of the apps had minor errors that did not detract from the educational objectives.

One of the apps had a poor design, therefore compromising its usability. 24% (6/25) of the apps had issues with design. 64% (16/25) had apps with good design and mode of navigation. 8% (2/25) of apps had an easy to use and well-designed interface which enhanced user experience.

None of the apps had an obvious conflict of interest. Meanwhile, 32% (8/25) of the apps had some conflict of interests that were clearly addressed; however, information on the app was presented in an unbiased manner. 64% (16/25) of the apps were created with some monetary incentive, remained relatively unbiased, and had factually correct information. Only one app was created with no conflict of interest or monetary incentive.

Detailed information regarding each app located in Tables 3 and 4.

Discussion

Literature does exist evaluating the use of fertility apps and how they rank amongst one another. Previous studies assessed apps found exclusively through the Apple app store, Google Play store, or a combination of these platforms[3,7,10,12].

Zwingerman et al.'s 2019 study evaluated about 200 apps across multiple store platforms; the study made mention of some notable apps; however, only one of them aligned with the apps reviewed in this present-day study[11]. It is important to note that while various studies have been completed in the past, there has not been a recent comprehensive review of existing fertility apps available on the market. This highlights the dynamic nature of the app store with the ongoing introduction and retirement of apps. Again, this continuous

Table 4: Grading of applications meeting inclusion criteria.

	Images	Videos	Special features	Privacy and security	Education	Content	Accuracy	Design	Conflict of Interest (COI)	Total
Clue Period Tracker & Calender	1	0	1.67	2.67	2	2.33	3	3	3	22.68
Cycles: Period & Cycle Tracker	1	0	1.67	2.33	2.67	3	3	3.67	3	26.02
drip	1	0	0	1.33	1	1.67	2.67	2.67	4	22.01
Eveline Ovulation Cycle Track	1	0	1	2	2	2.67	3	3	2	22.67
FEMM Period Ovulation Tracker	1	0	0	2.67	1.67	3.33	3	3.33	2.33	23.67
Fertility Friend FF App	1	0	1.67	1.67	1.67	2	2.67	2.33	2.67	22.02
Fertility Tracker- Sprout	1	0	0	2.33	1.67	2	3	3	2.67	23.01
Flo Period & Pregnancy Tracker	1	1	1	2.67	4	4	3.67	4	3	28.01
Glow: AI Ovulation Tracker App	1	0.67	0	1	2.33	2.33	3.67	3.33	3	23.01
Groove - Period & Fertility Tracker	1	0	0	0.67	1.33	1.67	2.33	2.67	3	18.67
iCycleBeads Lite	1	0.67	0	0.67	1	1.67	3	2.67	3.33	20.68
iPink Period Tracker	0.67	0	0	1	1.67	1.67	3	2.67	3.67	20.35
Kindara: Fertility Tracker	1	0	1	1	2	4	3	3	3	25
Modern Fertility Cycle Tracker	1	0.67	1	2.67	3	3	3.33	3	2	24.35
MyFLO Period Tracker	1	0	1	1	2	2	3	4	2	21
Obie: Fertility, cycle tracker	1	0	1	3	3	3.33	3	3	3.67	25.67
Orchyd: Period Tracker & OBGYN	1	0	1	2.67	2	3.33	3	3.67	2.67	25.68
Ovia: Fertility, Cycle, Health	1	1	1	3	3.67	3.67	3.67	3.67	3.67	30.36
Ovulation Calculator Fertility Tracker & Calendar	1	1	1	3	2	2	3	2	3.33	25
Ovulation Calculator, Calendar	0	0	0	1	1	1	3	1	2	13
PeakDay Fertility Tracker	1	0	0.67	3.33	3	4	3	3	3	27
Period & Ovulation Calculator	1	0	0.67	3.33	3	4	3	3	3	25
Period Tracker and Calendar	1	0	0.67	3.33	3	4	3	3	3	25
Period Tracker by GP Apps	1	0	0.67	3.33	3.33	4	3	3.33	3	27.66
Read Your Body	1	0	0	3.33	2	3	3	3	3	23.33

cycle allows for a multitude of apps to be made available; however, there lacks a system by which these apps are vetted and promote accurate health information. Meanwhile, other studies done were focused solely on one or a few apps; therefore, overlooking the hundreds of apps available to users across various platforms [7,10].

While these studies varied from this present assessment, collectively, they echoed similar findings. Ultimately, technology serves as an incredibly powerful tool in numerous capacities within medicine, specifically fertility. With the help of apps, women can navigate their menstrual cycles, follow their ovulation, and learn about their own bodies to make informed health decisions. Although this is the case, there still exists an overarching theme that free, effective, accurate, and evidence-based apps are difficult to discern for both users and healthcare providers.

A quick search of "Fertility" in the Apple app store revealed hundreds of apps. While the apps at the top of the list often had high user ratings or were ranked in Apple's "Top Charts", there were also promoted apps that were not necessarily associated with fertility or were simply menstruation calendars. Navigating these options comes with a number of barriers including, but not limited to, time spent using and assessing each app as well as costs of in app purchases such as subscriptions and add-on features. This can lead to frustration and lower satisfaction levels on the user end, leading to overall lower levels of app utilization [1].

Through our search of the Apple app store, we yielded 606 total apps by using the following search terms "fertility", "fertility tracker", "menstruation", and "menstruation tracker". Throughout the screening process, we noticed problematic aspects of the apps including a primary focus on menstrual tracking, limitations in education on fertility, and a lack of scientific evidence. After utilizing cost as an exclusion criteria, only 25 free apps from the Apple app store remained.

Upon further investigation into these apps, many of them often lacked tools beyond menstrual cycle and symptomatology tracking. Often times, these apps were comprised of calendars allowing for users to track the dates of their menstruation with the addition of a "peak fertility" days and "ovulation windows". While this can serve as a great way for one to track their menstrual cycle, it hardly offers any substantial education, learning, or appropriate content on fertility. When apps did offer content, it was also crucial to assess its accuracy and value as not all of it was necessarily scientifically backed. Upon

critical evaluation of the apps, only one app, Flo Period and Pregnancy Tracker, had used extensive substantial literature as the backbone of its functionality. Interestingly, this was the only app that had met all educational objectives.

There was an even distribution of apps either mostly, minimally, or incompletely fulfilling the detailed educational objectives as per Masaud et al.'s rubric [13]. Shockingly, zero apps provided evidence based information; however, a majority of these apps did not have factual errors but also did not explicitly state the resources used.

Furthermore, in more well-equipped apps, there was often the problem of cost. Numerous apps which may be free to download, often had associated costs ranging from monthly subscriptions to users purchasing necessary equipment such as hormone level tests, pregnancy tests, and basal temperature monitors. These app-specific, individualized costs can quickly add up, especially over the span of one's journey to become pregnant. In fact, these hidden expenditures may disincentivize users.

Most apps were compatible across both Apple and Android products, with a majority of these apps requiring functioning internet for usage. A majority of the apps had an effective design and mode of navigation which enhanced user experience. Surprisingly, a majority of apps did not have active advertisements present, instead opting for educational imagery and videos to help educate users. A notable aspect of the apps was that a majority did not have specific text search field features, which can potentially help users navigate the app and help them elucidate complex medical terminology.

A growing concern with healthcare apps is the protection of private health care information. Interestingly, a majority of apps we evaluated had clear privacy policy statements, declared data use or purpose, allowed users to opt out from data sharing, and explained in detail the type of security systems used. However, five apps had no clear mention of the privacy components listed prior. This is shocking as the typical app user would not be aware of the lack of security features and would be willingly giving away valuable, personal health information.

Upon further assessment of our 25 apps, it was noted that approximately only half of these were adequate, scoring 24 points and above, while the remaining were only moderately adequate, scoring between 12 and 23.99 points. This shows that even with thorough supposed screenings in place, there still exists a huge need on the user end to effectively navigate the complexities of finding a free, informative, user-friendly app that offers substantiated educational content.

There were discrepancies noted in multiple categories amongst the graders, which remains a limitation of this study. As two medical students in different stages of their clinical training and one second-year obstetrics and gynecology resident evaluated the apps, different learning styles and how each user approaches apps could have led to varied scores. Another limitation of this study is how only apps in the Apple app store were examined, as all three reviewers only have iPhone.

However, a clear benefit of this extensive and thorough review is that varied perspectives on vital aspects of fertility apps are reviewed. As stated previously each app was not only technically examined, but also strength of content and security were evaluated. This remains as the only extensive review of fertility apps that have undergone such extensive examination. Future directions include evaluating additional apps available on other operating systems, including Google's Android.

Conclusions

There exists a huge market for fertility apps and there is no shortage of these apps, however, the mere presence of a fertility app does not make it educational, useful, or helpful. Several apps lack crucial user necessary features, do not educate their users on fertility, or promote unsubstantiated facts which can lead users to make uninformed health decisions and have access to an abundance of misinformation. More strict review and research needs to be done to better fully understand the role of fertility apps on women's health and reproduction. Furthermore, it would be beneficial to study the needs of consumers in order to find adequate apps and resources best suited to them. By doing so, health care providers may provide their patients with powerful technological tools to understand their own health and make informed decisions regarding their fertility.

Competing Interests

The authors declare that they have no competing interests.

Author Contributions

Ranjitha Vasa: Involved with conception, design of the project. Involved with acquisition of the data and drafting the manuscript. This author gave final approval of the version to be published.

Shirley Huang: Involved with acquisition of the data and drafting the manuscript. This author gave final approval of the version to be published.

Sabrina Muhana: Involved with acquisition of the data and drafting the manuscript. This author gave final approval of the version to be published.

Ozgul Munneyrici-Delale: Involved with conception, design of the project. Involved with acquisition of the data and drafting the manuscript. This author gave final approval of the version to be published.

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