*Journal of the American Medical Informatics Association*, 29(2), 2022, 385–399
doi: 10.1093/jamia/ocab212
Advance Access Publication Date: 6 October 2021
Review

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# The messiness of the menstruator: assessing personas and functionalities of menstrual tracking apps

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Received 5 April 2021; Revised 8 September 2021; Editorial Decision 14 September 2021; Accepted 20 September 2021

## ABSTRACT

**Objective:** The aim of this study was to examine trends in the intended users and functionalities advertised by menstrual tracking apps to identify gaps in personas and intended needs fulfilled by these technologies.
**Materials and Methods:** Two types of materials were collected: a corpus of scientific articles related to the identities and needs of menstruators and a corpus of images and descriptions of menstrual tracking apps collected from the Google and Apple app stores. We conducted a scoping review of the literature to develop themes and then applied these as a framework to analyze the app corpus, looking for alignments and misalignments between the 2 corpora.
**Results:** A review of the literature showed a wide range of disciplines publishing work relevant to menstruators. We identified 2 broad themes: "who are menstruators?" and "what are the needs of menstruators?" Descriptions of menstrual trackers exhibited misalignments with these themes, with narrow characterizations of menstruators and design for limited needs.
**Discussion:** We synthesize gaps in the design of menstrual tracking apps and discuss implications for designing around: (1) an irregular menstrual cycle as the norm; (2) the embodied, leaky experience of menstruation; and (3) the varied biologies, identities, and goals of menstruators. An overarching gap suggests a need for a human-centered artificial intelligence approach for model and data provenance, transparency and explanations of uncertainties, and the prioritization of privacy in menstrual trackers.
**Conclusion:** Comparing and contrasting literature about menstruators and descriptions of menstrual tracking apps provide a valuable guide to assess menstrual technology and their responsiveness to users and their needs.

**Key words:** personal health informatics, menstruation, mobile health, menstrual tracking

## INTRODUCTION

While menstruation has been largely absent in technology, the past 5 years have witnessed the sharp rise of FemTech.[1] From new wearables and sensors to smartphone apps, technologies have been proposed to support self-discovery and body literacy,[2–5] to meet self-management needs for well-being[6–11] and reproductive

conditions,[12–14] and to promote feminist representation in technology.[15] Menstrual trackers are becoming mainstream commodities with high engagement,[16] and the research community has started assessing their design, intended use, and potential unintended consequences.[17–21] Menstrual tracking apps are a key area of personal informatics, with the potential to empower users and challenge oppressive social structures while enabling individual-level and population-level insights.

Beyond FemTech, attention to menstruation has surged, with the term *menstruator* emerging as a key focal point for ongoing conversations. The term is often accompanied by the refrain, "not all women menstruate, and not everyone who menstruates is a woman." The menstrual cycle is a sex-linked biological process regulated by reproductive hormones (estrogen, progesterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH)), culminating in several days of menstruation, where the uterine lining along with an unfertilized egg is shed through the cervix and vagina .[22,23] While irregularity is common, many menstruators experience this cyclical process every 21–35 days.[24] In the life cycle of a menstruator, the first period (menarche) occurs around puberty and ends in middle age via menopause. Menstruation is a common experience, but menstrual experiences are neither universal nor monolithic. Even (and especially) beyond gender, the menstrual experience varies. Intersectionality explains that an individual's identity cannot be represented as merely a sum of its parts, but rather through a nuanced understanding of oppressive experiences and discrimination (or privileges and advantages) that impact people differently based on the intersection of identities.[25–27] Across the lifecourse, culture, race, ethnicity, religion, caste, and socioeconomic circumstances profoundly shape the menstrual experience.[28–33] We describe menstruation as messy, not only because it is a messy physiological process but also because it is situated within a multifaceted sociocultural context. With menstruation so deeply stigmatized, we call for embracing the experience of messiness as authentic and valid and reject the conception of menstruation as in need of concealment and regularization ("less messy").

Given that the term "menstruator" has evolved into a crystallizing point for discussing menstruation, we use it as the basis for our scoping review to capture relevant themes across disciplines that characterize menstruators and their needs then apply this characterization as an analytic lens to evaluate menstrual tracking apps. Motivated by recent research tackling intersections of society and health,[3,34–37] we take up complex questions with an interdisciplinary team to attend to the sociotechnical configuration of menstrual trackers, guided by these key research questions: (1) Who is a "menstruator" and who are the intended users of menstrual tracking apps? (2) What are the needs of menstruators and what needs are menstrual trackers responsive to? (3) Where does current technology fall short? (4) What design directions can address these deficits?

## MATERIALS AND METHODS

### Scoping review of the literature

#### Search strategy and screening

To gather information about who a menstruator is and what their needs are, we conducted a scoping review following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Extension for Scoping Reviews guidelines.[38] Database searches were conducted by AP in March 2019 and updated in March 2020 to include literature through the end of 2019. Searches with the query "menstruator*" were conducted in Google Scholar, JSTOR, PubMed, OVID Medline, Web of Science, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Scopus, PsycINFO, ProQuest, and ACM Digital Library.

#### Data extraction and analysis

For each result, we extracted the full text, first author, year of publication, publication type (eg, journal article, book chapter, editorial, or commentary, etc.), title, geographic location, and discipline using a data extraction matrix created by the authors. We examined trends in publications across time and disciplines of study. For the thematic analysis,[39] we coded all publications by themes to characterize who is considered a menstruator and what needs are identified in the literature. Two coders (AP and KBJ) independently familiarized themselves with a subset of publications balanced over source and discipline of study. An initial list of themes was identified, then grouped into major themes, which were iteratively refined, named, and defined in a codebook, which was then used to code all included texts.

### Analysis of menstrual tracking apps

#### Search strategy and screening

To curate a corpus encompassing the broadest representation of menstrual tracking apps available and that potential users are most likely to encounter, we undertook a multipronged search strategy across both the Google and Apple app stores. First, we screened apps included in prior menstrual tracking app reviews,[18,19,40–44] then we added apps from the top 50 results across 6 distinct searches (menstrual OR period AND tracker OR calendar OR diary) on both app stores, ignoring duplicates. The first author (AP) completed the searches and data extraction in June 2020. We excluded apps that were categorized as fertility trackers and that listed fertility tracking as primary focus (while systematically applied, criteria sometimes required judgment calls). We also excluded apps for "low use" (defined as <200 reviews). We finally considered author expertise to ensure no major apps were left out, and added back any apps excluded due to low use but nonetheless deemed relevant to the current study. When both free and paid versions were returned, only the description of the paid app was included; we attempted to distinguish between free and paid features.

#### Data extraction and analysis

Extracted data included: app title, text description, images (logo and screenshots), and metadata (number of ratings, star reviews, and app category). Three authors (AP, KBJ, and ITW) conducted qualitative analysis following a Directed Content Analysis approach,[45] focusing on app descriptions. Using Dedoose for codebook development and coding, we started with the themes generated in the scoping review, and then iteratively revised the codebook through several rounds of double-coding subsets of the corpus and discussing how codes were applied. The codebook was revised until coders agreed that topics were meaningfully represented and could be applied systematically. We reached saturation while developing the codebook and coding the text of the app descriptions.

## RESULTS

### Findings of the scoping review

#### Search results

The flow diagram is provided in Figure 1 (left). Searches in Google Scholar returned 314 articles, JSTOR returned 4 additional results, and the remaining databases returned only duplicates, irrelevant

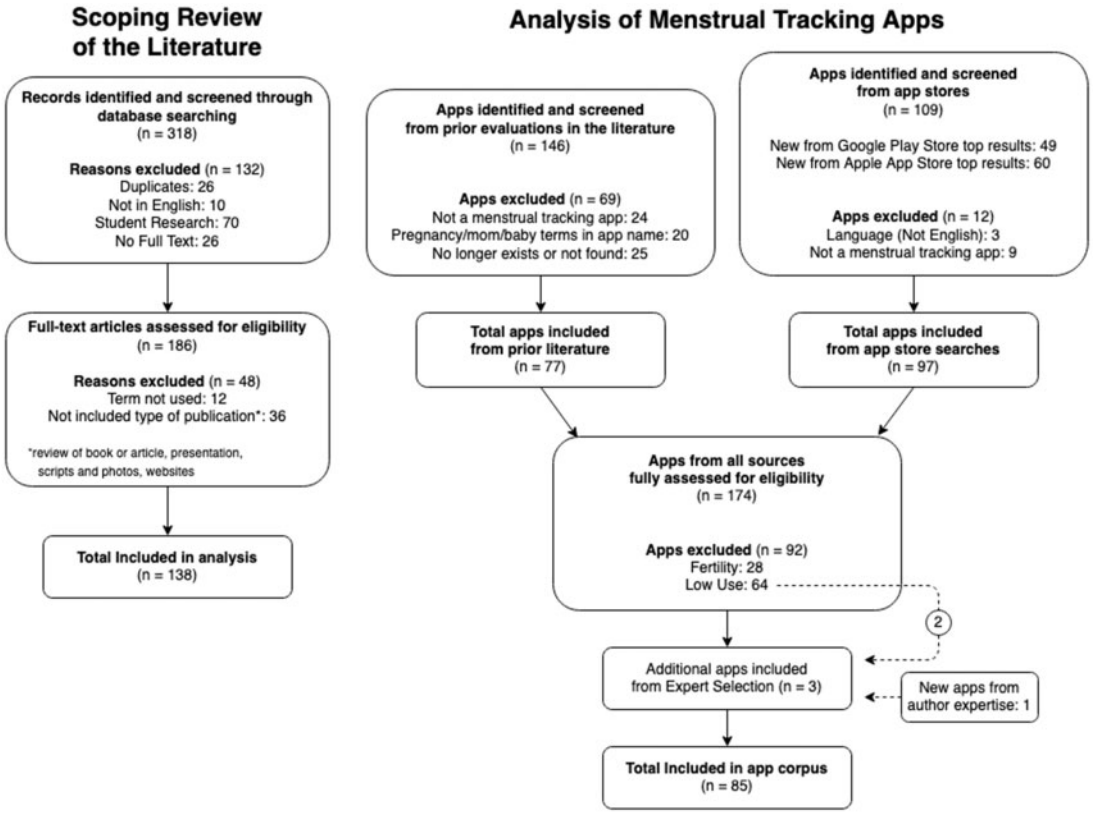


**Figure 1.** Flow diagram of search strategies for (*left*) scoping review and (*right*) curating app corpus.

results, or no results. The title and abstract of 318 total results were screened, leading to the exclusion of 132 results. Full-text screening was completed on the remaining 186 results, leading to the exclusion of 48 results. Overall, there were 138 scholarly outputs included in our synthesis; 39 of which were books.

### Trends in academic publications

Figure 2 visualizes publications using the term menstruator across decades and yearly for the 2010s. We note a striking uptick in the last decade, with an overall upward trend.

We further note that the term menstruator appears in an increasingly wide range of disciplines across time. Starting in 1953 until early 1980s, biomedical journals were the exclusive users of the term "menstruator." Publications in anthropology take over in the mid-1970s until early 2010s as the prominent field represented. In the 1990s and beyond, gender studies publications become predominant. We also note an increase in publications discussing menstruators from a variety of perspectives and applied fields, such as economics, law, and more recently, technology.

### Themes

An overview of themes is presented in Figure 3.

*Who is a menstruator?* This scoping review highlights that "menstruator" is used to be inclusive by broadening the scope of who is perceived as a person who menstruates, while also narrowing and adding nuance to the description of menstruators. The term encourages the inclusion of people who experience the biological process of menstruation, regardless of their gender. It also focuses on the varied lived experiences relevant to menstruation. Finally, it highlights the inherent dynamic and irregular nature of the menstrual cycle.

*Theme 1-1: Menstruators have been characterized by both sex-linked biological processes and social identity.* Early articles in the biomedical literature refer to menstruators through their sex-linked traits, for instance comparing characteristics of "early menstruators" versus "late menstruators" (based on the age of menarche).[46–48] The biological significance and evolution of menstruation are also represented, citing the certainty of adaptive benefits and uniqueness of human menstruation apart from other animals (ie, as "overt menstruators" and "copious menstruators").[49–51]

Later literature focuses on social identities rather than biological functioning around menstruation. Many recent articles in gender studies, economics/development/policy, and the humanities/social sciences employ the widely used axiom "not all women menstruate, and not all menstruators are women,"[52–55] centering gender (a social category) rather than sex (a biological category). This more recent use in menstrual discourse is applied to signal inclusion of transgender men, masculine of center individuals,[56] and nonbinary people who menstruate. On the other hand, there are many reasons women and girls do not menstruate, for example, premenarche, postmenopause, pregnancy or lactation, surgery or medical treatment, illness, stress, travel, and physical activity. Intersex individuals may or may not menstruate.[57] In addition, transgender women do not experience menstrual bleeding but may undergo cyclical hormonal fluctuations.[58] Many articles refer to these social categories, further complicating the constructs of gender and sex.[59–61] Nonetheless, womanhood is often referred to when discussing menstruators,[62,63] with a few articles arguing for menstruation to be inherent to womanhood, explicitly ex-

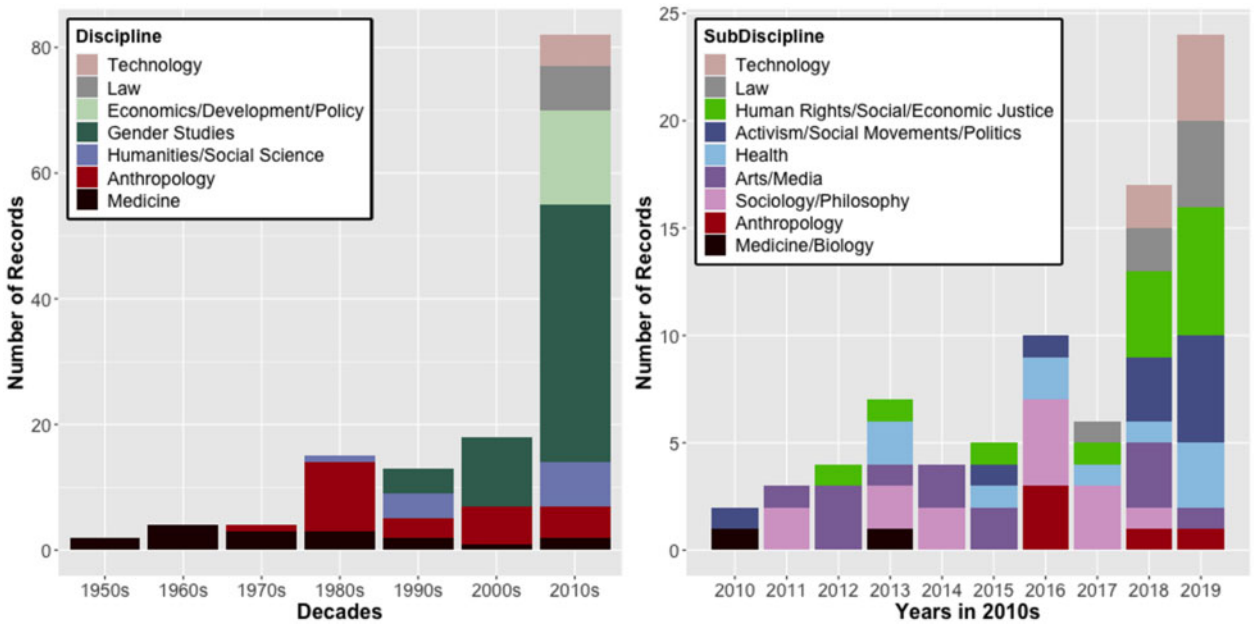


**Figure 2.** Characteristics of the literature: References over time by (*left*) discipline (by decade, all time) and (*right*) subdiscipline (by year, 2010s).

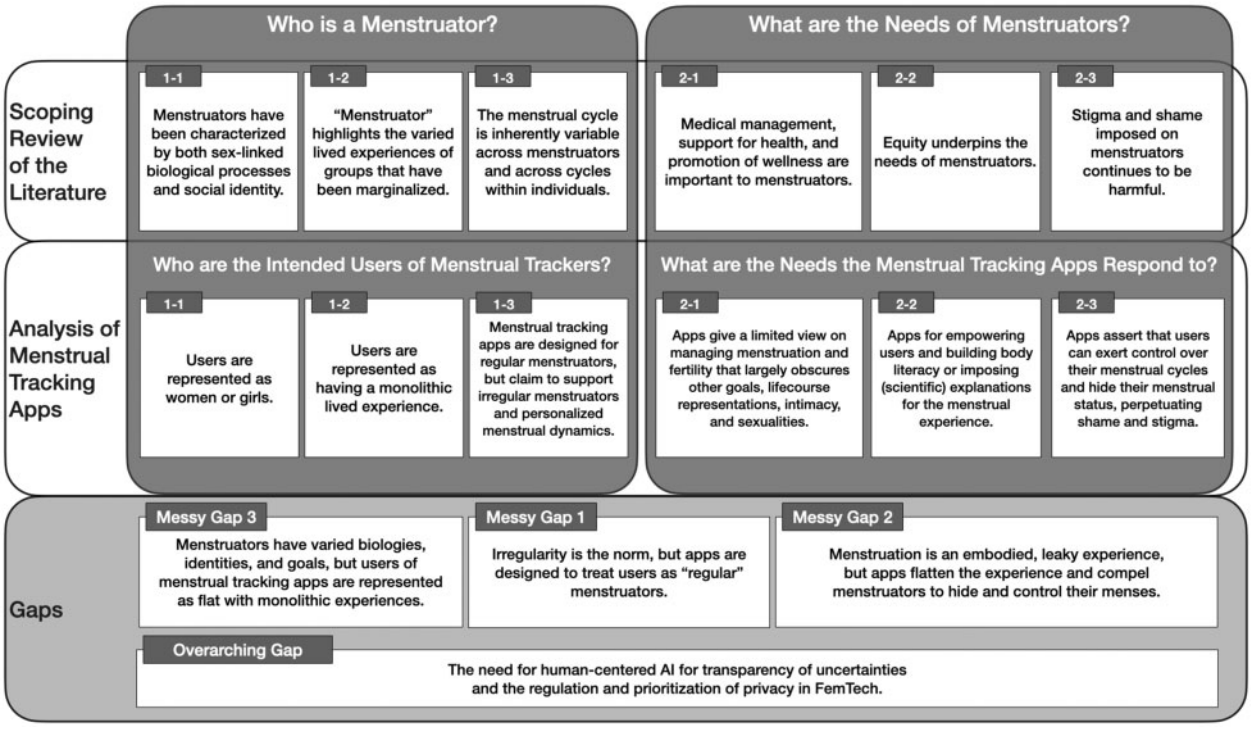


**Figure 3.** Overview of themes from the scoping review and analysis of apps, and the gaps identified from the analysis.

cluding some sexual and gender minorities.[64,65] Because of menstruation's complex relation between sex-linked traits, biology, gender, and life context, menstruation is more than a bodily process and encompasses a social dimension.

*Theme 1-2: "Menstruator" highlights the varied lived experiences of groups that have been marginalized.* The literature often uses "menstruator" to focus on the menstrual experience of groups that have been marginalized, centering functional needs and structural barriers associated with disadvantaged social locations. In particular, access to hygiene for under-resourced communities is a primary focus of the water, sanitation, and hygiene (WASH) sector, such as access to toilets that meet the needs of menstruators (eg, privacy, safety, facilities to wash or change pads).[66–69] More broadly, many menstruators have specific needs, including individuals experiencing homelessness,[70] incarcerated persons,[71] individuals with physical, mental, and developmental disabilities,[59] migrants, refugees, and asylum seekers,[72] racial and ethnic minorities,[73] and people living in

poverty.[74] Specifically, because these menstrual needs are not adequately addressed, these often intersecting aspects of lived experience and identity are further marginalized. Here, using the term menstruator positions the relevant needs of individuals who menstruate (based on "what"; context and relevant needs), rather than their identity ("who"; attributes such as sex/gender), thus weakening the link of menstruation to gender and instead focusing on the unique needs relating to an individual's bodily function specific to menstruation.[57] Although menstruation is a bodily function shared by many, it is experienced in diverse, context-specific ways.

*Theme 1-3: The menstrual cycle is inherently variable across menstruators and across cycles within individuals.* The literature describes how the "normal" 28-day cycle, broadly applied, is not consistent with the reality of the dynamic menstrual cycle; in particular, a recent study using Clue data affirms, "menstruation is characterized by variability rather than by regularity,"[75] demonstrating that the menstrual experience between menstruators and even within an individual's cycle varies with regard to length, frequency, and symptoms. Hasson[52] proposes that "complex arrangements of organs, tissues, hormones—produced in the body or taken in from outside—generate embodied experiences of regular, irregular, or absent bleeding." There is also longstanding evidence that new menstruators generally have irregular cycles,[76] and those going through the menopausal transition experience disruption or absence of regular cycles.[52]

*What are the needs of menstruators?* Our review highlights different menstrual needs, including instrumental needs to manage menstrual bleeding, which expand to other medical and wellness needs associated with menstruation. Importantly, needs extend beyond material needs into cultural messaging that harms menstruators and larger structural barriers that limit menstruators, particularly in accessing necessary resources.

*Theme 2-1: Medical management, support for health, and promotion of wellness are important to menstruators.* Most biomedical articles retrieved in our search, especially early ones, concentrate on medical management of the menstrual cycle. Most prominently, the early literature from the 1960s, 1970s, and 1980s centers reproductive health (fertility and contraception).[47,48,77,78] Content also details toxic shock syndrome,[79,80] including the need for individual awareness of risks, generating scientific knowledge, and political advocacy to regulate and hold accountable corporations producing commercial products.

Another pronounced body of work focuses on menstrual symptoms and disorders and treatments (eg, dysmenorrhea, chronic and cyclical menstrual pain, menstrual suppression),[46,52,59,81,82] and discusses care and self-management of chronic diseases, for example, the impact of eating disorders,[83] mental health,[84] and spinal cord injuries[85] on menstruation. Results call for robust menstrual health information, mechanisms to support menstruators accessing care from health providers, and tools to independently self-manage health and well-being. Results affirm that menstruation can be considered a vital sign for both menstrual and overall health.[86,87] However, some articles (particularly within gender studies) critique the medicalization of the menstrual cycle, explaining that even though menstruation is a common life process situated within the social realm, it has been understood and problematized through the adoption of a medical framework.[55,88,89] For some menstruators, medical treatments such as contraception or hormone replacement might constitute a fundamental aspect of care; suppressing menstruation can mitigate burdensome symptoms and painful periods, empower menstruators with bodily agency, and resist harmful menstrual expectations. However, social pressure to suppress menstruation to avoid the burden, messiness, and embarrassment can bolster and reproduce discipline, surveillance, and policing imposed on menstruators.[90] Considering technology, Eschler et al[43] assert, "giving menstruators the ability to manage their own information can be an important aspect of resisting the 'social control' of medicalized biology and conditions."

*Theme 2-2: Equity underpins the needs of menstruators.* The need to promote equity from social, economic, and gender justice perspectives is a prominent theme. Calls include advocacy to end the "tampon tax" (ie, charging sales tax on menstrual products) and advocating for free menstrual products[69,91–93] in particular settings (including eg, schools, shelters, detention).[74] They also address tensions between affordable single-use products and their environmental sustainability, suggesting do-it-yourself menstrual materials.[94] Human rights discourse focuses on addressing needs specific to groups that have been marginalized, specifically structural barriers beyond products and addressing underlying causes of unmet needs and ongoing stigma.[95]

Another equity-related topic calls for access to appropriate educational resources and better body literacy, as discussed across health-related humanities literature,[80] early menstrual advocacy literature (eg, the seminal book "Our Bodies, Ourselves" from the Boston Women's Health Collective[96]) and intersectional gender studies work.[57,97] Some results emphasize personal narrative and lay knowledge (potentially transformative), stories from menstruators, and representing menstruation not as inherently problematic.[76,78,88,98,99]

*Theme 2-3: Stigma and shame imposed on menstruators continue to be harmful.* The literature interrogates shame and stigma related to menstruation and how pervasive and harmful menstrual norms are socially constructed and reinforced. Particularly in anthropology, symbolic and religious attitudes toward menstruators highlight impurity, rituals for isolating menstruators, and menstruators as "weak bleeders" contrasted with warriors as "strong, masculine bleeders."[100–104] These older publications illuminate deep cultural, social, and religious interpretations underpinning stigmatizing menstrual discourse. Across the corpus, publications and their findings must be contextualized within the history of each discipline and interpreted cautiously with their limitations acknowledged. Notably, much of the older anthropological literature asserts a particular set of Western perceptions, rather than representing the voices of menstruators themselves.

Articles critiquing attitudes toward menstruation span pop culture and media (eg, through analysis of menstrual products ads urging concealment),[54,62,105–107] film, television, and literature (eg, representations of menstruation as abhorrent, or in horror genres),[108,109] menstrual educational materials (eg, bodily surveillance and management reinforcing menstrual normativity; problematic framing of menstruation exclusively around fertility and reproduction),[110–112] and day-to-day stigma and shame inherently ascribed to being a menstruator.[76,97] A few authors discuss positive representations or symbols of menstruation.[89,108] Nonetheless, because menstrual shame and stigma are so prevalent, the motivation to appear as a nonmenstruator appears among articles retrieved.[113,114]

## Findings of the analysis of menstrual trackers

### Search results and app corpus

A flow diagram is provided in Figure 1 (right). Our search yielded a total of 256 apps. One hundred seventy-four apps were included for data extraction and full review to assess eligibility. Ninety-two apps were excluded when assessed for eligibility to remove fertility trackers and apps with "low use." After manual review, 3 were added to the final corpus (Apple Cycle Tracking; Oky by UNICEF; FitrWoman integrating physical activity and menstrual tracking) resulting in of 85 apps from across app stores for evaluation. App ratings ranged between 2.35 and 4.9 stars, with a median of 4.55 and an interquartile range of 4.3–4.7.

### Themes

Illustrative quotes from apps are presented in Tables 1 and 2.

*Who are the intended users of menstrual trackers?* Menstrual trackers depict a largely normative representation of users. Users are assumed to be women, and womanhood is linked to menstruation and femininity. The lived experience of women is displayed as monolithic and privileged across domains (eg, race/ethnicity, sexuality, socioeconomic status, disability, access to housing, food, healthcare). Users are assumed to be regular menstruators, but apps claim to use machine learning to account for variation in cycles.

*Theme 1-1: Users are represented as women or girls.* The gendered assumptions and stereotypes about women underlying menstrual tracking apps may be the most obvious finding; app store searches returned visually homogenous, overwhelming pink, pastel, and flowery pages of results (images cannot be reproduced due to copyright, but we encourage readers to replicate the searches). Gender is implicitly and explicitly encoded using language (see Table 1) and visuals, ie, feminine imagery (eg, app icons depicting pink, purple, and pastel colors with flowers, hearts, butterflies, or feathers) and images of women (eg, app icons featuring women with long hair and screenshots of users who are thin white women). A substantial number of apps refer to anticipated users as women/ladies (n=52, 61%), girl (n=20, 24%), and females (n=15, 18%). Overall, two out of three apps (n=57, 67%) use feminine gendered language. Of the 28 apps without gendered language, another five include explicit images of women in the icons and screenshots; 17 more depict stereotypically feminine imagery and/or colors. Three apps are mostly neutral regarding gender, but still have pastels, hearts, or "cute" language. What it means to be a woman is elaborated by these assumptions around femininity designed into visual elements. Some of these images and language are particularly infantilizing (eg, cartoon mermaid and rabbit). Only three apps (4%) avoid gendered assumptions in their language, images (eg, circles, spirals, cube, blood drop), and colors (eg, bold).

*Theme 1-2: Users are represented as having a monolithic lived experience.* Representation of users are flat even beyond gender, as illustrated by the use of the word "every" in many of the apps. App descriptions send the message that they are a perfect, universal fit for every potential user; furthermore, apps make many assumptions, for example, that users are heterosexual, monogamous, and interested and able to focus on their fertility and family planning. Text often asserts that users work and take vacations, circumstances the app can apparently help handle.

*Theme 1-3: Menstrual tracking apps are designed for regular menstruators but claim to support irregular menstruators and personalized menstrual dynamics.* Assumptions about normal or typical menstrual cycles characterize the messages and features associated with many of the apps (see Table 1). Cycles are often assumed to be regular (either explicitly or implicitly in predictions), with 28-day cycles and consistency from one cycle to the next. Some app logos even incorporate "28" into their design (eg, app icons featuring the number 28). Cycles are also assumed to be ovulatory, which is not always the case (eg, due to polycystic ovary syndrome (PCOS) or hormonal contraceptive use). There is little mention of menstruators across the lifecourse or transitions, with the exception of pregnancy.

Many apps purport to support users with irregular cycles (see Table 1), generally by allowing users to customize cycle length or by using machine learning. Apps prompt users to log more data and claim to use data science, artificial intelligence (AI), or special algorithms to predict and map onto irregular cycles or individual menstrual dynamics. Despite complex menstrual cycle dynamics, they promise reliability and accuracy of predictions but provide little indication that these predictions may not be accurate.

*What are the needs the menstrual tracking apps respond to?* Menstrual trackers are designed to track, predict, and manage a menstruator's menses and ovulation/fertility window. Beyond these primary goals, apps also claim to facilitate health and wellness and help users cultivate menstrual awareness, control their cycles, and conceal their menstrual status.

*Theme 2-1: Apps give a limited view on managing menstruation and fertility that largely obscures other goals, lifecourse representations, intimacy, and sexualities.* A primary function of menstrual tracking apps is to log data about menstrual cycles to visualize, analyze, and predict the menstrual period (ie, when bleeding will start) with goals to prepare for days of bleeding, "prevent an accident," and plan (eg, for work or vacation). Apps also seek to predict the fertility window/ovulation for preventing pregnancy or optimizing chances of conception. Users can log days of bleeding, descriptors of flow (heaviness of flow, clots, color), and sometimes associated signs and symptoms. Many apps also keep track of ovulation information, for example, basal body temperature, cervical mucus, and ovulation tests. In reality, the menstrual cycle is a complex, dynamic cycle of hormones that fluctuates dynamically across time; nevertheless, most apps isolate 2 distinct events: bleeding and ovulation without mentioning other phases of the menstrual cycle (see Table 2).

However, some apps offer features to construct a more holistic representation of the menstrual cycle. Beyond details of flow and fertility, users can track symptoms, mood, weight, physical activity, diet, sleep, medications, and more. Customization of domains or app interface is sometimes supported. Furthermore, apps commonly support free-text notes, journal entries, or even photos to incorporate narrative alongside self-tracking and construct a comprehensive picture of the user's life. But these remain the exception and even when apps permit a more holistic representation, options are sometimes still limited and often draw from reductionist assumptions and stereotypes around menstruation, for example, "mood swings" and weight changes, which have been used to police girls and women and minimize their experiences.

As a result of their limited conception, menstrual trackers largely obscure realities of transitions from a menstruator to a nonmenstruator, and vice versa, and changes across the lifecourse, especially during perimenopause. One prominent exception, menstrual track-

**Table 1.** Who are the intended users of menstrual trackers?

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| *Corresponding to themes in scoping review:*<br>• Menstruators have been characterized by both sex-linked biological processes and social identity. | **[Theme 1-1] Users are represented as women or girls.**<br>The Easy Period Calendar is a must for modern women. (App 118)<br>It's a smart and simple female period tracker. (App 145)<br>It is period app for girls/women/ladies/teenagers. (App 087)<br>The main objective of this ladies periods calendar is to record menstrual cycles and personal period log for teenage girls and women. (App 047) |
| *Corresponding to themes in scoping review:*<br>• "Menstruator" highlights the varied lived experiences of groups that have been marginalized. | **[Theme 1-2] Users are represented as having a monolithic lived experience.**<br>An essential menstrual recording tool for every girl's life! (App 168)<br>Discreet menstrual diary for every woman. (App 039)<br>Woman Calendar, it is what every woman needs! (App 066) |
| *Corresponding to themes in scoping review:*<br>• The menstrual cycle is inherently variable across menstruators and across cycles within individuals. | **[Theme 1-3] Menstrual tracking apps are designed for regular menstruators but claim to support irregular menstruators and personalized menstrual dynamics.**<br>Please note that this application is based on the assumption that your periods are fairly regular. The date of your next period and the fertile period will not be accurate if you have very irregular periods. (App 049)<br>Contrary to others calendars, you only need your cycle start date and the cycle time (average 28 days) to configure it. (App 132)<br>Menstrual cycle and ovulation calendar, for teens or women trying to keep a regular cycle. (App 137)<br>Accurate period predictions even for irregular cycles. (App 146)<br>Predict your period, menstruation, fertile days by machine learning no matter you have irregular period or regular period. (App 087)<br>Log more symptoms to get improved predictions if you have irregular periods. (App 003)<br>Finally, an intelligent period tracker app that makes sense of what you track! Pslove Period Tracker not only accurately predicts your upcoming menstrual cycles & fertile days but also analyses trends in your body.<br>It's easy to get on top of your health! SEE THE FUTURE You can view your predicted periods and ovulation dates for months in advance. Using machine learning artificial intelligence, our predictions gets better over time to make the best calendar for women—the more you log, the higher the accuracy! (App 045) Learns from your inputs and makes better prediction of future periods and fertile windows through time, we use all up to date scientific methods available to track and plan your cycle. (App 093)<br>Accurate & Reliable. Accurate predictions based on your own menstrual history. Becomes even more accu rate with usage, by way of machine learning (AI). (App 086) |

AI: artificial intelligence.

ers often feature support for pregnancy (ie, pregnancy mode accounting for cessation of menstruation). Other nonmenstruating users are not visible or supported by current app functionalities.

Menstruators are often tied to their reproductive capacity (see Table 2), despite excluding apps that focus on fertility tracking. The fertile window is frequently central to design and guides users in family planning—either to support conception or help prevent pregnancy. Apps also use language such as "tracking intercourse" and finding a "safe period" for "activity." They do not include language about intimacy or sexual pleasure, and sexuality is tied primarily to intercourse for the purposes of family planning and managing fertility. Furthermore, discourse around reproductive capacity assumes heterosexuality.

Beyond supporting users in managing menses and fertility, many apps claim to facilitate health and wellness goals (see Table 2). Some apps enable users to review data, generate reports, and apply insights to monitor their health and identify anything that may be "off." A few explicitly mention breast health and cancer screenings (eg, pap tests). Some apps promote care, and others claim to support wellness, for example, integrating menstrual cycle and physical activity, diet, and/or meditation data.

Sometimes users are encouraged to use their self-tracked data to communicate with healthcare providers, with visualizations or exported reports. Other features for communicating with partners or community forums also support users in health and wellness goals. However, many of these functionalities (eg, exports of data and reports to use with providers) are either extremely basic or are premium features requiring payment or subscription.

*Theme 2-2: Apps for empowering users and building body literacy or imposing (scientific) explanations for the menstrual experience.* App descriptions explain that they can help users "learn more about your body" with self-tracked data and/or educational resources (sometimes as premium/paid features) (see Table 2). Apps say they can help users "listen to yourself" to "better understand your cycle" and "identify trends and patterns unique to your body." Apps promote benefits for users who want "to monitor their cycle and be aware of what is happening with their health." However, apps also claim they will "take out all the guess-work" and "give you all the relevant information you need about your period." Such claims that data can make sense of the body can have harmful implications. Implying that users are "lost," "confused," "worried," or "feeling in the dark" about their bodies/cycles, and need for apps to "show" them or allow them to "observe" their cycles or that computational models can "explain" menstrual experiences may actually disempower menstruators by over-riding embodied lived experience with a presumably more objective, quantifiable way to "know the body."

*Theme 2-3: Apps assert that users can exert control over their menstrual cycles and hide their menstrual status, perpetuating shame and stigma.* Many apps ($n = 27$, 32%) also declare that users have

**Table 2.** What are the needs menstrual tracking apps are responsive to?

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| *Corresponding to themes in scoping review:*<br>• Medical management, support for health, and promotion of wellness are important to menstruators. | **[Theme 2-1] Apps give a limited view on managing menstruation and fertility that largely obscures other goals, lifecourse representations, intimacy, and sexualities.**<br>It's easy to see predicted periods and fertility days—essential for planning dates and vacations and avoiding unpleasant surprises! (App 009)<br>DON'T FORGET Get reminders before your period & ovulation window arrives. You'll never stain your undies or be caught without your trusty sanitary pads or tampons again. (App 045)<br>With period calendar you can calculate your next menstrual period, ovulation days, fertile period. Menstrual cycle and ovulation calendar will help both in planning for pregnancy and addressing the issue of contraception. (App 156)<br>Track your menstrual cycle in easy to control calendar and predict ovulation, fertile days and next period. Add notes about menstruation, symptoms or intimacy and keep your health under control. It will serve you as both menstrual cycle tracker and ovulation calculator for pregnancy. (App 039)<br>A very simple and easy to use app. to monitor your periods, determine the date of ovulation and the fertile period. [. . .] It also calculates the time of ovulation and your fertile period. [. . .] helps you plan your activities better. (App 049)<br>App helps both women looking to conceive and those trying to birth control. It tracks your periods, cycles, ovulation and the chance of conception. Helps birth control in a natural way. (App 100)<br>Breast exam reminders. (App 024)//Keep track of you last Pap test. (App 056)<br>. . . will be your virtual gynaecologist, helping you to manage all aspects of female health and teaching you methods of prevention, crucial for the early diagnosis of tumours. (App 084)<br>. . . providing a hub of informative wellness tips and trends within an empowering women's community! (App 090)<br>Email and/or print your charts to share with your doctor, friends or family (App 060)<br>Community provides an extended friend group for discussing sex & health. (App 011)<br>SHARE WITH PARTNER feature allows you to share your emotional and physical health state with your Partner. (App 047) |
| *Corresponding to themes in scoping review:*<br>• Equity underpins the needs of menstruators. | **[Theme 2-2] Apps for empowering users and building body literacy or imposing (scientific) explanations for the menstrual experience.**<br>Listen to yourself, note your mood and symptoms to understand how they influence your health. (App 087)<br>See your health data visualized in beautiful charts. Identify trends and patterns unique to your body. (App 011)<br>Track your moods and symptoms to see the patterns and better understand your cycle. [. . .] see the statistics and identify trends and patterns. (App 146)<br>. . . wants to monitor their cycle and be aware of what is happening with their health. (App 006)<br>More than just a period tracker: it provides you with cutting edge science that helps you keep track of your health, understand what is going on with your body, flag potential issues and connect with a network of doctors and nurses to provide you the best health care. [. . .] Understand your health and the interplay of hormones in your body through our knowledge base. (App 060)<br>. . . exactly what you need to be in the know. (App 080)<br>Track, monitor, and understand your menstrual cycle with an app that truly gets you. (App 055)<br>If you feel lost and want to know more about your health, you can learn about your symptoms. (App 101)<br>Ovulation, infertile days or the menstruation itself will not surprise you anymore. (App 126)<br>No more surprises, worrying or feeling in the dark about your own reproductive health. [. . .] Take the guesswork out of predicting your most fertile days (App 018)<br>The perfect app to take out all the guess-work. (App 137)<br>Statistics: based on the information in your menstrual calendar, the app will give you all the relevant information you need about your period. (App 128)<br>Personalized daily cycle stories that explain where you're at in your cycle. (App 090)<br>We're not only backed by science; we've got period tracking down to a science. Track your menstrual cycle [. . .] to learn more about your body, mind, and self. (App 001)<br>The period tracker app that uses science to help you discover the unique patterns in your menstrual cycle and support healthy habits. [. . .] Track your period and health cycles to keep all aspects of your health and fitness in check. (App 141) |
| *Corresponding to themes in scoping review:*<br>• Stigma and shame imposed on menstruators continues to be harmful. | **[Theme 2-3] Apps assert that users can exert control over their menstrual cycles and hide their menstrual status, perpetuating shame and stigma.**<br>Take control! (App 126)//An app that truly gets you. [. . .] putting you back in control. (App 055)//It will help you to keep all monitored and controlled. (App 123)// . . . keep your health under control. (App 039)<br>[A] tool for any woman who wants to take more control over their body and health! (App 006)<br>A savvy period tracker and sex app for women who want to take control of their health and sex lives. (App 011)<br>An elegant and easy-to-use period tracker that helps you take control of the many aspects of your menstrual cycle—from ovulation, fertility and periods, to birth control pills, moods and other symptoms. [. . .] Perfect for any woman to take control of her health and keep organized. (App 028)<br>. . . teaches you to live in your FLO so you can control your hormones, rather than letting them control you. Take your health into your own hands and relish being a woman instead of cursing your gender. (App 031, quote from doctor in text description)<br>It is easy to track your menstrual cycle than ever before, take full control of your menstrual cycle by setting period reminders, fertile window reminder and ovulation day reminders. (App 105) |

(continued)

**Table 2.** continued

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| | The application is elegant and very intuitive. Perfect for women who want to control the regularity of their menstrual cycle, check fertility and safely have sex. (App 118) |
| | For teens or women trying to keep a regular cycle. [. . .] stop guessing and stop worrying. [. . .] With this amazing, easy-to-use all-in-one cycle tracker, calendar and calculator, everything is totally under control. (App 137) |
| | The first-ever period tracker and fertility app that tells you what to do to be symptom-free. Learn why you have symptoms and how to fix your period naturally. (App 031) |
| | FitrWoman is evidence-based and research driven, using the latest scientific research to provide simple changes and solutions that women can implement in their daily routine. (App 107) |
| | Discreet reminders/notifications. (App 047)//A neutral icon for home screen. (App 089)//DISCREET icon name (App 024) |
| | Discreet privacy mode. (App 045) |
| | Discreet reminders [. . .] Protect your most private data from curious eyes. (App 028) |
| | Can safely save your secrets and private notes. (App 118) |
| | Keeping your cycle information and period notes hidden from others. (App 093) |
| | SHHHH. . . IT'S A SECRET Our brand new Privacy Mode makes it easy for you to view your period countdown, even in a crowded space! You will no longer be self-conscious on checking on your periods in public. (App 045) |
| | Customize the notification text to make it discreet, to avoid never being embarrassed in public. (App 087) |
| | Your period will never awkwardly surprise you now that you can have a precise tracker and calculator. Download this app and make those bad days much easier! (App 150) |

control over their menstrual cycle and can manipulate it at their discretion (see Table 2). Descriptions instruct users to "take full control of your menstrual cycle," and say they can instruct them how "to fix your period naturally" by "telling you what to do to be symptom-free," and how "to control the regularity of their menstrual cycle." Apps claim to rely on "the latest scientific research." However, it is unclear how apps enable control beyond the ability "to manage your period or get pregnant;" apps offer only the illusion of control.

Apps advertise their discreet designs so that users can conceal the app on their devices, hide or camouflage reminders on calendars, and avoid disclosure of menstrual status. Sometimes apps employ gender-neutral iconography in service of discreteness. Messaging implies users should hide menstrual status and symptoms and that it is something to be embarrassed about (see Table 2), which reinforces the longstanding stigma around menstruation. Apps employ "discreet privacy mode" as a veil for perpetuating stigma, which is different from protecting data privacy, data ownership, or informed use of data for other purposes.

## DISCUSSION

Reviewing multidisciplinary literature enabled us to characterize the identities ("who") and needs ("what") of menstruators. Using this framework for the analysis of menstrual tracking apps revealed their limitations and opportunities to support and empower menstruators. Our findings highlight the narrow view of intended users and uses of menstrual trackers. Key events, menstrual bleeding and ovulation, are overrepresented and detached from the menstrual cycle as a whole, which is seen as controllable. The lives of menstruators are decontextualized and their experiences assumed universal.

Some medical experts have suggested menstruation should be considered "the fifth vital sign,"[86,87,115,116] highlighting the potential value of menstrual tracking apps and FemTech beyond self-tracking.[9] At the individual level, this may include designing personal informatics tools to empower and affirm the embodied experiences of users while gaining personalized insights and advancing precision medicine. At the population level, big data generated from menstrual tracking apps can be used to fill knowledge gaps. However, currently available apps largely hinder these aims by their limited framing, flat representation, and treatment of the menstrual cycle as rigid, tidy, and quantifiable. This review affirmed that there are many kinds of menstruators, but current menstrual trackers serve and advocate for a particular type of user, defined along normative expectations. Existing menstrual trackers are designed with narrow goals—managing menstrual bleeding and conception—whereas the scoping review identified broader needs of menstruators across ensuring health and wellness, overcoming shame and stigma, and ensuring equity. Others have also found that the needs of menstruators are not met with existing designs of menstrual trackers,[18,19,117] and the Human-Computer Interactions community has recently highlighted these topics.[118] Our findings and implications contribute toward the common goal of designing more inclusive FemTech that meets the multifaceted needs of menstruators.

*An imagined FemTech future* will require a fundamental reframing of the problem-solution coupling to expand what a "successful period" looks like. It must avoid rigid, shameful, and negative but also overly romanticizing views, making room for different kinds of users/menstruators, and generating dialog to combat stigma and oppressive sociocultural norms. Søndergaard[119] proposes "troubling design" to address designing within this reframe. Fox et al[21] explore "menstrual sensemaking," emphasizing multiplicity over algorithmic ways of knowing and dimensionality over norms, and troubling notions of the body as knowable, controllable, and presupposed for reproduction—promoting pragmatic technical adaptations, like richer capture of experiences, as a direction for future design. Fox and Epstein[20] suggest a modular approach that allows people to flexibly align designs with identity and goals. Almeida et al[3] propose reconceptualizing technology for women's health as "intimate care technology," where the care tasks involve interacting with bodily functions, products, and hygiene that are often hidden, private, and intertwined with taboos. Here, technology is responsive to the body in flux, including transitions and bodily health across the lifecourse, and can facilitate interactions with the "leaky" body to promote self-knowledge and body literacy essential for self-care and well-being in relation to bodily experiences. Menstruation is inherently messy, and designing to embrace this could better meet the resulting needs.

## Gaps and design implications

Broadly, this review demonstrates menstruators have varied identities and needs; however, existing menstrual trackers do not account for the messiness inherent in the menstrual cycle and are not adequately designed to support the range of menstrual experiences. Specifically, we have identified 3 clusters of messiness and one overarching gap that menstrual tracking apps do not currently support; we offer implications for enhancing design to fill these gaps.

### Messy gap 1: Irregularity is the norm, but apps are designed to treat users as "regular" menstruators

The menstrual cycle is complex, and irregularity is in fact the norm;[75,120–124] yet menstrual tracking apps, and especially their predictions, are designed to treat users as "regular" menstruators, based on the "ideal" 28-day cycle. Assumptions impose prescriptive, narrow expectations about periods/ovulation (length, duration, regularity, pain levels) based on limited, outdated studies, and reduce the menstrual cycle to bleeding and ovulation, rather than acknowledging its complex and often unpredictable dynamics. Sociocultural norms also come into play (eg, Fox[20,21] connects 28-day norms to the fertility awareness method, explaining that design decisions inscribe particular histories so apps inherit computational and moral orientations). Finally, apps lack references to fluctuations, transitions within an individual's menstrual cycle, or shifts between categories of menstruator and nonmenstruator (eg, due to menarche, menopause, lactation, hormonal treatments, therapies, weight, exercise, illness, travel, or stress).

*Design implications.* Rather than relying on prescriptive norms, apps should retool these narrow expectations. Apps could facilitate exploring the menstrual cycle and personal data with curiosity, for example, with visualizations or without quantification. When quantified, messaging should explain to users that menstrual cycles are inherently unpredictable and variable. Computational approaches can also extend beyond using only cycle history to incorporate contextual and day-to-day data for predictions.

Enabling health and wellness goals for both individuals and the population at large by using the menstrual cycle as a vital sign could facilitate care, help monitor one's health, and alert users and healthcare providers about potential concerns. This vital sign is quite individualized, so apps should allow users to construct a picture of their own "normal," supported by novel computational approaches.[125] Customization tailored for a user's menstrual cycle could personalize the experience, enable users to compare their ongoing experiences with their own baseline rather than sending a universalizing message about "what is normal." At the population level, filling gaps in biomedical knowledge about the menstrual cycle and menstrual disorders demands we study variations among different populations around the world with different cultural and environmental exposures; this large-scale characterization depends on common data elements, interoperability, and data quality.

### Messy gap 2: Menstruation is an embodied, leaky experience, but apps flatten the experience and compel menstruators to hide and control their menses

The menstrual experience is often messy and requires engaging with one's body parts and bodily fluids. However, apps reinforce the necessity of concealment. The norms of keeping menstrual experiences hidden are a consequence of menstrual stigma. Across history, the female body has been positioned as monstrous or dangerous and the leaky body as abhorrent.[126] Menstruators are told to conceal and to be discreet. Messages around the need (and ability) to plan for, manage, control, and hide menstruation are harmful. Enabling users to pass as nonmenstruators reinforces stigmatizing messages.

The rich, unruly experience of menstruation is flattened by limitations in data capture and disjointed data streams from various sources. In the apps, fields available for tracking are limited (and tinged with assumptions and stereotypes, eg, about mood changes), and structured tool designs restrict what can be documented, hampering crafting a holistic person-centered representation. The menstrual experience is reduced to quantifiable data points, and these "objective" data elements often prioritized above the menstruator's lived experience. As a result, menstrual tracking apps construct a data-mediated body privileging science and quantitative metrics over embodied lived experiences of menstruators.

*Design implications.* Menstrual tracking apps need a reframe. Instead of hiding, controlling, shaming, and policing menstruating bodies, a new framework should enable menstruators to engage with the embodied messiness of their cycle with curiosity and self-discovery to facilitate developing body and menstrual literacy. To reflect the messy realities of menstruators, tools could extend beyond tracking and predicting bleeding and ovulation to incorporate the full, dynamic menstrual cycle and beyond the menstrual cycle to incorporate the full breadth of personal care. Menstrual tracking apps should devise novel methods to capture and create workable representations of these experiences by integrating quantitative and qualitative data capture, both directly related to the menstrual cycle and across other domains. Furthermore, apps should enable users to use narratives to tell their stories, reflect on their experiences, and generate and document insights about their lived experiences.

### Messy gap 3: Menstruators have varied biologies, identities, and goals, but users of menstrual tracking apps are represented as flat with monolithic experiences

Menstruators have varied biology, identity, and goals, but users of menstrual tracking apps are represented as homogeneous, drawing from and reinforcing harmful, exclusionary stereotypes. Users of menstrual trackers are assumed to be feminine, female menstruators, with a narrow scope of goals centered on reproduction and bleeding management. App design needs to accommodate different kinds of users, across tangled spectrums of sex and gender, and at the intersection of various other axes of identity and structural marginalization. Considering diverse needs of users also highlights the personal informatics and care needs and possible cyclical patterns of nonmenstruators (including those with a menstrual cycle but no menses, eg, with an IUD[19]) which are not easily separable from those of menstruators who use menstrual trackers.[58,127] An individual's identity cannot be represented as merely a sum of its parts, but rather through a nuanced understanding of oppressive experiences and discrimination that impact people differently based on the intersection of identity categories.[25–27] Attending to and incorporating complex and overlapping identity perspectives supports design that is responsive to intersectional identity-related experiences.[128]

*Design implications.* Users of menstrual tracking apps differ in identity, needs, and sociocultural experiences. Thus, no universal design will meet these diverse design requirements. Nevertheless, there is an unmet need to support diverse goals and diverse users (across cultures, religions, identities, communities). Enabling personalization/

customization of the app interface, data fields, and goals offers one key way this can be addressed. Designers could recruit diverse volunteers for participatory design, which seeks to design apps that allow users to explore and engage with *their* menstrual experience. Bardzell[36] suggests "designing from the margins," which reframes marginality as a resource, and incorporates expertise of diverse perspectives that promote inclusive and responsive technology. The resulting designs could challenge normative assumptions of femininity, fertility, able-bodiedness, etc., even beyond individual users. Expanding depictions of a "successful" or "acceptable" menstrual cycle (or lack of), rather than imposing either a shameful or overly positive lens, can more meaningfully address the assorted needs of menstruators. By designing technology to account for the embodied experience of menstruation, a feminist approach to design[36,37] has the potential to transform apps from body management tools into a nurturing and empowering experience.

Menstrual tracking apps could facilitate connecting with one's body, identities, and communities, with the potential to affirm gender, whatever that means to the user. For some women who menstruate, the menstrual cycle is a way to celebrate their womanhood or femininity; others may find the link dysphoric or may not link their gender and their period at all. For men or masculine people who menstruate, these apps can provide practical day-to-day security and support long-term gender affirmation and wellness.[21] On the other hand, nonmenstruators may also use these apps to affirm their identities and messy, embodied experiences. Women (who may or may not have ever menstruated, voluntarily or involuntarily, temporarily or permanently) could use menstrual trackers to affirm relations with their bodies and aspects of (menstrual) cycles outside of bleeding and ovulation. Transgender women may experience hormonal cycles[129] that could be tracked and cared for with these care tools, in addition to affirming their gender. Not all validation must be positive—those with chronic illness or painful menstruation may use tools to validate their illness experience and communicate with family and providers. A further messiness is accommodating users across transitions, for example, adolescents premenarche may benefit from getting to know themselves as they go through puberty (similarly, transgender people undergoing gender-affirming hormone therapy may experience puberty or "second puberty" that aligns with their gender[130]) menstruators experiencing perimenopause-related fluctuations, and myriad reasons someone might start, stop, or connect with the menstrual cycle. Although it may seem like a messy contradiction, including nonmenstruators in the design of FemTech may be necessary to meet needs across the spectrum of users.

#### Overarching gap: the need for human-centered AI for transparency of uncertainties and the regulation and prioritization of privacy in FemTech

A final gap spanning several key findings calls for human-centered AI to address technical limitations, design choices, and policy concerns related to menstrual trackers. Apps make big promises for offering predictions and personal insights with data science and AI, assuring accurate, precise, and reliable calculations. Users, particularly irregular menstruators, are directed to track more volume of personal data, with assurances that this added detail will improve predictions and insights about the body. However, there is no discussion or transparency about the inherent unpredictability of menstruation, limitations of analysis methods, or disclosures of (un)certainty of predictions, while their promises go beyond current state-of-the-art capabilities. It is not clear that more data improve individual predictions; however, technology companies certainly benefit from more data for training their analytics and for boosted app engagement. Furthermore, upstream data issues around classification and collection impact the success of models and encode systematic bias into AI, for example, binary gender classification excludes nonbinary people from datasets and models and ignores their lived experiences.[131]

Apps also assert that they protect user privacy; but instead of protecting the user's data and app usage, privacy is framed around maintaining secrecy around a user's menstrual cycle and hiding their period. As others have documented, many apps for intimate care do not take data privacy seriously leading to risks of exploiting data.[40,132,133]

*Design implications*. Human-centered AI aims to cultivate a synergistic partnership between users and their technologies. Especially for apps released commercially, user-centered design methods should rely on and elevate the lived experiences and needs of end-users, particularly users who have been historically excluded. Input from these users can inform inclusive data definitions and mitigate concerns of failing to capture and account for important nuance and complexity.

To address limitations in computational approaches and to increase control of end-users over automated insights, design solutions can draw from research in open-source, interpretable models[134–137] and explainable AI[138–140] to clearly communicate expectations about the accuracy of prediction models and explain which data were used for calculations.[141–143] Designers can also explore mechanisms to communicate about uncertainties in the algorithmic processes and for particular predictions. And rather than offering certainties, technology could offer mechanisms to explore the menstrual cycle rather than seeking to explain it.

When it comes to person-generated health data, there is a need for policy around data ethics related to data ownership and privacy. Regulatory oversight needs to hold businesses accountable for how users' data are collected, stored, used, and shared, beyond obscure terms and services.[40,44,144] Users need more control over who has access to their data and how to revoke this access. Designers and entrepreneurs should take ethics seriously, instead of sending users stigmatizing messages about hiding their period. The menstrual cycle is a messy biological process, which could be embraced instead of trying to force menstruation and menstruators into a clean, tidy experience.

### Limitations

The scoping review may have been limited by our focus on the term "menstruator" rather than comprehensively reviewing the literature on the menstrual cycle. This allowed us to key into a specific dynamic around this term but may have also obscured other relevant literature that could have informed our analysis. In addition, selection and use of databases may limit results returned, although we relied on a range of databases to capture literature from different disciplines. Still, limitations on what is published in the literature and biases in the research presented mean further work is needed to document and address the needs of menstruators. Finally, this research predominantly focuses on an English-speaking, Global North perspective of menstruation.

## CONCLUSIONS

This paper provides an analysis of menstrual tracking apps that leverages a rich multidisciplinary body of literature to generate a frame

of analysis that we use to interrogate the framing, messaging, and design of apps. We identify gaps as well as opportunities to support diverse menstrual needs with technology. Our interdisciplinary team utilized data sources and methods that allowed us to triangulate findings from other studies and enabled us to identify a key area ripe for technological innovation. Human-centered AI offers a novel approach to addressing key limitations uncovered related to privacy of data, explainability of methods, and transparency around uncertainties. By designing technology to account for the embodied experience of menstruation, a feminist approach to design has the potential to transform apps from body management tools into a nurturing and empowering experience.

## FUNDING

AP gratefully acknowledges support from the National Library of Medicine (award # T15 LM007079 and R01 LM013043). During the time of this work KJ was supported by NINR T32NR007969 (PI: Bakken).

## AUTHOR CONTRIBUTIONS

All authors contributed substantially to this research, the development of the review approach, and interpretation of the findings. AP and KBJ were responsible for constructing the literature corpus and completing the scoping review of the literature. AP, KBJ, and ITW were responsible for creating the app corpus and coding the apps. All authors contributed to drafting, reviewing, and revising the manuscript, and all approved the final version.

## ACKNOWLEDGMENTS

The authors would like to thank the members of the Menstrual Health and Gender Justice Working Group for their helpful comments, particularly Nancy Reame, Marni Sommer, Lauren Houghton, and Anja Benshaul-Tolonen. In line with feminist methodologies, the authors acknowledge the importance of reflexivity and transparency with our work. The authors are all academic researchers at US and European institutions. We represent an array of disciplines, experience levels, and academic interests. Two authors are members of the Queer community. The authors represent a diversity in nationality and are predominantly white and from privileged socioeconomic backgrounds. We also represent a diversity in menstrual experiences.

## CONFLICT OF INTEREST STATEMENT

None declared.

## DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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