Bridging the Gap: Reimagining Menstrual Tracking Apps to Meet the Needs of Women with PCOS

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Abstract

Menstrual tracking applications, a vital part of the FemTech industry, aim to empower all women, but often misrepresent or exclude women with diverse health experiences in their design. One such group is women with Polycystic Ovarian Syndrome (PCOS). PCOS is a chronic, hormonal condition affecting 8–13% of reproductive-aged women with symptoms such as irregular cycle, increased weight, acne, and increased prevalence of depression and anxiety. Despite their potential, many menstrual tracking apps fail to serve women with PCOS adequately. For instance, these apps assume that all users have regular menstrual cycles, offering predictions that fail to accommodate the irregular patterns caused by PCOS. The present study aims to explore how menstrual tracking applications can be adapted to better serve individuals with PCOS by being guided by the principles of woman-centered design and CEHRES roadmap, a widely used roadmap for development of eHealth technologies. Semi-structured interviews were conducted with women with PCOS, which were analyzed to reveal key insights into participants' PCOS management strategies, barriers to management, challenges with existing period trackers, and desired features for a PCOS-specific application. These findings were used to identify desirable app features such as personalization, holistic self-tracking, discussion forums, reduced assumptions about cycle patterns and motivational messages for self-management. These insights informed redesign of *Flo*, a popular period-tracking app, to accommodate it to the needs of women with PCOS. This research contributes to the growing body of feminist HCI by advocating for inclusivity and challenging normative assumptions within menstrual-tracking.

Keywords: Menstrual-tracking apps, PCOS, FemTech, mHealth, Self-tracking, Woman-centered approach

Contents

Technology Statement

1. *Did you use any tools or services to paraphrase text from other sources (for example, a thesaurus or the Academic Phrasebank)? Please name them*.

   I used ChatGPT for academic phrases and words.

2. *Did you use any tools or services to check spelling or grammar? Please name them.*

   I used Grammarly to check grammar.

3. *Did you use any tools or services to typeset the given text? Please name them.*

   I only used Google Docs.

4. *Did you use any tools or services to generate part of the text? If so, please name them.*

   I used Mendeley to generate citations.

5. *Did you use any generative AI tools or software for other aspects of your thesis? If so, please name them.*

   I used Figma to design the prototype. I also used ATLAS.ti for the thematic analysis

Bridging the Gap: Reimagining Menstrual Tracking Apps to Meet the Needs of Women with PCOS

For centuries, people have monitored and measured various aspects of their bodies with tools like thermometers to record temperature and pen and paper to keep track of their physical and mental conditions (Sysling, 2020). With technological advancements, this tracking has shifted to smartphones and wearables like smartwatches, making self-tracking more efficient by introducing ubiquitous and continuous means of tracking (Lupton, 2016). The most popular form of self-tracking is tracking for health-related information such as physiological and behavioral data on sleep, physical activities, emotional well-being, and social and sexual interactions (Selke (Ed.), 2016).

Within health tracking, technology catering to women has been on the rise, including applications that track the menstrual cycle (Epstein et al., 2017). Menstrual-tracking apps provide women with tools to log data such as the dates of menstruation, sexual activity and mood, which keep a track of and use to predict future cycles (Lupton, 2015). This user data is also used to offer insights into fertility and ovulation phases, equipping users with knowledge about the optimal time for reproductive potential.

Menstrual-tracking applications like Clue, Glow, and Flo have millions of users across the globe (Tylstedt, 2023). They claim to empower women and increase their autonomy over their bodies by enhancing their self-knowledge of their reproductive processes (De Stefano & Müller, 2021). Beyond helping women understand their bodies, the insights gathered by these apps also help in contributing to broader scientific knowledge on female health (Corbin, 2017).

Moreover, these apps can also play a crucial role in destigmatizing topics like menstruation and women's reproductive health (Chopra et al., 2021).

While menstrual tracking applications contribute significantly within women's health technology, they don't come without their own set of criticisms. This thesis aims to examine menstrual-tracking apps through the lens of women-centered design as proposed by Almeida and colleagues (2020). This woman-centered approach focuses explicitly on the experiences and needs of women in design, especially those related to health and body by prioritizing designing both with and for women, placing empathy at its core. Unlike human-centered design, which seeks to cater to the needs of all humans, woman-centered design goes a step beyond it by deliberately putting the focus on disparities faced by women. This approach integrates principles of humanism, activism, and inclusivity to ensure that the unique and diverse experiences of women are kept at the forefront in the design process.

Many menstrual-tracking apps fall short of serving this goal of woman-centered approach (Almeida et al., 2020) of being inclusive as they solely cater to women who fit the societal standards of normalcy (Corbin, 2017). For example, these apps assume that all users are heterosexual, cisgender women who have regular, predictable menstrual cycles. By categorizing women according to rigid norms shaped by biased and limited design, menstrual-tracking apps fail to account for the vast diversity of women's experiences (Corbin, 2017). Furthermore, most menstrual-tracking applications, with a few exceptions, adopt a reductionist approach, explicitly focusing on tracking menstrual flow and fertility while neglecting other important aspects of reproductive health, such as stress, nutrition, and weight (Pichon et al., 2022). This narrow design alienates individuals who fall outside this limited framework, including those

experiencing menopause, hormonal imbalances, or conditions like endometriosis and Polycystic Ovarian Syndrome (PCOS) (Tylstedt, 2023).

PCOS, in particular, exemplifies the challenges faced by individuals underserved by current period-tracking tools. PCOS is a hormonal condition affecting 8–13% of reproductive-aged women and has endocrine, reproductive, cardiometabolic, dermatologic, and psychological implications (Teede et al., 2023; WHO, 2023). A common symptom is an irregular menstrual cycle, which is often linked to ovarian dysfunction. However, the experience of PCOS is quite subjective and varied with some individuals also facing symptoms such as infertility, insulin resistance, acne, disordered eating, and excessive hair growth, among many others (Teede et al., 2023).

Polycystic Ovarian Disease (PCOD) is a related condition, which shares overlapping symptoms with PCOS. The key difference is that in PCOD the ovaries release immature eggs leading to hormonal imbalances and swollen ovaries. On the other hand, PCOS is characterized by excess androgen production due to endocrine issues, which makes eggs more prone to develop into cysts (Vidushi, 2022). While PCOS is generally considered more severe than PCOD (Vidushi, 2022), both conditions have similar manifestations and are often used interchangeably by healthcare professionals. Although this thesis uses the term PCOS for simplicity and clarity, the research includes individuals with both PCOS and PCOD and its findings are applicable to both the conditions.

Current menstrual-tracking apps tend to overlook individuals with PCOS. For example, since these users may not have regular periods, monthly app predictions could become irrelevant for them. Additionally, because PCOS can affect fertility, apps that heavily focus on conceiving

and sending reminders about reproductive potential can cause discomfort among those dealing with infertility (Tylstedt, 2023). This highlights the need for more menstrual-tracking apps to be more inclusive, especially when their aim is to empower all women (Tylstedt, 2023).

Feminist HCI research emphasizes the importance of designing technologies without making universal assumptions about the users' contexts (Keyes et al., 2020). This could mean developing ways to track reproductive health beyond algorithmic predictions (Fox et al, 2020). Expanding depictions of what an "acceptable" menstrual cycle should be like can challenge normative assumptions about femininity, fertility, and able-bodiedness. Furthermore, designing for individuals with PCOS can help transform menstrual-tracking technologies into nurturing and supportive tools for them by addressing their unique needs and fostering a sense of empowerment (Pichon et al., 2022). Consequently, this study aims to understand the needs of women with PCOS and redesign an existing menstrual tracking application accordingly to make it more inclusive for them as well as have a holistic approach in accommodating their needs. Therefore, the central research question of this thesis is as follows: *How can menstrual-tracking apps be adapted to better serve individuals with PCOS?*

To capture the subjective experience of women with PCOS, a qualitative approach involving the end users was adopted using the CEHRES roadmap (Van Gemert-Pijnen et al., 2011). This approach offers clear guidelines for keeping the needs of the end-users at the forefront of the design process of e-health technologies and includes five intertwined phases and connecting cycles, namely contextual inquiry, value specification, design, operationalization, and summative evaluation.

This study's methodology draws inspiration from the first three phases of CEHRES roadmap. First, semi-structured interviews with women having PCOS were conducted to understand their experience. Next, value specification was used to identify core design values using the insights from the interviews. Finally, four prototype screens were developed based on the value specification phase to demonstrate the potential for improvement in the current design of menstrual tracking apps. This was accomplished by redesigning a well-known menstrual-tracking application, Flo. Through this approach, this study aims to contribute actionable insights for adapting menstrual tracking apps to accommodate the unique needs of individuals with PCOS.

Theoretical Framework

Self-tracking Technologies and Feminist HCI

Digital self-tracking has evolved significantly in recent years, enabling detailed measurement and monitoring of individuals' bodies and activities (Lupton, 2016). This evolution has given rise to the concept of the "quantified self," which involves people using digital tools like wearable devices and smartphone applications to measure and monitor their activities, bodies and behaviors. Health-related monitoring of factors like physical activity, food consumption, mood and weight has emerged as one of the most popular forms of self-tracking, wherein individuals collect data on their health to improve their self-knowledge of their bodies and optimize their health (Lupton, 2016).

Despite health tracking becoming more ubiquitous in recent years, aspects linked specifically to women's health have largely been underrepresented (Corbin, 2017). For instance, Apple's HealthKit app is designed to monitor nearly every health metric imaginable, including

blood alcohol levels to sodium intake, and yet it initially excluded menstrual tracking, a vital aspect of health for many women, causing frustration among many female users (Duhaime-Ross, 2014). This oversight of women in health tracking and treating the male as the norm has led to a lack of awareness around conditions related to women's health in society as well as most healthcare products being primarily tailored to men.

In response to these gaps, the Female Technology or FemTech industry has emerged and offers technologies, wearables, and applications that are designed specifically to address women's health needs (Tylstedt, 2023). These solutions focus on period-tracking, fertility, pregnancy, sexual wellness, and reproductive health of women and seek to empower women by improving their knowledge of their own body and providing them with tools to manage their health.

Despite FemTech's positive intent, feminist scholarship has brought forth several inconsistencies within these technologies. A notable concern is that many of these technologies are funded by predominantly Caucasian male investors, whose limited perspective may not account for the full spectrum of women's health experiences (Corbin, 2017). This limited perspective can lead to applications relying on incorrect and stereotypical assumptions about the female body. Furthermore, FemTech also inevitably plays a role in defining the default female body, which can be a dangerous precedent (Corbin, 2017). For instance, self-tracking technologies within FemTech categorize women and limit their data input to a range of normal values. This not only creates restrictions on who can use these products, but also deem women who fall outside of these categories as 'others', thereby ignoring the inherently individual and unique nature of women's embodied experiences (Corbin, 2017).

This critique of Femtech perpetuating certain norms can be further understood through Foucault's (1984) concept of biopower, which describes how technology and medicine subtly regulate bodies and behaviors by promoting and valuing dominant discourses of health that are then internalized by the individuals (Bobel et al., 2020). In this way, biopower is a form of social control which pressurizes individuals to conform to societal norms through voluntary self-subjugation and self-disciplinary practices (Bobel et al., 2020). FemTech, including period-tracking applications, exemplifies and perpetuates biopower as they encourage users to adopt ideals of self-discipline and body optimization that conform with societal standards of health (Balfour, 2023). Such technologies extend patriarchal control by enforcing a constant state of self-surveillance in women and pathologizing deviant experiences (Balfour, 2023).

According to Bardzell (2010), while FemTech plays an essential role in addressing women's needs and seeks to empower them, it is equally essential to consider the needs of women from marginalized backgrounds, whose identities are influenced by intersections of race, age, and ability. Almedia and colleagues (2020) further support this, by emphasizing the value of empathy when addressing sensitive and often neglected topics in women's health in design. Their approach rejects universalized assumptions and demands diverse perspectives, particularly of those from marginalized communities at the forefront of design (Almedia et al., 2020).

According to feminist scholarship, one must constantly challenge technologies that maintain the default assumption of the abled, cisgender, white body as the universal subject of analysis (Keyes et al., 2020). Feminist theories also urge designers to remain open to questioning dominant assumptions and uncovering untold stories without assuming full understanding (Rosner & Bennett, 2019). In line with this argument, this study seeks to challenge dominant narratives by focusing on diverse experiences of menstruators, with a focus on individuals with

Polycystic Ovary Syndrome (PCOS). The next section delves into the nuances of PCOS, which would provide a foundation to critically analyses the assumptions and narratives perpetuated by menstrual-tracking applications covered later in this section.

PCOS and mHealth Interventions

Polycystic Ovarian Syndrome (PCOS) is a common endocrine disorder having reproductive, metabolic, and psychological manifestations and affecting around 13% of women of reproductive age (Ee et al., 2021). An adult is diagnosed with PCOS if they have any two of the three criteria based on revised consensus Rotterdam criteria. These criteria are: i) clinical/biochemical hyperandrogenism, ii) ovulatory dysfunction marked by irregular cycle and iii) polycystic ovaries on ultrasound or elevated anti-mullerian hormone (AMH) levels after other causes of these features are excluded (Teede et al., 2023).

PCOS is experienced differently by every individual. However, a key symptom observed by 75% to 85% of patients is ovulatory dysfunction (Unfer et al., 2024). Ovulatory dysfunction causes disruption of the menstrual flow pattern and results in fewer than 6 to 8 menstrual periods per year. Infertility issues are also associated with ovulatory dysfunction, affecting 70-88% of all patients (Unfer et al., 2024). Other symptoms include insulin resistance, a higher prevalence of obesity, and symptoms due to excess androgens including acne, hirsutism, and scalp hair loss (Ee et al., 2021). Psychologically, PCOS can lead to an increased prevalence of anxiety and depression (Ee et al., 2021).

PCOS is a chronic condition with no definitive cure and requires lifelong management (Teede et al., 2023). Healthcare professionals recommend lifestyle interventions such as

maintaining a healthy diet, physical activity, awareness, and stress management, which can help alleviate the symptoms such as hyperandrogenism and menstrual irregularity (Frias-Torale et al., 2021; Teede et al., 2023; Kazemi et al., 2020). However, there is evidence for high attrition rates when it comes to implementation of these lifestyle interventions owing to the significant level of self-management and commitment required to adhere to the recommended lifestyle modifications (Ee et al., 2021). Barriers like limited access to reliable information, inadequate social support, difficulty prioritizing their health due to family caregiving responsibilities, financial challenges, and the lack of safe exercise spaces further complicate self-management (Ee et al., 2021). Additionally, aspects of PCOS itself can pose hindrance to adherence to lifestyle changes, such as fatigue, anxiety, depression, challenging emotions, disordered eating, stress, sleep issues, and limited health literacy (Ee et al., 2021).

Given the chronic nature of PCOS and the emphasis on self-management, mobile health (mHealth) interventions, like health tracking apps, present a promising solution due to their increased convenience, accessibility and cost effectiveness (Mehregany & Saldivar, 2020). This is supported by a study that reveals how most participants expressed a high intent in adopting a PCOS-specific mHealth app (Boyle et al., 2018).

Mobile health tracking has been recognized as an important tool in self-management when it comes to chronic health conditions such as PCOS (McBain et al., 2015). This is linked to the role health tracking plays in empowering patients by providing them with information on their own health and involving them in decision-making by encouraging them to adjust their lifestyle themselves in response to monitored data (Bhat & Kumar, 2020).

That being said, existing health tracking tools often fail to effectively capture data that are important to users or provide meaningful insights to clinicians (Bhat & Kumar, 2020). Another study supports this by revealing how existing PCOS-related information sources and self-management tools are inadequate to enhance self-management effectively or provide high-quality information (Boyle et al., 2018). This gap underscores the need for mHealth technologies to provide reliable tools that will empower women with PCOS to better manage their condition.

Reductionism and Lack of Inclusivity in Menstrual-Tracking Apps

Menstrual-tracking application serves as a prominent example of self-tracking within FemTech. A leading app in this category, Flo, has over 60 million active users, highlighting the widespread adoption of these applications. Menstrual-tracking apps allow women to log and track data about their menstrual cycle and gain insights into their reproductive health. Subsequently, these apps claim to empower women by offering them self-knowledge over their reproductive health (De Stefano & Müller, 2021) as well as by playing a role in destigmatizing the bleeding body which has been considered “impure” and “out of control” in the past (Bobel et al., 2020).

That being said, like other self-tracking applications, period-tracking applications compel menstruators to monitor and regulate their cycles. This surveillance becomes internalized, as highlighted previously in Foucault’s (1984) concept of biopower, and subtly encourages women to align with prevailing health norms and ideals (Balfour, 2023). As a result, women who don't conform to these algorithmic standards may feel marginalized, leading them to feel distanced from others (Gallant, 2003).

An example of a health norm in the case of menstruation is a regular, 28-35 days cycle. Menstrual-tracking apps like Flo assume this normative cycle for their user and provide predictions based on that. When the cycle doesn't align with the predictions, it characterizes the cycle as late and abnormal (Corbin, 2017). Hence, for users with conditions like PCOS, for whom irregular cycle is quite the norm, receiving unreliable predictions might make them feel disconnected from the period-tracking application (Epstein et al., 2017). Furthermore, this can inevitably lead to these users comparing themselves against a standardized ideal that does not account for their experience (Kristensen & Prigge, 2017). Hence, this calls for a more inclusive design of menstrual-tracking applications.

Beyond failing to be inclusive for individuals with PCOS, many menstrual tracking applications adopt a reductionist approach by primarily focusing on fertility and conception tracking and fail to address the broader aspects of reproductive health (Fox et al., 2020). While platforms like Flo and Clue allow users to log emotional and mental health data, their tracking systems are neither comprehensive nor nuanced enough to reflect the subjective experience of the menstrual cycle (Pichon et al., 2022). For instance, selecting "mood changes" in an app cannot fully capture the depth and complexity of the user's emotional state throughout the cycle.

This limitation is supported by findings from a study by Epstein and colleagues (2017), who stated that various aspects of well-being including mental state, headaches and even heart rate were often aligned with the individual's menstrual cycle and the participants' expressed a desire to comprehensively track these. One participant shared, "I was consistently being depressed right before it happened. I would be really unhappy and grumpy, and then I'd get my period." (Epstein et al., 2017). Thus, comprehensive tracking of mental and emotional aspects of the menstrual cycle would help women identify trends in their cycle and avoid reducing the

bodily experience of menstruation to data points (Pichon et al., 2022). While this holistic tracking is valuable for all users, it is especially crucial for women with PCOS, whose mood-related symptoms tend to be more exacerbated than those experienced by women without PCOS (Phimphasone-Brady et al., 2024).

To challenge this reductionist approach, Fox and colleagues (2020) propose the notion of multiplicity which recognizes diverse ways of experiencing and tracking menstruation beyond rigid algorithms. They also advocate for dimensionality in period-tracking apps, which emphasizes moving beyond averages and norms in order to acknowledge the individualized nature of menstrual health. Together, multiplicity and dimensionality advocate for a more inclusive and adaptable framework, shifting period-tracking from an idealized "one-size-fits-all" model to a more inclusive and flexible framework (Fox et al., 2020). Implementation of these principles in period-tracking apps can empower those with PCOS to manage and understand their reproductive health without the pressure to conform to narrow standards (Fox et al., 2020). For instance, this could include providing features that allow users with PCOS to flexibly track factors like sleep patterns, nutrition, and period pain, as well as add personal notes, making the tracking process more subjective, nuanced, and reflective of their individual experience.

As Almeida and colleagues (2020) put it, technology should be modified to fit people, instead of modifying people to fit technology. In line with this philosophy, period-tracking apps should become more inclusive to accommodate the unique menstrual experiences of individuals with PCOS. This leads to the first sub-question:

a) *How can period-tracking apps be redesigned to make them more inclusive to the experience of individuals with PCOS?*

As discussed previously, women with PCOS face numerous barriers in effective management of their condition (Ee et al., 2021). Furthermore, existing mHealth solutions often fail to adequately address the specific needs of women with PCOS (Boyle et al., 2018). This highlights the potential of menstrual tracking apps to go beyond basic tracking and adopt a holistic approach to reproductive health by offering features that can provide meaningful support in PCOS management. Consequently, the second sub-question is as follows:

b) *How can period-tracking apps be redesigned to actively support self-management of PCOS?*

Design Approach

In order to address the sub-questions, this study adopts Almeida et al.'s (2020) woman-centered approach. This approach emphasizes inclusive, activist and participatory approaches to design and views women as active participants and embodied knowers of their own health. Bardzell (2010) further emphasizes the important role of women in co-creating solutions alongside designers. While health experts provide essential insights, it's equally as important to consider the perspective of end-users, who will ultimately interact with the technology.

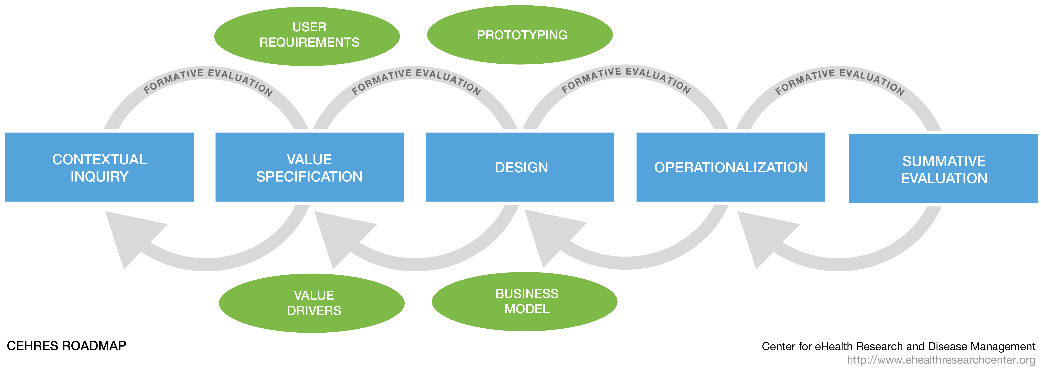
The Centre for eHealth Research roadmap (CEHRES roadmap), one of the most widely used frameworks for developing e-health applications, aligns with this participatory approach (Van Gemert-Pijnen et al., 2011). CEHRES roadmap offers a co-design framework that emphasizes developing eHealth applications *with* stakeholders rather than *for* them. This approach can be used for developing technologies from scratch as well as redesigning existing technologies in different contexts and hence, is a useful approach for the current study.

CEHRES roadmap has five phases (see Figure 1). First, contextual inquiry is conducted to understand the goals, needs and context of key stakeholders, Including prospective users, as well as the limitations of the current technology. In the value specification phase, the values and priorities of different stakeholders are identified and translated into design recommendations. Next, in the design phase, a prototype is developed based on these findings. The operational phase involves launching and marketing the application. Finally, summative evaluation intends to find out how the technology is being used and its impact.

In alignment with the CEHRES roadmap (Van Gemert-Pijnen et al., 2011) and woman-centered approach (Almeida et al. 2020), this thesis incorporates semi-structured interviews with individuals with PCOS to answer the research question: *How can menstrual tracking apps be adapted to better serve individuals with PCOS?* This approach ensures that the participatory design process includes diverse user voices to incorporate inclusivity within the technology.

Figure 1

CEHRES Roadmap



Method

Study Design

This study utilized a qualitative design framework adapted from the CEHRES roadmap (Van Gemert-Pijnen et al., 2011) to investigate the specific needs of individuals with Polycystic Ovarian Syndrome (PCOS) in relation to period-tracking applications. The CEHRES roadmap is especially developed for e-health interventions, offering a structured design process with guidelines for comprehending user needs and values. This study will focus on three of its five phases due to time constraints.

Phase I: Contextual Inquiry

The aim of the contextual inquiry is to understand the goals and context of key stakeholders, including prospective users. Due to time constraints and limited access to participants' environment, the contextual inquiry was adapted and changed to conducting semi-structured interviews with individuals diagnosed with PCOS/PCOS for the purpose of collecting data. Semi-structured interviews allowed thorough investigation of the participants' lived experience, needs, and challenges with PCOS/PCOD as well as their pain-points with the current technology.

Phase 2: Value Specification

In the value specification phase, the user needs highlighted in the interviews were narrowed down by the researcher. The user needs were converted into concrete design solutions. This helped to determine precise goals for the app and strategies to achieve them.

Phase 3: Design

In this phase, Figma was used to redesign Flo based on the insights gathered from the contextual inquiry and value specification phases. While multiple iterations of the prototype based on usability testing are a key part of the design phase, these were not included in this study due to time constraints.

Participants

The interviews involved 10 participants diagnosed with either Polycystic Ovarian Syndrome (PCOS) or Polycystic Ovarian Disease (PCOD) who were recruited from the researcher's personal network and social media platforms. All participants identified as cisgender women, with a mean age of 22.1 years, and were from India. To be eligible for the study, the participants had to be familiar with at least one menstrual-tracking application and either regularly use it or have used it in the recent past (See Table 1).

Table 1. Description of Participants

Participant Number	**Age**	**Gender**	**Nationality**	**Currently using a Menstrual-tracking app**	**Year of Getting Diagnosed**
P1	22	Female	Indian	Yes	2019/2020
P2	22	Female	Indian	Yes	2023
P3	23	Female	Indian	No but has used one in the past	2017

P4	23	Female	Indian	Yes	2020/2021
P5	22	Female	Indian	Yes	2022
P6	22	Female	Indian	Yes	2022
P7	20	Female	Indian	Yes	2020
P8	24	Female	Indian	Yes	2021
P9	21	Female	Indian	Yes	2020/2021
P10	22	Female	Indian	No but has used one in the past	2018

Procedure

A one-on-one semi-structured interview was conducted with the participants that lasted for around 15-25 minutes. The interviews were conducted online as the participants lived in geographically distant locations, making it challenging to conduct in-person interviews. The session was audio recorded and participants were asked to read and sign an informed consent form beforehand (see Appendix B).

The key questions were planned in advance, but the interview included some more contextual questions to allow in-depth exploration and keep the possibility of exploring other aspects of the topic that may arise during the interview open. The key questions were classified into three categories: the participants' individual experience with PCOS, their experience with menstrual-tracking applications that they used, and what they would like to see in a menstrual-

tracking application to make them more PCOS-friendly (see Appendix A). ATLAS.ti software was then used to carry out a thematic analysis. This was then followed by the value specification and design phase, respectively.

Results

Ten semi-structured interviews with individuals diagnosed with PCOS were conducted to explore the research question: *How can menstrual tracking apps be adapted to better serve individuals with PCOS?* The interviews were audio recorded and transcribed for thematic analysis. ATLAS.ti was utilized for flexible coding which was then exported. The codes (see Appendix C) informed the emergence of five key themes: Firstly, Management Strategies, which highlighted the various approaches participants used to manage their symptoms. The second theme, Barriers to PCOS Management, addressed the challenges participants faced in managing their symptoms. Thirdly, Limitations of Menstrual Tracking Apps identified the difficulties participants encountered while using menstrual tracking applications. The final theme, Features for Supporting PCOS Management identified the desirable features proposed by the participants to improve the user experience and PCOS support offered by menstrual tracking applications. These themes served as the foundation for the value specification and design phases, which are addressed later in this section.

Management Strategies

This theme covers the diverse self-management strategies participants employed to manage their symptoms of PCOS and improve overall well-being. The key identified strategies

were stress management, physical exercise and diet management, sense-making via community, and relying on intuitive methods.

Stress Management

Participants identified stress as a significant factor in exacerbating their PCOS symptoms. Stress was often described as a trigger for irregular cycles. One participant talked about how stress and irregular menstruation were linked by a vicious cycle: *"I could see that if I was stressed in my life, it would affect my period cycle. So it was like, weird, because the stress would affect the periods, the periods would affect the stress.*" (P9) To manage their stress, some participants engaged in various stress management strategies such as meditation: *"What I did to manage the symptoms was…meditate a lot, try to calm myself down.*" (P9)

Physical Exercise and Diet Management

Participants commonly observed that focusing on diet and exercise helped in regulating the cycle and improvement in symptoms. Avoiding processed foods and having a nutrient-dense meal proved helpful to many. One participant noted: *"I definitely take a protein-oriented meal in the start of my day…And that has worked really well for me." (P10)*

Participants noted a direct connection between regular exercise and symptom control. One participant emphasized the benefits of weight training: *"Weight training is one of the main things that I've tried…that's working well for me.*" (P10) Beyond weight training, any form of physical movement, coupled with a healthy sleep routine, was helpful for many. As one participant explained: *"I think just some form of movement works…and try to eat healthy."* (P2)

Sense-making via Community

Community support was a vital tool for understanding and managing PCOS. Participants turned to friends, online forums, and Instagram for advice, validation, and shared experiences. One participant found Reddit as a helpful source to navigate her condition: *"There's like one community [on Reddit]...They just discuss what worked for them, what did not work for them, and like, how they're managing the things that come about with their symptoms"* (P10). Social media, including influencers, also played a role in spreading awareness. As another participant shared: *"Most of the information I gather is from reels and people who are posting about PCOS on Instagram"* (P4).

Relying on Intuitive Methods

Some participants prioritized paying close attention to their bodies' needs as a way to manage their condition. This approach involved relying on an intuitive understanding of their physical and mental symptoms to predict the next period as well as knowing what their body requires at a given time in the cycle:

> "*I think I have gotten used to how it [PCOS] will impact my body and what I need, what I should, like prepare myself for if I'm going to get my period… allowing my body to rest and listening more to it, rather than defying it and going in completely. I'll do whatever I want, kind of a direction*." (P10)

Participants had become attuned to their bodies over time, which allowed them to identify patterns and deal with their symptoms.

Overall, to manage their symptoms of PCOS, participants employed strategies that emphasized a balance of physical activity, nutritional mindfulness, mental well-being, intuitive understanding and community support. These self-guided strategies offer key insights when addressing solutions to support PCOS management via a menstrual tracking application.

Barriers to PCOS Management

Despite having numerous strategies, participants faced several challenges in managing their symptoms. These obstacles often hindered their ability to maintain consistency in lifestyle changes or access appropriate support. First recurring barrier was the lack of understanding and awareness around PCOS, even among healthcare professionals. Many participants felt they were not receiving adequate health from their doctors, who often provided oversimplified advice, such as focusing solely on weight loss: *"All the gynecologists in India have just one thing to say about it, lose weight, lose weight and lose weight… it's not something that you need a doctor telling you when you're looking for a sustainable solution*." (P3) Another participant remarked on the lack of empathy from the doctors, stating, *"Doctors don't understand what you're going through. They just dismiss it like it's very normal." (P4)*

Furthermore, participants emphasized how PCOS was often undervalued as a serious condition, which added to their struggles. Many felt that the medical community as well as the people around them weren't very empathetic about women's health concerns. As one participant stated:

> *"I wouldn't say it [PCOS] is considered as a debilitating condition or as something that does have an impact on your everyday life, to the extent that I would say that it is. I know*

it is called a lifestyle disorder by some people, but also it can cause heart dysfunction or like disorientation in your lifestyle, altogether in your routine and in your regular life." (P10)

Additionally, participants struggled with sustaining lifestyle changes such as dieting, exercising, and tracking symptoms. This was because the high level of commitment required to manage their condition effectively was often overwhelming and led to a lack of consistency. One participant shared:

"[diet] always needed to be so proper…Living alone by myself in a foreign country, it wasn't something that I could stick to like rigorously. And so while I did try to do it for about three months, I never noticed any difference. And I just kind of stopped when it didn't give me the results that I was hoping for." (P3)

Medication being offered by the doctors as a solution was another area of concern, with participants being reluctant to rely on hormonal pills or devices like IUDs as long-term solutions due to negative side-effects. One participant reflected, *"The last time I went to a gynecologist…she gave me a birth control pill and told me to have it every single day for the rest of my life. And then I realized it is not something that I want to do to my body and I decided against it." (P6)*

Overall, barriers to management included lack of awareness and empathy from the community, difficulty in staying consistent to the routine and reluctance towards medication as a potential solution. This calls for the need of a more informed approach by healthcare providers and intervention tools that can help in addressing these barriers.

Limitations of Menstrual Tracking Apps

In addition to the addressed barriers, the participants also struggled with the menstrual tracking applications they used and expressed several reasons for dissatisfaction. They deemed these apps as overly simplistic and lacking the features necessary for managing PCOS. Many pointed out the apps' reductionist approach as they focus solely on tracking menstrual cycles without accounting for other lifestyle factors that should be considered when tracking reproductive health, including diet, exercise, and sleep. As Participant 1 stated, *"When you talk about PCOS, there are so many other things that also come into account, like your diet, your sleeping habits. So, I am not completely…happy with that aspect." (P1)* Another participant noted, *"It's just a Notes app for me. It tracks my period, literally. There's nothing more, nothing less." (P6)*

The apps were also criticized for their lack of meaningful insights or guidance. For instance, a participant shared frustration about how the app simply labeled irregular cycles as "abnormal" without offering actionable advice: *"It does note that it's irregular… and then it categorizes it into abnormal. That's all, that's how far it gets." (P6)*

Participants also found the predictive algorithms unreliable, particularly for those with irregular cycles. Despite logging symptoms and highlighting their PCOS condition, the apps failed to adapt or provide accurate predictions. One participant observed, *"Even if they tried to predict my cycle, taking PCOS into account, they did not give me accurate dates at all. They were always off by at least 10 days."* Another participant shared how she often feels disconnected from the application:

"It [the application] sends a notification when I'm 5, 7 or 10 days late, are you pregnant? Should we turn to pregnancy mode? Sure, do that. Of course, why not? That is what I'm planning. That is what I've been looking for all this time. So that's also pretty annoying…I feel very disconnected from the app when it does that." (P6)

Most participants found these predictions unnecessary and unreliable, with many using the app primarily to log their period dates for personal tracking rather than for cycle predictions.

Overall, participants found the menstrual tracking application they were using to be too reductionist to cater to their needs. They also deemed the algorithmic predictions redundant for them. These limitations of menstrual tracking apps reflect a disconnect between user expectations and existing solutions, and should be addressed in the redesign of menstrual-tracking application.

Features for Supporting PCOS Management

Participants identified several features that they wished to see in a menstrual tracking application that can better support them in managing PCOS. These suggestions included improved tracking features, support through community, designing for positive and smooth experience, personalization, tools for improved meaning-making, and actionable advice for management.

Improved Tracking Features

Participants identified numerous aspects of PCOS that they felt required more efficient and insightful tracking than what current period tracking apps offer. They

emphasized the need for comprehensive, nuanced tracking features that extend beyond logging period dates.

Participants emphasized the need for adaptable tracking systems that could account for the irregularities and unique patterns of PCOS. For instance, they would like to keep track of if they skipped a day of bleeding during their period. Furthermore, being able to track the amount of the flow was also important to them:

> *"My cycle was always like, so I would get my cycle for the first five days, then it would stop for two days, and then I would get it again for seven days, and they just did not have an option for that. Like, how do I log that in?" (P3)*

Tracking the intensity and type of pain during periods also emerged as a priority. Participants wanted to be able to track the levels of pain on different days and also know better about the radar of pain they are tracking. As Participant 3 pointed out, she wanted to be able to track *"Cramps, leg pain, because that is also a huge thing. My back hurts a lot, when I'm on my period…so maybe, like one, a feature that allows you to rate pain on different levels and factors*." (P3)

One participant showed interest in being able to track levels of fatigue as her period would severely affect it:

> "*Whenever I used to go to my GPA appointment, they would ask, how was your mood? How tired did you feel? And I just did not remember that after three months. So maybe, maybe a feature that would help me in tracking if I got out of bed that day, for one thing."* (P3)

Additionally, some would also like to track their dietary intake: *"It would be nice if I can track my food, and based on…what I'm eating, it tells me if I am eating proper for it [PCOS] or not.*" (P5)

Several participants also expressed the need to track their medication within the application, especially hormonal pills: "*It will also be helpful for the app to have a feature of whether you are on some sort of pill or or any other thing to manage your PCOS… how that pill is affecting your cycle." (P3)*

Some participants also pointed out the need for tracking emotions in a more detailed and extensive manner beyond the limited options that their apps provide. Participant 8 expressed her appreciation for the option of journaling down her emotions that her current period-tracking application provided: *"I like this app because it lets you add your feelings. You can put different emojis for each day. And it also gives you a diary to write about how you're managing with it, what kind of theme it has.*" (P8)

Some participants also expressed a desire to link their period-tracking app with other fitness apps to learn more about the physiological links of their condition: "*It also helps you understand your fitness and your cardio health, and how it can be linked to your cycle.*" (P1)

Support Through Community

Participants highlighted the importance of empathy from other individuals with PCOS as well as the healthcare professionals in providing support. Participants shared how talking about PCOS with other people helps them not take as much stress about their

condition and validates their experiences: *"Community support and people who've already been through it... offer a lot of reassurance to me... without them, I will get extremely anxious"* (P2). Talking about community support, another participant echoed, “It still helps to know that, *"Okay, hey, you’re growing hair on your face too. It’s not just me. It’s every girl’s problem."* I like that.” (P8)

The need for having resources to reach out to healthcare professionals on the application was also found to be useful: “*Telling me that, if you need help, here are some numbers or websites where you can read more information, talk to more people.*” (P8)

Designing for Positive and Smooth User-Experience

Participants identified several user-centered features to make the overall experience of using the app more positive and smoother. One participant did not like how their current period perceived the delay in their periods with negative symbolism:

> “*One thing I did not like was when it would just be like, your periods late for five days, or your period’s been late for 10 days. And I think that would just cause more stress because I'm like, I'm aware that my period's delayed…but if it's late, they'll have this gray bubble. And I know it's so silly, but this gray bubble feels like impending doom situation or something.”* (P9)

Instead of the negative symbolism, participants appreciated the idea of positive reminders and notifications, with one participant suggesting receiving messages with motivating text, such as, "*Don’t forget to exercise. You will get your periods soon" (*P8*).*

Additionally, a couple participants expressed not wanting to have too many features at the expense of the interface seeming congested. "*If I'm using the app, I don't want the app to have too many things. It should be straightforward for me… I don't use an app for all its features.*" (P7)

Personalization

Participants consistently emphasized the need for greater personalization in period tracking apps to better address their individual experiences with PCOS. Several participants highlighted the importance of tailoring the app experience to account for PCOS:

> *"[The application] doesn't recognize the fact that I have PCOD. Like, I have nowhere to put that in my app. So, every month, when I'm supposed to have my periods, it just asks me, "Did you forget to put in your periods?" And I'm just like, "No, I didn't forget.""* (P8)

Furthermore, they desired an application that could give more personalized solutions to account for the condition's variability. Some participants suggested involving an AI tool to improve the recommendations:

> *"A personalized AI tool that can help you give answers as per your cycle and pattern as it would know things about your PCOS specifically. [Rather] than just articles, because articles are quite general. And PCOS is something I'm sure varies from person to person, for some people it's too late, for some too early*." (P1)

Other participants highlighted the need to accommodate diverse symptoms of PCOS and give recommendations accordingly. "*I have insulin resistance PCOD. So what kind of exercise I would need to do compared to you would be different*." (P5) On a similar note, another participant highlighted the need to let the user add their own customizable symptoms that they can track regularly: "*[Since] I've gone through the diagnosis, I know what my symptoms are, right? So, if I enter that [symptoms], it asks me on its own through notifications [to track the symptoms]*." (P7)

Tools for Improved Meaning-Making

Participants were frustrated with the lack of tools to help them interpret logged data in the existing applications. They expressed a desire for apps that could provide insights into their condition, including a snapshot of their reproductive health at the end of their cycle: "*I wish it could just give some reviews after a month; during this time you were, like, going through this…so during ovulation, your this thing was worse, during PMS, this thing was worse. It would be easy if the app does this for me*." (P4)

Participants expressed a strong desire for actionable recommendations within menstrual-tracking apps to better manage their PCOS symptoms. While a lot of current period tracking applications have informational resources about female health, they rarely include PCOS as a topic of interest: "*It just does not have, like, articles about PCOS or PCOD or any health resources…[the information is] insightful but doesn't cover PCOS."* (P9)

A couple of participants noted how these applications could benefit from prompting users who show symptoms of PCOS to get some tests or see a gynecologist: *“Maybe [the app] can tell you something about getting a blood test…it would have been really nice to have more awareness around when to seek help… or when to…get yourself checked.”* (P10).

Actionable Advice for Management

Participants identified the need for menstrual tracking apps to provide actionable advice for managing PCOS-related challenges. The key identified areas in which they wanted recommendations and resources were pain, stress and diet management.

Pain being a prominent concern for most participants, a desire for apps to offer tools and exercises to alleviate discomfort was expressed by many. For instance, one participant mentioned wanting *"ways to get rid of the pain without medication and all of those things."* (P1). Another appreciated the existing features on their current application for relief from cramps and other symptoms: *"It also…links to feet rub exercises, massages, and it tells you what to do, how to relax yourself during periods, to deal with pain. Also, it has period pain relief videos, menstrual cramp relief videos, yoga exercises—all of that.” (P8)*

Participants appreciated apps that offered calming features to help mitigate stress, considering the role stress management plays in managing PCOS symptoms. One participant shared, *"This app also has videos and sounds in it. So, it’s like, ‘Hey, do you want to listen to some bird sounds in the forest and meditate?’—which is cool."* (P8).

Diet management also emerged as a critical area where participants sought guidance. Participants emphasized the importance of credible nutritional advice tailored to PCOS. One participant explained, *"General recommendation as to what you can do to manage it, like, how can you exercise? How can you change your diet? What foods you should eat? What vitamins do you need in your body?"* (P2). Additionally, participants also emphasized the need for reliable information amongst all the misinformation surrounding PCOS on the internet: *"I feel like, if you go on Instagram, you're like, oh, have this for PCOS, have that. And that's not really certified, and people shouldn't trust that."* (P9).

These suggested features reflect a desire for apps to empower users with actionable insights, empathetic community support, and comprehensive tracking systems. Incorporating these aspects into menstrual-tracking applications could transform them into more empowering tools for PCOS.

Overall, the emerged themes shed light on the multifaceted and personal experience of PCOS. Participants reported a wide range of symptoms and strategies employed to manage these symptoms, with a strong focus on weight management through diet and exercise. Furthermore, their dissatisfaction with the current apps and the barriers they face in managing their condition revealed several gaps in current provisions that warrant improvement. Finally, participants offered valuable suggestions for adapting current menstrual tracking applications for improved PCOS support, highlighting the important role end-users play in co-creation of effective solutions.

Phase 2: Value Specification

Drawing from the insights gained from the thematic analysis of the interviews, several values were identified to guide the redesign of the Flo app to cater to women with PCOS. Flo, a menstrual-tracking app founded in 2015, is currently being used by over 380 million users globally, offering features that enable users to track their cycles, monitor symptoms, and gain personalized health insights (Flo official website). The widespread adoption of this app highlights its demand and credibility in the FemTech space. Leveraging this established platform to introduce features that can better cater to individuals with PCOS can amplify the impact of these features, raise awareness and set a precedent for inclusivity in other menstrual-tracking applications.

The identified values to guide the redesign of Flo are: customized tracking for PCOS, personalization via chatbot, holistic self-tracking, awareness through articles and community, minimization of assumptions and design for increased empathy and engagement. These values address the specific needs and challenges faced by individuals with PCOS, providing a strong foundation for redesigning Flo.

Value 1: Customized Tracking for PCOS

As highlighted in the sub-theme *Improved Tracking Features*, participants expressed a need for an app experience specifically tailored for PCOS. Flo offers an option for users to indicate if they have PCOS during the onboarding. However, the experience of the app remains untailored even after opting for PCOS. To fill this gap and account for the suggestion of having a more holistic tracking system and maintaining a smooth user experience, the app can list common symptoms of PCOS as potential items users can track as well as allow users to add their own symptoms. Given the variability of PCOS, it would be up to the user to decide and select the

symptoms they wish to track. For instance, someone who mainly experiences pain and fatigue during periods, can customize their app to solely focus on tracking and providing insights on those symptoms. This would keep the app from pushing features the users are not interested in and keep the interface simple. Selecting PCOS as a condition should also modify other aspects of the app experience, as outlined in the subsequent values.

Value 2: Personalization via Chatbot

Participants desired personalized recommendations for their health and one of the suggested ways was using an AI chatbot as highlighted in the theme *Personalization*. This can be achieved using an AI chatbot that could provide insights based on logged data. Additionally, it can guide users who haven't specified PCOS to seek diagnosis if they display symptoms of PCOS. While Flo offers a chatbot feature, its functionality remains limited and untailored to women with PCOS, highlighting potential for improvement.

However, it’s important to acknowledge that AI can only serve as a tool and not replace healthcare professionals. Hence, the advice given by AI should be limited and direct the users to the relevant healthcare professional when necessary. Additionally, the app can also enhance personalization by generating monthly health snapshots summarizing insights, such as correlations between diet, exercise, and symptom improvement.

Value 3: Holistic Self-tracking

As discussed under the sub-theme 'Improved Tracking Features,' PCOS management goes beyond menstrual tracking, and participants expressed a need for tools to track a broader

range of symptoms and lifestyle factors. The app should allow users to track various aspects such as diet, exercise, flow, medication, fatigue levels, pain intensity, and emotional well-being.

Flo already covers tracking of medication and emotional well-being. However, it can benefit from diet tracking, especially in a PCOS-oriented manner. This tracking could include not just tracking for calories but going beyond it and nudging the users to include micro and macro-nutrients beneficial for PCOS. The app could also provide tracking for intensity and type of pain as well as the level of fatigue experienced by the user, areas which are currently completely missing in Flo. Additionally, the app could be linked to fitness and meditation apps like FitBit and Calm to provide an integrated health perspective.

Flo does not allow users to log interruptions in their menstrual flow, which was a common occurrence for some participants. If there's a one-day gap in bleeding, the app mistakenly counts it as the start of a new cycle. To better accommodate irregular flow patterns, the app should offer more flexible tracking. This would include letting users record breaks in their flow during a period and also allowing them to log varying levels of flow intensity.

Value 4: Awareness through Articles and Community

As noted previously, one of the most common barriers to effective PCOS management is the lack of awareness and prevalence of misinformation. To address this, the Flo app could include short, readable articles on PCOS, developed in collaboration with healthcare professionals. While Flo currently offers a variety of articles on reproductive health, these are primarily designed for abled menstruating individuals and lack sufficient focus on hormonal

disorders. Hence, it could include evidence-based articles offering knowledge on PCOS as well as actionable insights such as advice on pain, stress and lifestyle management.

As noted in the theme, *Management Strategies*, participants often acquired advice on PCOS from the community, whether online or offline. Recognizing the value of community, discussion forums where users can share their experiences and seek advice from other users with PCOS can be helpful in fostering awareness as well as empathy. These forums could be moderated to ensure a safe, supportive space for users, avoiding misinformation or triggering content.

Value 5: Minimization of Assumptions

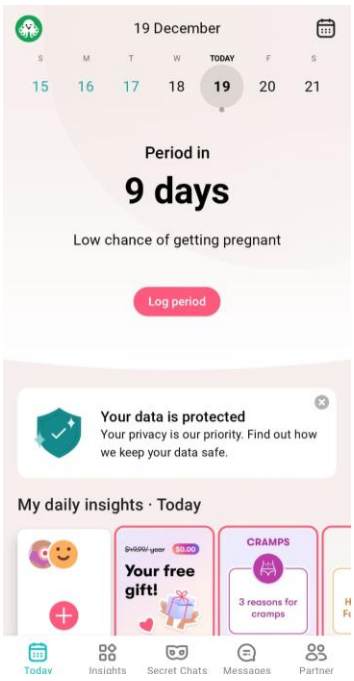
Participants repeatedly expressed frustration with the emphasis and assumptions around pregnancy and sex in menstrual tracking apps as highlighted in the theme, *Limitation of Menstrual Tracking Apps.* For example, Flo asks users during onboarding whether they are looking to conceive. However, its recommendations for every phase of the cycle are still catered to the possibility of getting pregnant, even if the participants have deselected pregnancy as a goal (see Figure 2). Instead of this, the app can, for instance, suggest what a participant can do to optimize their health during a particular phase. On a similar note, if a period is late, Flo often implies pregnancy as a possibility. Instead, the app could consider a broader range of reasons for a delayed period, such as menopause, endometriosis, menarche, or PCOS.

Furthermore, if Flo is customizing for PCOS (see Value 1), the app should shift the focus from cycle prediction to self-knowledge, acknowledging the irregularity of the user's cycle. This could mean changing the verbatim on the home screen to "Period in 9 days" (see Figure 2) to simply

showing the date of the last logged period. This would give the user the agency to make a more intuitive and informed decision about their cycle.

Figure 2

Home screen of Flo



Value 6: Design for Increased Engagement and Empathy

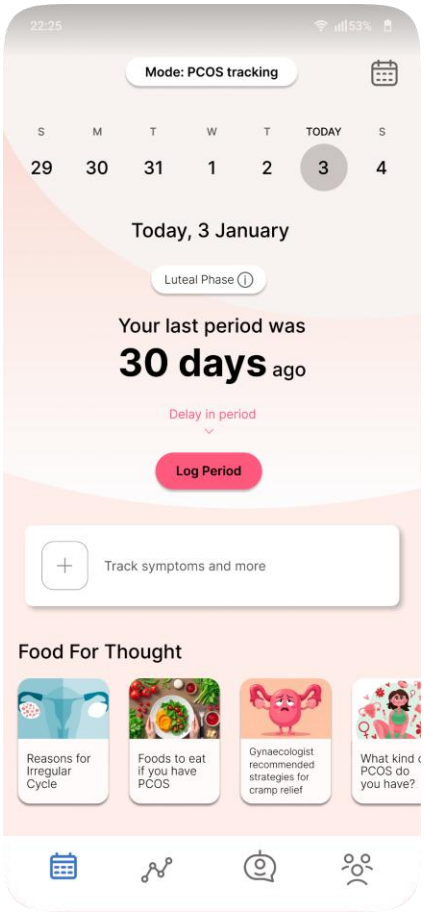
Lack of consistency in maintaining a healthy routine was identified as a management barrier. To support consistency, the app could have gamified elements to encourage tracking and management, such as badges for logging symptoms consistently or completing lifestyle challenges (e.g., hitting the micronutrient requirement of the week).

Furthermore, participants valued empathy and motivational messages as highlighted in the sub-theme *Designing for Positive and Smooth User-Experience*. To reflect this, the app's

tone should be empathetic and supportive, avoiding negative or stress-inducing language. Furthermore, incorporating motivational messages, like: “I know today was hard, but congratulations for walking 2000 steps regardless!” could encourage behavior change.

Figure 3

Redesign of Flo Home screen



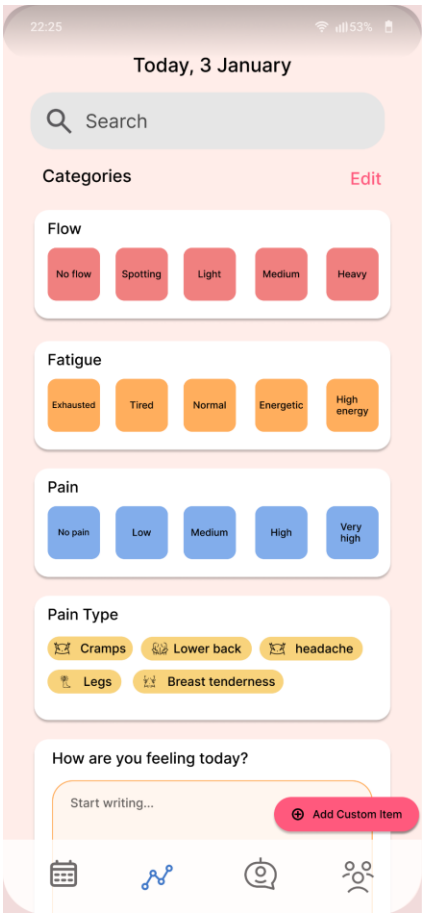
Phase 3: Design

In the design phase, the insights and values established in the value specification phase are used to inform design of the application. In this study, Figma was used as the design tool to develop four prototype screens that reimagined the interface of the Flo app and integrated some of the emerged design recommendations described in the value specification phase.

Firstly, the homescreen of the Flo app was redesigned to emphasise the date of the last period instead of predicting the next period (see Figure 3). This change aims to provide a more realistic and less stressful approach for users with irregular cycles. Users can use the information presented on the screen and make their own assumption about their period. The screen also includes a more prominent and intuitive tracking button, replacing the ambiguous one in the

Figure 4

Improved Holistic Tracking



original app (see Figure 2), to prompt users to log their symptoms. Additional features include curated articles on PCOS and a button that provides information on the user's current phase in the menstrual cycle (e.g., luteal phase), offering more holistic insights into the menstrual cycle.

Next, the value of holistic self-tracking influenced the redesign of the tracking screen to introduce features such as note-taking, tracking the intensity and type of pain, fatigue levels, and blood flow (see Figure 4). It also includes an “Add Custom Category” feature, that allows users to personalize their tracking by selecting categories or symptoms most relevant for them.

Figure 5

AI chatbot “Flower”

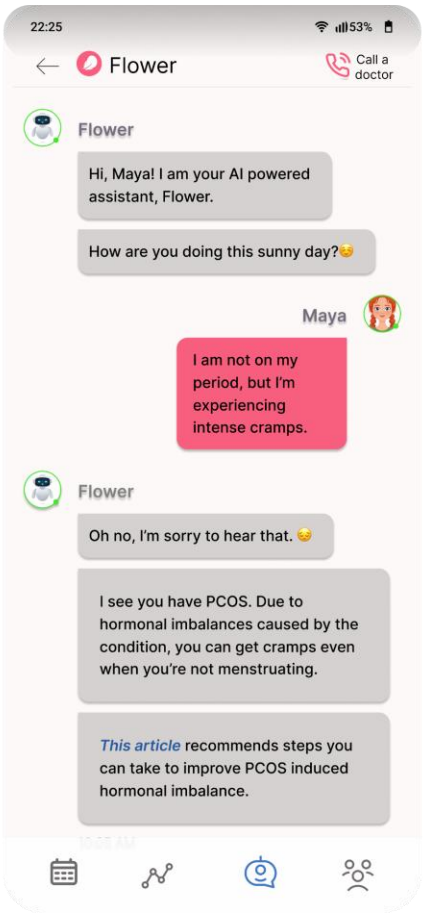
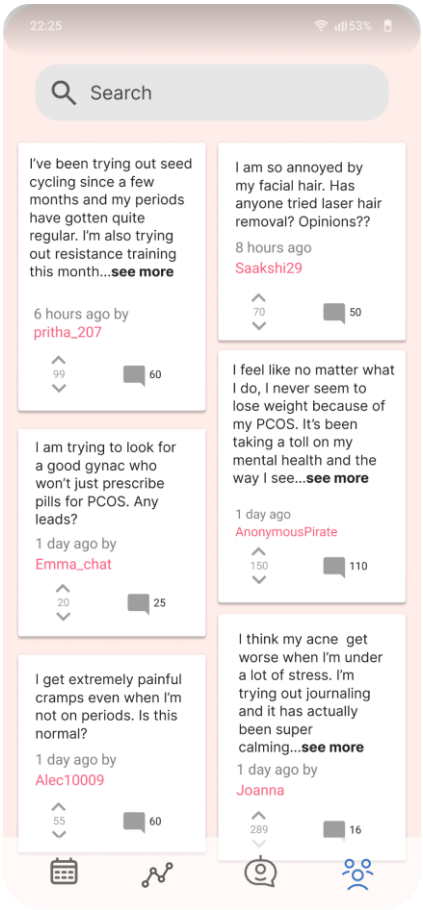


Figure 6

Discussion Forum



To demonstrate the value of personalization, an AI chatbot named "Flower," was added to replace Flo's original health assistant (see Figure 5). The chatbot incorporates tailored advice for PCOS, maintains a positive and empathetic tone, and offers users the option to contact healthcare professionals for specialized support.

Finally, a discussion forum where users with PCOS can interact and share their experiences was designed (see Figure 6). This forum aims to foster peer-to-peer learning, validation of experiences and empathy among users managing similar challenges.

Overall, the design phase demonstrates the potential of enhancing the design of Flo by introducing new features and reimagining its current interface to make it more effective and inclusive for individuals with PCOS. By revamping the home screen, improving the tracking system and AI assistant and introducing a discussion forum, the updated app provides better support for those managing PCOS.

Discussion

This study employed a qualitative research design guided by the CEHRES roadmap (Van Gemert-Pijnen et al., 2011) to investigate how menstrual-tracking apps can be adapted to better serve individuals with PCOS. The first phase involved conducting semi-structured interviews with 10 participants diagnosed with PCOS to identify their needs, challenges with existing apps and desired features for enhancing their functionality. Thematic analysis revealed five primary themes: management strategies, barriers to management, limitations of current apps, features for empowering PCOS management, and features for improved meaning-making. These themes guided the value specification phase and the redesign of Flo using Figma, demonstrating the proposed design recommendations. The main findings and their implications are discussed in the subsequent sections.

Main Findings and Recommendations

To redesign menstrual-tracking apps to be more inclusive for individuals with PCOS *(RQ-a),* several key areas of improvement emerged from the research. Firstly, participants highlighted the importance of tailoring period-tracking apps to account for PCOS, confirming the necessity of designing apps that accommodate bodies and experiences that deviate from standard

norms (Corbin, 2017). The proposed value to reflect this included incorporating the option to specify PCOS as a condition during the onboarding process or setting it as a health goal.

Secondly, participants expressed dissatisfaction with the apps' reliance on assumptions about cycle regularity. One suggested way to address this was by shifting the focus of the app away from assuming a pattern and providing predictions. Instead, the app could focus on presenting records about past menstruation, empowering users to interpret and reflect on their data. This aligns with Fox and colleagues (2020) previously mentioned suggestion that rather than offering definitive predictions and quantification, period-tracking apps could embrace uncertainty and dimensionality, allowing users to interpret and contextualize their data. Additionally, reducing focus on predictions would help the user avoid the negative emotional experience of not getting the predicted cycle outcome, which can potentially affect the user's self-confidence (Schneider et al., 2019).

Furthermore, the participants were frustrated about the apps' assumption of their interest in conception. The suggested value was to alter the app's verbatim and recommendations to account for a diverse range of goals beyond pregnancy also advocated by Fox and colleagues (2020). This is especially important for women with PCOS who often face infertility challenges and as a consequence, might feel alienated (Tylstedt, 2023).

Instead of focusing on fertility, the app can adopt a holistic approach to reproductive health by providing insights into various phases of the menstrual cycle and integrating holistic tracking of various aspects including detailed tracking of diet, exercise, flow, medication, fatigue, type and intensity of pain as well as emotional well-being. Additionally, integrating with other health apps could provide users with more comprehensive insights, enabling a seamless connection between various aspects of their health data. This is in line with Fox and colleagues'

(2020) emphasis on centering period tracking on self-knowledge rather than solely fertility. By enabling comprehensive tracking of symptoms, the app can encourage self-discovery, and reflection processes, empowering users to make more informed decisions about their health (Chopra et al, 2021).

To improve PCOS symptom management in a menstrual-tracking app *(RQ-b)*, the findings highlighted the need for extensive customization and improved meaning-making features. Some participants suggested granting the user the ability to select and track symptoms relevant to their unique experiences, including diet, pain, flow, fatigue, emotional well-being, and exercise. This flexibility can potentially reduce tracking fatigue and enhance user engagement over time (Kim et al., 2017). Selecting preferred tracking features also facilitates the generation of clinically relevant reports, which can improve consultations with healthcare providers (Luo et al., 2019).

Some participants suggested the adoption of an AI chatbot to provide personalized advice and recommendations. Interestingly, AI chatbots have proven to be a useful tool to investigate behavioral change and enhance users' health in mHealth technologies due to the intuitive, user-friendly interfaces and real-time recommendations tailored to individual needs (Fadhil & Gabrielli, 2017). As such, an AI chatbot could be a valuable tool for promoting behavioral change and addressing the key barrier of maintaining consistency in managing PCOS symptoms. However, given the complexities of PCOS, a hybrid approach combining chatbot automation with human intervention is ideal as advocated by Fadhil and Gabrielli (2017). For instance, while a chatbot might provide basic symptom summaries and general advice, it should also facilitate connecting directly with healthcare professionals for more nuanced support.

Notably, most participants expressed dissatisfaction with their current healthcare professionals due to inadequate understanding and support. Most menstrual tracking apps overlook this by failing to include features that offer direct access to medical professionals as a form of intervention (Eschler et al., 2019). Incorporating contact details of competent healthcare providers could significantly improve management and the tools available to the users.

The study revealed that participants often faced challenges with limited understanding and trust in PCOS-related information available online or through healthcare professionals. This finding aligns with Boyle et al.'s (2018) research, which highlights the scarcity of high-quality, reliable information sources on PCOS. Participants frequently turned to social media platforms like Reddit, Instagram influencers, and peer discussions for advice. However, they noted that these platforms often contain significant misinformation, a concern echoed by Malki et al. (2024), who underscore the prevalence of inaccurate information about women’s health online.

The study revealed that participants often struggled with limited understanding and trust in PCOS-related information available online or via their healthcare professionals. This finding is in line with Boyle and colleagues' (2018) research which reveal the limited availability of PCOS-related information sources that offer high-quality information (Boyle et al., 2018). The participants in the current study, instead, turn to social media platforms like Reddit, Instagram influencers, and peer discussions for advice. However, they noted how these sources are often plagued with misinformation, a concern echoed by Malki and colleagues (2024) who note the prevalence of misinformation about women’s health online.

To address this barrier, offering articles on PCOS co-created with trusted healthcare professionals could help enhance users' understanding and trust in the information provided

(Malki et al., 2024). Research has also demonstrated how individuals benefit from online support groups, particularly those that provide anonymity, where they can discuss stigmatized topics such as sexuality, menopause, and mental health (Chopra et al., 2021l). Based on these insights, introducing an online support group or discussion forum within the menstrual-tracking app could be highly beneficial to support emotional and informational needs, especially with an added option to maintain anonymity and privacy.

The final critical finding to support management of PCOS was the significance of empathy and motivational messaging for participants. Motivational and positively reinforcing messages have been shown to significantly improve user engagement and adherence to health recommendations, especially in the case of chronic disease management (Sittig et al., 2020). Furthermore, research on doctor-patient interactions has shown that empathetic validation and emotionally supportive communication lead to better adherence and long-term health improvements (Tietbohl, 2021; Heyn et al., 2021). Drawing from these insights, incorporating similar reinforcing and empathetic messages tailored to individuals with PCOS could help them sustain self-management. This could include messages encouraging balanced nutrition or affirming users' progress.

Overall, to make menstrual tracking more inclusive for women with PCOS, the findings highlight the significance for features like minimization of assumptions around cycle regularity and user goals, shifting away the focus from predictive features, and holistic tracking of symptoms. Furthermore, to aid management of PCOS symptoms, the research emphasizes the need for customized tracking, personalization using AI, access to informational and healthcare resources, discussion forums and motivational messages to support self-management.

Theoretical Implications

By offering recommendations for adapting menstrual-tracking applications to be more inclusive to women with PCOS, this study makes a significant contribution to feminist HCI by advocating for inclusivity and diversity, principles central to Almeida and colleagues' (2020) woman-centered approach. Addressing the needs of women with PCOS aligns closely with Keyes and colleagues' (2020) feminist approach of challenging dominant assumptions and accommodating underrepresented perspectives in technologies. Furthermore, this focus on individuals with PCOS also exemplifies "designing for the margins," fostering empowerment and validating the diverse lived experiences of women who are often overlooked in FemTech development (Bardzell, 2020).

The suggestion of minimization of assumptions while designing these technologies is in line with Balfour's (2023) critique of menstrual-tracking applications as vessels of biopower, perpetuating societal norms of "regular" cycles. By advocating for features like minimizing assumptions about the user's goals and cycle regularity as well as shifting focus to increased self-knowledge, the findings offer alternate ways to relate to the technology in a manner that doesn't encourage users to conform to reproductive health norms. This approach facilitates users to connect with their body and validates their unique journey, thereby reframing period-tracking technologies as tools for empowerment rather than surveillance.

Furthermore, incorporating holistic tracking of symptoms such as pain, fatigue, and emotions, supports Fox and colleagues (2020) call for multiplicity and dimensionality in designing menstrual-tracking applications. Allowing users to decide which symptoms to track and how to contextualize their data challenges the traditional role of self-tracking technologies as

mere tools for analytics and predictions. Instead, the research urges menstrual-tracking apps to shift the focus to capturing the complexity of users' lived experiences and foster contextual understanding of their health data (Lupton, 2016).

Finally, by involving the end users in the design process, the study underscores the value of co-creating solutions with end users to address nuanced barriers and priorities in FemTech (Almeida et al., 2020). This method ensures that lived experiences and user needs are central to the development of health technologies, fostering solutions that resonate deeply with diverse communities.

Practical implications

The implementation of this study's findings and design recommendations into a popular menstrual-tracking app like Flo can have profound practical implications. A primary outcome is an opportunity to make menstrual-tracking apps more relevant and inclusive for women with health challenges. By accounting for conditions like PCOS and incorporating features such as empathetic messages, discussion forums, and holistic tracking tools, menstrual-tracking applications can better serve the users in self-management of their symptoms by improving their self-knowledge and fostering greater connection and empowerment. This implementation can also improve healthcare experiences by providing clinicians with detailed, user-generated records of symptoms like pain, fatigue, flow, diet, emotional well-being, allowing for more efficient care during consultations.

Additionally, adaption of period-tracking apps to cater to PCOS can help bridge the gap identified in the lack of accessible, high-quality information and self-management resources for

PCOS (Boyle et al., 2018). Furthermore, by offering educational content and raising awareness about diagnostic criteria of PCOS, these apps can avoid delays in diagnosis in young users. Early awareness can lead to improved health management and limit long-term symptoms (Garad & Teede, 2020). Additionally, features that normalize conversations about PCOS and other hormonal conditions contribute to destigmatizing female health, fostering a more supportive environment for users navigating these challenges (Pichon et al., 2022).

Beyond individual benefits, the research sets a precedent for practitioners, designers and developers to move beyond normative assumptions in the design of period-tracking tools and acknowledge perspectives and goals of all kinds of menstruators including those who are lactating, pregnant, have diverse health conditions or going through menarche or menopause. Such inclusivity can also extend beyond period-tracking technologies and inspire other self-tracking technologies to address a broader range of experiences.

Limitations and Future Work

The study has three primary limitations. Firstly, all participants were South Asian and from Urban India, which can make the findings of the study less generalizable. One reason for this is that the manifestations of PCOS differ from one ethnic group to another (Sendur & Yildiz, 2021). For instance, Indigenous Australian women with PCOS are more obese and insulin resistant than other ethnic groups, while South Asian women are more hirsute (Sendur & Yildiz, 2021). Additionally, this sample would also lead to a cultural bias as cultural factors can significantly influence self-monitoring behaviors, including self-tracking practices (Gudykunst et al., 1987). For instance, individuals from individualist cultures, such as those in North America,

may exhibit higher self-monitoring tendencies compared to those from collectivist cultures like East Asia (Gudykunst et al., 1987).

Secondly, relying solely on a qualitative approach, such as interviews, while ensuring depth of the collected data, limits its scope. A mixed-methods approach, combining surveys, observational studies, usability testing and interviews can provide a more comprehensive understanding of user behaviors and needs. Research on mHealth supports the value of mixed methods, particularly the Iterative Convergent Mixed Methods Design approach, which integrates qualitative and quantitative data collection by emphasizing qualitative insights in the early development phases, followed by more quantitative driven evaluations (Alwashmi et al., 2019). Incorporating quantitative data collection in this manner would ensure that the redesigned period-tracking app not only meets the needs of the initial participants, but also caters to a wider audience, thereby ensuring that the solution is effective, efficient and satisfactory for a larger user base.

Finally, due to time constraints, the continuous evaluation aspect of CEHRES roadmap (Van Gemert-Pijnen et al., 2011), which included iterative cycles of collection of user feedback and refinement of prototype based on that, was not included. This iterative cycle is an important aspect of the design process to ensure high standards of functionality and usability are maintained and user needs are met (Alwashmi et al., 2019; Van Gemert-Pijnen et al., 2011). Additionally, the design phase was restricted to developing a few prototype screens and did not include detailed functionalities, workflows, or user experience elements.

Beyond addressing the limitations of the current study, future research on menstrual tracking apps could expand its scope to accommodate a diverse range of experiences such as

endometriosis, menarche and menopause. For instance, women going through menopausal transition may experience disruption in the regular cycle and other physiological changes, which these apps could help track and provide better understanding for (Pichon et al., 2022).

Furthermore, since menstrual tracking applications frequently cater to cisgender, heterosexual women (Fox et al., 2020), their design, inadvertently, excludes non-binary, transgender, or queer individuals (Polo et al., 2023). Transgender women, for example, while not experiencing menstruation, might still encounter menstrual symptoms such as bloating, food cravings and mood swings, often referred to as “bloodless period” (Lowik, 2020). To accommodate for their experience, a period-tracking app can be used to affirm and track their symptoms.

In this way, menstrual-tracking technologies can expand their scope beyond bleeding and ovulation to serve as a tool that can validate and monitor diverse bodily experiences, including those of non-menstruators. Incorporating these perspectives in future research would not only make these technologies more inclusive but also ensure they represent the needs of marginalized groups.

Future research could also benefit from the involvement of key stakeholders such as healthcare professionals, app developers, and technology owners. Healthcare professionals could ensure that menstrual tracking apps are incorporating evidence-based features. Conversely, app developers and technology owners could provide insights into technological feasibility and market value. This holistic stakeholder perspective could inform the design and implementation of more effective and user-friendly menstrual tracking applications, ensuring alignment with clinical standards and technological capabilities.

Conclusion

By integrating principles of woman-centered design and CEHRES roadmap, this study provides valuable insights to understand how to modify menstrual-tracking technologies to better address the needs of women with PCOS. The findings reveal the need for features like personalization, improved and nuanced tracking, discussion forums, reduced assumptions and personalization, which challenge the traditional role of menstrual-tracking technologies as simply being vessels to present analytics and predictions. Instead, these features reimagine such technologies as tools for self-management, self-reflection and personal meaning-making. The study highlights the potential of menstrual-tracking apps to empower, validate, and cater to the needs of diverse menstruators and contribute to the growing body of feminist HCI by challenging dominant assumptions within it. By representing the experiences of marginalized groups, FemTech and other mHealth technologies can play a transformative role in supporting and affirming diverse experiences, ultimately contributing to the development of a more inclusive digital health system.

References

Alwashmi Meshari F and Hawboldt, J. and D. E. and F. M. D. (2019). The Iterative Convergent Design for Mobile Health Usability Testing: Mixed Methods Approach. *JMIR Mhealth Uhealth*, *7*(4), e11656. https://doi.org/10.2196/11656

Almeida, T., Balaam, M., & Comber, R. (2020). Woman-centered design through humanity, activism, and inclusion. *ACM Transactions on Computer-Human Interaction*, *27*(4). https://doi.org/10.1145/3397176

Balfour, L. (2023). FemTech: Intersectional Interventions in Women's Digital Health. In *FemTech: Intersectional Interventions in Women's Digital Health*. Springer Singapore. https://doi.org/10.1007/978-981-99-5605-0

Bardzell S.(2010). Feminist HCI: taking stock and outlining an agenda for design. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*; 2018 Apr 20; New York, NY: ACM; 2010: 1301–10. doi: 10.1145/1753326.1753521.

Bennett, C. L., & Rosner, D. K. (2019, May 2). The promise of empathy: Design, disability, and knowing the "other." *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3290605.3300528

Beratarrechea, A., Lee, A. G., Willner, J. M., Jahangir, E., Ciapponi, A., & Rubinstein, A. (2014). The Impact of Mobile Health Interventions on Chronic Disease Outcomes in Developing Countries: A Systematic Review. *Telemedicine and E-Health*, *20*(1), 75–82. https://doi.org/10.1089/tmj.2012.0328

Boyle, J. A., Xu, R., Gilbert, E., Kuczynska-Burggraf, M., Tan, B., Teede, H., Vincent, A., & Gibson-Helm, M. (2018). Ask PCOS: Identifying Need to Inform Evidence-Based App Development for Polycystic Ovary Syndrome. *Seminars in Reproductive Medicine*, *36*(1), 59–65. https://doi.org/10.1055/s-0038-1667187

Bhat, K. S., & Kumar, N. (2020). Sociocultural Dimensions of Tracking Health and Taking Care. *Proceedings of the ACM on Human-Computer Interaction*, *4*(CSCW2). https://doi.org/10.1145/3415200

Luo, Y., Liu, P., & Choe, E. K. (2019, May 2). Co-designing food trackers with dietitians: Identifying design opportunities for food tracker customization. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3290605.3300822

Corbin, B. (2020). Digital Micro-Aggressions and Discrimination: FemTech and the "Othering" of Women. *SSRN Electronic Journal*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3630435

De Stefano, A. D., & Müller, T. (2021). *The Rise of Femtech: An analysis of the Femtech industry and its female entrepreneurs' experiences*. CBS Research Portal.

Dorthe Brogård Kristensen, & Carolin Prigge. (2017). Self-tracking: Empirical and philosophical investigations. In *Self-Tracking: Empirical and Philosophical Investigations*. Springer International Publishing. https://doi.org/10.1007/978-3-319-65379-2

Duhaime-Ross, A. (2014, September 25). Apple promised an expansive health app, so why can't I track menstruation? *The Verge*. https://www.theverge.com/2014/9/25/6844021/apple-promised-an-expansive-health-app-so-why-cant-i-track

Ee, C., Pirotta, S., Mousa, A., Moran, L., & Lim, S. (2021). Providing lifestyle advice to women with PCOS: an overview of practical issues affecting success. In *BMC Endocrine Disorders* (Vol. 21, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s12902-021-00890-8

Epstein, D. A., Lee, N. B., Kang, J. H., Agapie, E., Schroeder, J., Pina, L. R., Fogarty, J., Kientz, J. A., & Munson, S. A. (2017). Examining menstrual tracking to inform the design of personal informatics tools. *Conference on Human Factors in Computing Systems - Proceedings*, *2017-May*, 6876–6888. https://doi.org/10.1145/3025453.3025635

Eschler, J., Menking, A., Fox, S., & Backonja, U. (2019). Defining Menstrual Literacy with the Aim of Evaluating Mobile Menstrual Tracking Applications. *CIN - Computers Informatics Nursing*, *37*(12), 638–646. https://doi.org/10.1097/CIN.0000000000000559

Fadhil, A., & Gabrielli, S. (2017). *Addressing challenges in promoting healthy lifestyles: the al-chatbot approach*. 261–265. https://doi.org/10.1145/3154862.3154914

Flo. Flo health . (n.d.). https://flo.health/

Fox, S. E., Menking, A., Eschler, J., & Backonja, U. (2020). Multiples over models: Interrogating the past and collectively reimagining the future of menstrual sensemaking. *ACM Transactions on Computer-Human Interaction*, *27*(4). https://doi.org/10.1145/3397178

Frias-Toral, E., Garcia-Velasquez, E., de los Angeles Carignano, M., Rodríguez-Veintimilla, D., Alvarado-Aguilera, I., & Bautista-Litardo, N. (2021). Polycystic ovary syndrome and obesity: clinical aspects and nutritional management. *Minerva endocrinology*

Gallant, M. P. (2003). The influence of social support on chronic illness self-management: A review and directions for research. In *Health Education and Behavior* (Vol. 30, Issue 2, pp. 170–195). https://doi.org/10.1177/1090198102251030

Garad, R. M., & Teede, H. J. (2020). Polycystic ovary syndrome: improving policies, awareness, and clinical care. *Current Opinion in Endocrine and Metabolic Research*, *12*, 112–118. https://doi.org/https://doi.org/10.1016/j.coemr.2020.04.007

Gudykunst, W. B., Yang, S. M., & Nishida, T. (1987). Cultural differences in self-consciousness and self-monitoring. *Communication Research,* 14(1), 7-34

Heyn, L. G., Løkkeberg, S. T., Ellington, L., van Dulmen, S., & Eide, H. (2023). Understanding the role of positive emotions in healthcare communication – A realist review. In *Nursing Open* (Vol. 10, Issue 6, pp. 3447–3459). John Wiley and Sons Inc. https://doi.org/10.1002/nop2.1604

Kazemi, M., Pierson, R. A., McBreairty, L. E., Chilibeck, P. D., Zello, G. A., & Chizen, D. R. (2020). A randomized controlled trial of a lifestyle intervention with longitudinal follow-up on ovarian dysmorphology in women with polycystic ovary syndrome. *Clinical Endocrinology*, *92*(6), 525–535. https://doi.org/10.1111/cen.14179

Keyes, O., Peil, B., Williams, R. M., & Spiel, K. (2020). Reimagining (women's) health: HCI, gender and essentialised embodiment. *ACM Transactions on Computer-Human Interaction*, *27*(4). https://doi.org/10.1145/3404218Kim, Y.-H., Jeon, J. H., Lee, B., Choe, E. K., & Seo, J. (2017). OmniTrack. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *1*(3), 1–28. https://doi.org/10.1145/3130930

Lowik, A. (2020). “Just because I don’t bleed, doesn’t mean I don’t go through it”: Expanding knowledge on trans and non-binary menstruators. *International Journal of Transgender Health*, *22*(1–2), 113–125. https://doi.org/10.1080/15532739.2020.1819507

Luo, Y., Liu, P., & Choe, E. K. (2019, May 2). Co-designing food trackers with dietitians: Identifying design opportunities for food tracker customization. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3290605.3300822Lupton, D. (2015). Quantified sex: a critical analysis of sexual and reproductive self-tracking using apps. *Culture, Health and Sexuality*, *17*(4), 440–453. https://doi.org/10.1080/13691058.2014.920528

Lupton, D. (2016). The diverse domains of quantified selves: self-tracking modes and dataveillance. *Economy and Society*, *45*(1), 101–122. https://doi.org/10.1080/03085147.2016.1143726

Malki, L. M., Patel, D., & Singh, A. (2024). “The Headline Was So Wild That I Had To Check”: An Exploration of Women’s Encounters With Health Misinformation on Social Media. *Proceedings of the ACM on Human-Computer Interaction*, *8*(CSCW1). https://doi.org/10.1145/3637405

Mehregany, M., & Saldivar, E. (2020). Opportunities and obstacles in the adoption of MHealth. In *HIMSS Publishing eBooks* (pp. 7–20). https://doi.org/10.4324/9780367648008-2

McBain, H., Shipley, M., & Newman, S. (2015). The impact of self-monitoring in chronic illness on healthcare utilisation: A systematic review of reviews. In *BMC Health Services Research* (Vol. 15, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s12913-015-1221-5

Pichon, A., Jackman, K. B., Winkler, I. T., Bobel, C., & Elhadad, N. (2022). The messiness of the menstruator: assessing personas and functionalities of menstrual tracking apps. In *Journal of the American Medical Informatics Association* (Vol. 29, Issue 2, pp. 385–399). Oxford University Press. https://doi.org/10.1093/jamia/ocab212

Polo, I. M., Quijano, P. R., Domínguez, L. M., Zistecatl, X. R., & Doniz, N. F. (2023). My body is mine: menstrual apps and the sociotechnical normalization of gender. *Sexualidad, Salud y Sociedad (Rio de Janeiro)*, *39*. https://doi.org/10.1590/1984-6487.sess.2023.39.e22305.a.en

Schneider, H., Wayrauther, J., Hassib, M., & Butz, A. (2019, May 2). Communicating uncertainty in fertility prognosis. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3290605.3300391

Selke (Ed), S. (2016). Lifelogging Digital self-tracking and Lifelogging-between disruptive technology and cultural transformation.

Sendur, S. N., & Yildiz, B. O. (2021). Influence of ethnicity on different aspects of polycystic ovary syndrome: a systematic review. In *Reproductive BioMedicine Online* (Vol. 42, Issue 4, pp. 799–818). Elsevier Ltd. https://doi.org/10.1016/j.rbmo.2020.12.006

Sysling, F. (2020). Measurement, self-tracking and the history of science: An introduction. *History of Science*, *58*(2), 103–116. https://doi.org/10.1177/0073275319865830

Teede, H., Tay, C. T., Laven, J. S. E., Dokras, A., Moran, L. J., Piltonen, T., Costello, M. F., Boivin, J., Redman, L., Boyle, J., Norman, R., Mousa, A., Joham, A., & International PCOS Network*, . (2023). International Evidence-based Guideline for the Assessment and Management of Polycystic Ovary Syndrome 2023 (Version 1). Monash University. https://doi.org/10.26180/24003834.v1

Tietbohl, C. K. (2022). Empathic Validation in Physician–Patient Communication: An Approach to Conveying Empathy for Problems With Uncertain Solutions. *Qualitative Health Research*, *32*(3), 413–425. https://doi.org/10.1177/10497323211056312

Tylstedt, B., Normark, M., & Eklund, L. (2023). Reimagining the cycle: interaction in self-tracking period apps and menstrual empowerment. *Frontiers in Computer Science*, *5*. https://doi.org/10.3389/fcomp.2023.1166210

Unfer, V., Kandaraki, E., Pkhaladze, L., Roseff, S., Vazquez-Levin, M. H., Laganà, A. S., Shiao-Yng, C., Yap-Garcia, M. I. M., Greene, N. D. E., Soulage, C. O., Bevilacqua, A., Benvenga, S., Barbaro, D., Pintaudi, B., Wdowiak, A., Aragona, C., Kamenov, Z., Appetecchia, M., Porcaro, G., … Nestler, J. (2024). When one size does not fit all: Reconsidering PCOS etiology, diagnosis, clinical subgroups, and subgroup-specific treatments. In Endocrine and Metabolic Science (Vol. 14). Elsevier B.V. https://doi.org/10.1016/j.endmts.2024.100159 ‘

Van Gemert-Pijnen, J. E., Nijland, N., van Limburg, M., Ossebaard, H. C., Kelders, S. M., Eysenbach, G., & Seydel, E. R. (2011). A holistic framework to improve the uptake and impact of eHealth technologies. *Journal of Medical Internet Research*, *13*(4): e111.

Do PCOD and PCOS mean the same thing or are they different. (2022, May 30). UNICEF India. https://www.unicef.org/india/stories/do-pcod-and-pcos-mean-same-thing-or-are-they-different

World Health Organization: WHO & World Health Organization: WHO. (2023a, June 28). *Polycystic ovary syndrome*. https://www.who.int/news-room/fact-sheets/detail/polycystic-ovary-syndrome

Appendix A

Interview Guide

PCOS

1. When did you get diagnosed with PCOS?
2. Why did you go for a diagnosis in the first place? / What kind of symptoms do you have?
3. Which symptom affects your daily life the most?
4. How does PCOS affect your mental health?
5. Do you take any steps to manage your symptoms? (if not, then why?)
6. How is your cycle?
7. Do you use any application to help with your symptoms? (sleep tracker, fitness trackers)

Menstrual tracking apps

1. What menstrual tracking application do you use?
2. How regularly do you use this application?
3. What kind of things do you track on it?
4. What features do you like about the menstrual tracking application you use?
5. What do you not like about the menstrual tracking application you use/ pain points?
6. As someone with PCOS, do you think it caters to your needs? Why/why not?
7. Since PCOS often causes irregular cycles, how does this impact your use of period tracking apps?

Modification

1. If there is an application specifically for managing symptoms of PCOS, what kind of features would you want it to have?

2. What would you like to track on it?
3. Would you like more detailed insights on how hormones fluctuate with PCOS and how that impacts your body?
4. Do you regularly consult with healthcare professionals for your PCOS? Would you find it helpful if the app could generate reports or logs that you could share with your doctor?
5. How important is community support for you (e.g., forums, discussion groups with other women with PCOS)?

Appendix B

Informed Consent Form

Researcher

Kashish Kukreja

Tilburg School of Digital Sciences and Humanities, Tilburg University

Signature

By signing this informed consent form, you voluntarily agree to participate in this study. Signing this form does not interfere with your right to withdraw from this study at any time without an explanation. By signing this informed consent form, I (the participant) confirm that I have read and understood the entire information letter and confirm that:

○ I have been given the opportunity to ask questions about the study and that these questions were answered to my complete satisfaction.

○ I had sufficient time to decide whether I would participate or not.

○ I know that participation is completely voluntary.

○ I know that the duration of the study is 45 minutes

○ I know I can decide to withdraw from the study at any time, without any negative consequences and without providing any explanation.

○ [For personal data] I know I have the right, in principle, to request access to and rectify, erase, restrict or object to the processing of my personal data.

○ I know that my research data will be processed as described in the information letter and only the researcher team has access to this data.

○ I give permission to use my research data for the purposes that are mentioned in the information letter that belongs to this study.

○ I give permission to store my research data for the period of 10 years. I hereby voluntarily agree to participate in the study.

Name participant:

Signature:

Date :

To be completed by the researcher(s): I hereby declare that I have fully informed the above-mentioned participant about this study.

Name researcher:

Signature:

Date :

Appendix C

Codebook

Theme	Meaning	Sub-theme	Sub-theme	Example
Barriers to PCOS Management	Challenges faced by participants to manage their symptoms of PCOS.	consistency		"It [diet] always needed to be so proper…Living alone by myself in a foreign country, it wasn't something that I could stick to like rigorously. And so while I did try to do it for about three months, I never noticed any difference. And I just kind of stopped when it didn't give me the results that I was hoping for." (P3)
		incompetent healthcare		"All the gynecologists in India have just one thing to say about it, lose weight, lose weight and lose weight… it's not something that you need a doctor telling you when you're looking for a sustainable solution." (P3)
		lack of awareness		"I would definitely say that there is a big lack of research and any kind of insight into women's health when it comes to things like these." (P10)
		limitations of pills		"The last time I went to a gynecologist…she gave me a birth control pill and told me to have it every single day for the rest of my life. And then I realized it is not something that I want to do to my body and I decided against it." (P6)
Limitations of menstrual tracking apps	Pain points and limitations of the current period	reductionist		"When you talk about PCOS, there are so many other things that also come into account, like your diet, your sleeping habits. So, I am not completely…happy with that aspect." (P1)

	tracking apps used by the participants.	unreliable predictions		"Even if they tried to predict my cycle, taking PCOS into account, they did not give me accurate dates at all. They were always off by at least 10 days."
Features for Supporting PCOS Management	Desirable features participants would want to see in a menstrual tracking app to better engage with the app and manage their symptoms.	Designing for positive and smooth user experience		“One thing I did not like was when it would just be like, your periods late for five days, or your periods been late for 10 days. And I think that would just cause more stress because I'm like, I'm aware that my period's delayed…but if it's late, they'll have this gray bubble. And I know it's so silly, but like, this gray bubble just like impending doom situation or something.” (P9)
		Support through community		"Community support and people who've already been through it... offer a lot of reassurance to me... without them, I will get extremely anxious" (P2)
		Improved Tracking Features	diet tracking	“It would be nice if I can track my food, and based on kind of what I'm eating, it tells me if I am eating proper for it or not.” (P5)
			tracking of emotions	“I like this app because it lets you add your feelings. You can put different emojis for each day. And it also gives you a diary to write about how you’re managing with it, what kind of theme it has.” (P8)
			tracking of fatigue	“Whenever I used to go to my GPA appointment, they would ask like, how was your mood? How tired did you feel? And I just did not remember that after three months. So maybe, maybe a feature that would help me in tracking if I got out of bed that day, for one thing.” (P3)
			tracking of flow	“My cycle was always like, so I would get my cycle for the first five days then it would stop for two days, and then I would get it again

				for seven days, and they just did not have an option for that. Like, how do I log that in?" (P3)
			pain tracking	"Cramps, leg pain, because that is also a huge thing. My back hurts a lot, when I'm on my period…so maybe, like one, a feature that allows you to rate pain on different levels and factors." (P3)
		Personalization		"I have insulin resistance PCOD. So what kind of exercise I would need to do compared to you would be different." (P5)
		Actionable advice for management	Diet Management	"General recommendation as to what you can do to manage it, like, how can you exercise? How can you change your diet? What foods you should eat? What vitamins do you need in your body?" (P2).
			Pain Management	"Like ways to get rid of the pain without medication and all of those things." (P1).
			Stress Management	"This app also has videos and sounds in it. So it's like, 'Hey, do you want to listen to some bird sounds in the forest and meditate?'—which is cool." (P8).
		Tools for improved meaning-making	PCOS	"It just does not have, like, articles about PCOS or PCOD or any health resources... insightful but doesn't cover PCOS." (P9)
			Menstrual Cycle	"I wish it could just give some reviews after a month; during this time you were, like, going through this..so during ovulation, your this thing was worse, during PMS, this thing was worse. It would be easy if the app does this for me." (P4)
Management Strategies	Strategies already being used by	Stress Management		"What I did to manage the symptoms was…meditate a lot, try to calm myself down." (P9)

	participants to manage their PCOS better.	Physical Exercise and Diet Management		“Weight training is one of the main things that I've tried…that is something that's working well for me.” (P10)
		Relying on Intuitive Methods		“And I wouldn't say that I am very much fully aware of how it treats my body, but I think I have gotten used to how it will impact my body and what I need, what I should, like prepare myself for if I'm going to get my period… allowing my body to rest and listening more to it, rather than defying it and going in completely. I'll do whatever I want, kind of a direction.” (P10)
		Sense-making via Community		"Most of the information I gather is from reels and people who are posting about PCOS on Instagram" (P4).

Appendix D

Data Storage

The transcripts of the interviews can be found here: Thesis Interview Transcripts