Rethinking Menstrual Trackers Towards Period-Positive Ecologies

Anupriya Tuli
IIIT-Delhi
New Delhi, India
anupriyat@iiitd.ac.in

Surbhi Singh
Sachhi Saheli
New Delhi, India
drsurbhisingh22@gmail.com

Rikita Narula
Sachhi Saheli
New Delhi, India
rikita.sachhisaheli@gmail.com

Neha Kumar*
Georgia Tech
Atlanta, Georgia, USA
neha.kumar@gatech.edu

Pushpendra Singh*
IIIT-Delhi
New Delhi, India
psingh@iiitd.ac.in

ABSTRACT

Menstrual tracking is a mechanism widely engaged towards preserving menstrual dignity, as natural birth control, for ensuring adequate preparation for an upcoming cycle, among other motivations. We investigate the design of digital menstrual trackers towards enabling period-positive ecologies in otherwise stigmatized contexts. We examine menstrual tracking practices across ages (12–65 yrs.) using a combination of methods—3 surveys (450+ responses), a cultural probe (10 adolescents), interviews (16 adults), and a review of (9) mobile applications. Our analysis highlights the diversity across menstrual tracking practices and the role of relationships in influencing these practices throughout the menstrual journey. We also identify menstrual tracking as an avenue towards the emancipation of those who menstruate. Finally, we draw on Martha Nussbaum's central human capabilities to discuss sociotechnical implications for redesigning digital menstrual trackers towards crafting just and period-positive futures.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**.

KEYWORDS

Menstrual tracking; Menstrual dignity; Digital menstrual trackers; Menstrual journey; Capabilities; Liberation; Period-positive futures

ACM Reference Format:
Anupriya Tuli, Surbhi Singh, Rikita Narula, Neha Kumar, and Pushpendra Singh. 2022. Rethinking Menstrual Trackers Towards Period-Positive Ecologies. In *CHI Conference on Human Factors in Computing Systems (CHI '22), April 29-May 5, 2022, New Orleans, LA, USA.* ACM, New York, NY, USA, 20 pages. https://doi.org/10.1145/3491102.3517662

*Both authors are advisors of this research work.

CHI '22, April 29-May 5, 2022, New Orleans, LA, USA

ACM ISBN 978-1-4503-9157-3/22/04…$15.00
https://doi.org/10.1145/3491102.3517662

1 INTRODUCTION

Gendered health and wellbeing have increasingly become topics of interest for Human-Computer Interaction (HCI) researchers in recent years. Menstrual health in particular has been explored extensively through studying the different stages of the menstrual journey, ranging from the early years of menstruation (e.g., [56, 88, 98]) to fertility (e.g., [23–25]), and menopause (e.g., [10, 22, 65]). Within menstrual health, researchers have explored information-seeking practices (e.g., [37, 99]), intimate data collection (e.g., [29, 36]), education (e.g., [56, 98, 101]), infrastructures (e.g., [34, 38, 39, 100]), product design (e.g., [71]), and menstrual syndromes [21]. Of these wide-ranging aspects, researchers have been actively studying menstrual tracking at different points along the menstrual journey (e.g., [23, 29, 33, 37, 46–49, 102]).

Menstrual tracking is typically adopted towards understanding one's body better [29], avoiding stain stigma [100], or as natural birth control [26]. Fundamentally, these efforts aim to preserve menstrual dignity by 'controlling' menstruating bodies to conceal menstruation and menstrual stain [13]. Digital menstrual trackers being sociocultural products [24, 68, 69] propagate this construct of *menstrual dignity through privacy* by targeting the desire to "gain a sense of control of periods" [48] to market themselves. The challenge with this approach is that it promotes 'treatment' and 'medicalization' of a natural bodily phenomenon "that needs to be fixed" [48, 51]. This prior research calls for rethinking digital menstrual trackers, asking if we can design trackers as supportive tools for facilitating positive body association with one's body and creating body awareness of *others*, as opposed to tools selling and promoting control over the body through predictions [24]. Our research revisits the purpose of menstrual trackers from being a tool to 'control the body' to a tool to build routines, promote healthy lifestyle choices, and importantly, attempt changing unjust social structures by promoting a shift towards period-positive ecologies.

We situate our work in the urban settings of Delhi, India, where menstruation has historically been a conversational taboo resulting in negative period experiences, low self-esteem, and fear of embarrassment on account of menstruation [99–101]. Using a combination of methods, we investigate to ask:

(1) How do menstruators at different points along their menstrual journeys engage in menstrual tracking? What are the factors affecting these choices?

(2) Do these tracking practices evolve as they gradually transition from menarche to menopause, making different life choices (e.g., sexual activity, abstinence, marriage, childbearing, voluntary childlessness, hysterectomy, etc.)?
(3) What are their experiences with and aspirations of digital menstrual trackers?

Following Kumar et al.'s recommendation [61], we take a *long view* for our investigation—across the menstrual journey (from menarche to menopause)—by engaging with menstruating women between the ages of 12 and 65. We analyze multiple surveys, a cultural probe investigation, remote interviews, in addition to reviewing mobile applications, employing the lens of Martha Nussbaum's central human capabilities [78, 79]. The use of this lens makes the struggles of experiencing life as a menstruating individual in a heavily stigmatized context visible, and makes visible the potential for digital menstrual trackers towards the crafting of period-positive futures. Our research makes three contributions to HCI. First, taking a long view, we provide a deeper understanding of menstrual tracking practices in a highly stigmatized context, where menstrual tracking is not integrated into the lives of menstruating individuals. Second, we unpack the relationships across digital menstrual trackers, menstrual dignity, and Nussbaum's central capabilities critical for ensuring just societies. Third, building on our learnings from descriptive accounts, we discuss the potential of digital menstrual trackers as an avenue to promote and support central capabilities, followed by detailing sociotechnical recommendations for (re)designing menstrual trackers as a pathway towards period-positive ecologies.

Our paper begins with positioning our work in the existing literature at the intersection of menstrual tracking, the body, and HCI. Next, we critique and establish the role of the human rights framing of menstrual dignity and digital menstrual trackers in propagating an unjust social construction of menstrual bodies. We then describe the methods we used to take a long view for investigating menstrual tracking practices through menstrual journeys. We next present our findings, followed by the discussion section where we engage with Nussbaum's capabilities approach [78] to propose rethinking digital menstrual trackers as a capability-building tool to nurture period-positive futures.

2 RELATED WORK

2.1 Menstrual Tracking and HCI

The HCI community in recent years has seen an increase in the number of studies on menstrual health with a specific focus on exploring various aspects of menstrual tracking. In 2017, Epstein et al. presented an extensive analysis of user engagement with tracking applications across the United States [29]. Since then, researchers have looked at different transitions and tracking needs for the menstrual journey, i.e., menstrual tracking (e.g., [29, 30]), fertility tracking (e.g., [23, 25, 49]), and menopausal tracking (e.g., [48, 102]). The literature highlights various assumptions and biases in the design of menstrual tracking apps, including non-inclusion of sexual and gender minorities, the conflation of menstrual tracking and fertility planning, and non-consideration of women's life transitions—young adulthood, pregnancy, and menopause [29, 30, 35]. Eschler et al. further highlight the limited menstrual literacy support for early menstruators and perimenopausal users [30]. To mitigate these assumptions, it becomes imperative to expand these apps to support menstrual sensemaking practices of users [25, 35, 37]. Researchers also call for critical reflection around collecting and sharing intimate data through digital technologies. Søndergaard and Hansen used the speculative design of a smart menstrual cup to call for critical reflection on the tech-based commercialization of intimacy through quantification and sharing of menstrual data [89]. Fox et al. further posit the possibility of future menstrual tracking technologies leading to new forms of intimate surveillance by systems of power (e.g., family sensing and workplace sensing) [36].

The prevalent tracking technologies designed to support different transitions of the menstrual journey have garnered criticism for perpetuating a dualist understanding of the self, or that the mind and body are separable [51]. Recent years have seen critical scholars raising voices against the Cartesian dualism—approach of mind-body dualism, which promotes 'medicalization' of a natural process like menstruation and menopause [48, 50]. For example, scholars have emphasized taking a *period-positive* approach where menstruation is not viewed as a 'problem' [17] or a health symptom that needs to be 'fixed' [48, 51]. Aligning with the third wave of HCI (embracing "experience and meaning-making") [14], critical scholars have proposed a shift in viewing menstrual tracking by prioritizing phenomenological and embodied inquiry [18, 48, 50, 51]. Answering this call, Homewood and colleagues have explored phenomenological approaches to design menstrual and fertility tracking devices using *ambiguity* and non-traditional data visualizations (with colorful ambient light [51] and saliva crystals [49]) to support user's sensemaking practices. However, they observed epistemological tensions while applying their phenomenological commitments into practice. The lack of quantified input and output led to users deeming the designed trackers "inaccurate or obsolete" compared to prevalent trackers that reflect Cartesian dualism. This work calls for taking a balanced approach to design the use and presentation of scientific knowledge about the body that it "does not have to replicate its Cartesian dualist roots" [51].

Researchers have studied tracking apps for different stages of the menstrual journey independently and through the personal informatics lens. As discussed, this approach focuses on the *quantified self* [67] and views menstrual tracking apps as a tool for knowing one's body (e.g., [29, 48]). Fox et al. posit, "menstruation can be understood as an assemblage—of one's own bodily experiences, the tools one takes up to make sense of them, the actions one might be prompted to partake in as a result of tool use, wider social norms and expectations, and the standards the developers project and reinforce through the protocol of the app" [37]. Thus, a personal informatics approach does not alone account for the role and potential impact of the user's social ecology [16], including the stakeholders who otherwise play a pivotal role in menstrual journey, e.g., parents, partners, siblings, and peers [26, 101]. In recent attempts, researchers have explored designing menstrual and fertility trackers for the *shared space* to initiate conversations on the subject [33, 46, 49]. However, these attempts primarily focused on the menstruator with optional to no involvement of others.

Our research views a menstruating body as evolving and experiencing different transitions throughout the menstrual journey from menarche until menopause. We extend the ongoing discourse by

taking a *long* view [61] for studying menstrual tracking practices of menstruators at different points along their menstrual journeys in an urban Indian context (see [99–101]). Based on our engagements with menstruators, we also identify key relationships which play a critical role in shaping an individual's menstrual tracking practices throughout their menstrual journey.

2.2 Menstrual Dignity, the Body, and HCI

> "All persons, regardless of rank or social class, have an equal intrinsic worth or dignity. Human dignity is an innate worth or status that we did not earn and cannot forfeit."—Immanuel Kant (cited in [44])

The concept of dignity is central to Universal Declaration of Human Rights [74]. That said, people's understanding of the concept of dignity differs widely [55]. Historically, the term has been associated with different and/or opposite meanings [55, 86]. Different fields have associated dignity differently (e.g., dignity and spirituality, dignity and clinical studies, dignity and human rights, etc). Mccrudden posits, "the meaning of dignity is context specific" [70]. In this work we examine dignity at the intersection of menstruation and human rights—menstrual dignity.

According to a 2017 report on menstrual health management and human rights by WASH United, menstrual dignity means menstruators do not have to compromise (or be denied of) their basic human rights on the pretext of menstruation—a biological phenomenon [104]. The report posits a correlation between menstruation hygiene management (MHM) and right to health, education, and work. According to the human rights framing, poor MHM constraints menstruators from fully participating in society [13]. The lack of an enabling environment (across professional and everyday settings) for managing menstruation safely and with dignity leads into a barrier to gender equality [104]. The MHM advocates across the globe assert that without good 'hygiene and management' other human rights are in jeopardy [13]—"most importantly of the right to human dignity, but also the right to non-discrimination, equality, bodily integrity, health, privacy and the right to freedom from inhumane and degrading treatment" (cited in [43]). Thus, the international organizations, NGOs, and practitioners in the field actively work towards ensuring easy access to infrastructure (including toilets, water, soap, and sanitary products) to facilitate safe and dignified management of menstruation to avoid shame, embarrassment, and the loss of human dignity [13].

Following Kant (see the epigraph above) [44], it can be argued that if dignity is innate then it cannot be compromised due to our biology (menstruation in this case). Although using a human rights framework has garnered much needed attention (discourses and funds) on a conversational taboo topic, Bobel critiques the social construct of menstrual dignity by asking "if menstruation is normal and healthy, why must it be managed to ensure dignity?" [13]. The author pushes back on *how* the framework is being used, where the human right devolves to the right to privacy that, if secured, enables one to pass as a non-menstruator (to escape stain stigma). The MHM's message to its core is "menstrual concealment is a human right" saliently promoting that "without products, it appears, dignity is out of reach" (ibid).

We can attribute the tension in the trope of dignity to operationalise a human rights framing to the concept of dignity being "complex, ambiguous, and multivalent" [55, 73]. Taking stock of multidisciplinary writings on dignity, Jacobson posits two distinct but easily conflating meanings of the concept—*human dignity* and *social dignity* [55]. The author (re)defines the Kantian conceptualization of dignity as human dignity which is innate, inalienable, cannot be destroyed, nor it is contingent, conditional, contextual, or comparative. Whereas social dignity is grounded in human dignity and one experiences, earns or bestowed through social interactions. Social dignity can further be characterised as *dignity of self* and *dignity-in-relation*. The dignity individual attaches to oneself often mirroring the "dignity they see (or fail to see) in the eyes of others" during social interactions is *dignity of identity* or dignity of self (ibid). The social dignity can also be viewed as dignity-in-relation to an individual (value/worth we reflect towards an individual through words or deeds), and time and place (the way dignity is embedded in spatio-temporal fabric) (ibid).

Using Jacobson's distinction [55] we can see that social construction of the menstrual dignity is reduced to preserving "human dignity through privacy". It is this framing of human dignity which Bobel [13] criticises by highlighting following flaws—(1) a unilateral approach of *privacy–>no evidence of menstruation–>no shame–>dignity preserved;* (2) menstruation is collapsed to include only the bleeding period (5–7 days) of the whole cycle; (3) fails to capture cultural diversity (e.g., menarche is celebrated in south India [94]) by promoting western standard of embodied care, i.e., non-menstruating (male) embodiment; (4) fails to challenge the underlying root cause, i.e., the social construction of menstruation as taboo which leads to negative period experiences (embarrassment and discomfort); (5) views menstrual body as a site of reform which requires hyper-regulation/control/discipline and not the structures, ideologies, and social interactions. Bobel calls for building intellectual infrastructure rather than only focusing on providing civic infrastructure to manage menstruation safely and privately—"spending more time on education [i.e., body-positive menstrual literacy] and less time on cleaning up the body is a step in the right direction" [12, 13]. The onset of the Covid-19 pandemic led to further marginalization of menstruators [103], making a stronger case for working towards nurturing "an enabling sociocultural environment for those who menstruate" [7]. It has become imperative to discard the *human dignity* framing and embrace the *social dignity* trope when designing interventions for positive period experiences as explained by Bobel, "the intervention we need is transparency—forthright, matter-of-fact, inclusive, evidence-based, honest engagements with bodies in their unique, diverse, and dynamic social context" [12, 13].

Recent years have seen HCI scholars exploring new ways of associating with "bodies in/with/through technologies" embedded in social contexts [3, 91]. Researchers are actively practicing menstrual activism (e.g., [37, 77]) and leveraging embodied interactions (e.g., [8]) to understand, support, and build positive relationship with menstruating body to facilitate positive period experiences. For example, researchers have explored the concept of *intimate touch* to promote embodied interaction with the menstrual body and its bodily fluids [8]. Woytuk et al. leveraged the modality of *touch* to facilitate (re)construction of knowledge about the self by

bringing close to one's menstrual body and nurturing an appreciation for the changing body [18]. Similarly, Menarche Bits is an open prototyping kit centred around soma design to engage young menstruators in designing embodied menstrual technologies to support them in "trusting their menstruating bodies" by focusing on the movements of the menstruating body [90].

Taking an activist stance, scholars have stressed on acknowledging and accounting for the multiplicity of the body, identities, action (e.g., menstrual sensemaking) when designing menstrual technologies [4, 37, 58]. Homewood posits reframing the menstrual cycle as a feminist and not androcentrically biased design problem with inclusion and choice of the individual at the core while acknowledging that there is no single clear feminist framing of the menstrual cycles as a design problem [47]. The author suggests, "it is equally as feminist for women to choose to conceal their menstrual cycles, aligning themselves to the second-wave ideology of transcending their biology, or for women to bleed freely in public and choose not to adhere to societal taboos through discussing and displaying their menstrual cycles with pride." However, current menstrual tracking technologies re-enact androcentric ideals, focusing on providing solutions to the same longstanding problem of the uncontrolled female body (ibid). For instance, digital menstrual trackers are sociocultural products that reflect and capitalize on the societal norm of preserving menstrual dignity by selling control over menstruating bodies [24, 48, 68, 69]. The current menstrual tracking apps lacks adequate menstrual literacy support [30] missing out on opportunity to (re)define a positive association with one's body [24] and create body awareness of *others*. For creating "greater awareness and respect" for menstruators and their agency to make decisions over their bodies and lives, menstrual health education is the key [32, 69]. Taking a stance against the social construction of menstrual dignity, we revisit the design of digital menstrual trackers as a pathway towards period-positive ecologies.

2.3 Nussbaum's Capabilities Approach

Martha Nussbaum's capabilities approach [78, 79] directs attention to struggles of experiencing life as a woman, promotes an adequate analysis of it, and makes pertinent recommendations for actions packaged as *central human capabilities*. Nussbaum posits a set of ten central requirements in the form of capabilities (freedoms or opportunities) as a social minimum for an individual to live a life that is worthy of human dignity, making it a fitting choice for our study. A society that falls short of guaranteeing central capabilities at appropriate threshold levels falls short of being a fully just society. The capabilities approach is structured to support multiple realizability, i.e., they can be interpreted and concretely articulated as per the context of use [78]. The list of central human capabilities includes (1) **bodily health** and (2) **bodily integrity**, which for our study translates to menstrual and reproductive health, menstrual mobilities, and sexual and reproductive health rights (SRHR) [78]. Next are (3) **senses, imagination, and thought**, (4) **practical reason**, and (5) **emotions**, which are associated with menstrual literacy shaping liberty of conscience and expression without anxiety and fear of stigma. Then there are (6) **affiliation** and (7) **life** directly associated with having meaningful relationships, allies, and period-positive environments where a menstruator's life is not reduced to be worth living by creating stigmatized identities. The remaining are (8) **other species**, (9) **play**, and (10) **control over one's environment**. Nussbaum points out that the list comprises combined capabilities connected to one another in many complex ways. Realizing these capabilities entails asking what an individual is able to do and be, given the opportunities and liberties, while evaluating the available resources and how they support (or not) the individual to function truly humanly (ibid).

Although Nussbaum's central capabilities approach is criticized as a reductionist approach [84, 92], Kumar et al. demonstrate how it can serve as "a productive starting point for understanding women's wellbeing in the Global South because it goes beyond economics discourse and requires attention to women's specific contexts that might support or inhibit the capabilities" [61, 85]. Scholars have also engaged with Nussbaum's approach to (re)evaluate SDGs [45, 75], explored the relevance of the approach for designing technology for development purposes [59, 81, 82], applied the capabilities approach to healthcare contexts [63] and more recently to assess women's health in Global South contexts [61, 93]. We extend this body of work by drawing on central human capabilities to propose sociotechnical recommendations for designing digital menstrual trackers as capability-building tools to build period-positive ecologies. Our choice to engage with this approach aligns with Kumar et al.'s call to "shift focus from women's health to wellbeing" [61].

3 METHODS

We conducted our research in Delhi, India, in collaboration with Sachhi Saheli—a non-profit organization (NGO) that has been working closely with the state government on providing menstrual health education for the past four years [87]. Our study, approved by the IIIT-Delhi's Institutional Review Board, was conducted between February 2019 and August 2020. Taking the long view to health and wellbeing [61], we examined the menstrual tracking practices of women menstruators across ages (12–65 yrs.) and at different stages in their menstrual journeys (adolescence, adulthood, and menopausal years) using a combination of methods. Thus, for analysis, we distributed our participants into *adolescence* (up to 18 yrs.), *young adulthood* (18–39 yrs.), and *menopausal years* (40 yrs. and above) per the mean age at marriage [80], childbearing age groups [20, 52], and perimenopausal age in India [1].

We conducted a preliminary survey to develop a basic understanding of prevalent menstrual tracking practices in our study context. Corroborating insights from the survey and existing literature [99, 100] informed our overall study design. Next, we conducted detailed surveys with adolescents and adults at scale, and concurrently reviewed available menstrual tracking apps to curate a set of features/services being offered to support menstrual tracking. Insights from the surveys (e.g., need-based menstrual tracking practices and low engagement with digital menstrual trackers) and the taboo nature of our study topic shaped the need for further engaging with our participants via non-traditional methods. Aligning with Gaver and colleagues' [41, 42] recommendation for using cultural probes, we designed different cultural probe workshops for menstruators at different stages of the menstrual journey. However, with the onset of the COVID-19 pandemic, we could conduct only one of the planned workshops with adolescents. We revisited

Method	Age (yrs.)	Annual family income (USD)	Smartphone	Menstrual journey stage
Preliminary survey (27)	Min 19, Max 45, Median 24	Low: <$11K (6), Middle: $11K–$26K (11), >$26K (7), No response (3)	Personal (27)	Young adulthood (25), Menopausal years (2)
Adult survey (210)	Min 18, Max 58, Median 25, No response=24	Low: <$11K (42), Middle: $11K–$26K (77), >$26K (54), No response (37)	Personal (210)	Young adulthood (25), Menopausal years (16)
Adolescent survey (220)	Min 12, Max 17, Median 14, No response 31	Low: <$11K (136), Middle: $11K–$26K (18), >$26K (1), No response (55)	Personal (53), Shared=157	Adolescence (210)
Cultural probe (10)	Min 14, Max 17, Median 15	Not applicable as we recruited participants from a foster care NGO	No ownership (9), Shared (1)	Adolescence (10)
Remote interviews (16)	Min 21, Max 65, Median 37	Low: <$11K (4), Middle: $11K–$26K (5), >$26K (7)	Personal (16)	Young adulthood (12), Menopausal years (4)

Table 1: Demographic details of our participants across different methods. We recruited participants using a combination of convenience sampling and purposive sampling [31]. For each method, we began by explaining the study objective to our participants, followed by seeking written consent from the adult participants and guardians of the minors supplemented with written assent from the adolescent participants.

our study design and decided to conduct remote interviews given pandemic-enforced restrictions. Table 1 includes the demographic details of the participants across different methods. We now present our study methods and data analysis approaches in detail.

3.1 Preliminary Survey

We conducted a preliminary survey with 27 adult women menstruators to gauge and develop an initial understanding of menstrual tracking practices in our study context. We designed the survey by building on literature [29, 99, 101] and modifying it for our suitability. The survey included open-ended and closed-ended questions about menstrual tracking (perceived importance, practices, methods, and source of information), and technology-based health tracking. For example, *"Is keeping track of the menstrual cycle essential? If yes, when should one start tracking?" "What is the best and worst advice offered to you about practicing menstrual hygiene?"* The survey was administered on paper, in both Hindi and English during a *"period fest"* organized by our partner NGO [95]. We open coded the subjective responses [15] and calculated percentages for the rest. The observed themes of *"myths and taboo," "cultural practices,"* and *"irregularity"* align with existing literature [99, 101]. Themes specific to menstrual tracking included: *"tracking mentally," "never felt the need," and "did not find app useful."* 70.37% respondents mentally tracked their cycles, and only 37.04% reported using tracking apps, similar to the pattern reported by Tuli et al. [101]. However, 66.67% of participants acknowledged the importance of menstrual tracking, and 70.37% believed menstruators should track since the onset of menstruation. These initial insights shaped and informed our study design towards developing a deeper understanding of menstrual tracking practices of urban Indian women.

3.2 Survey with Adolescent and Adult Menstruators

We conducted different set of surveys with adolescents and adult menstruators to understand their knowledge, experiences of, and practices around menstrual tracking. Both the surveys were iteratively co-designed with members of Sachhi Saheli including a gynecologist and menstrual educators. The surveys included questions gauging menstrual tracking practices, menstrual literacy, use of health technologies, demographics, and filter questions. The filter questions were aimed to capture the respondent's stage in their menstrual journey by capturing their experience (menarche/perimenopause/menopause/none), age (current and of menarche), and gender. Some questions were multiple choice, such as: *"How do you predict your period?" "How did you come to use this method for predicting your period?" "You would feel comfortable in sharing your tracking information with who among the following?"* Others were more open-ended: *"Is there anything you particularly like/dislike about your method(s)? If so, what?" "Have you ever tried using mobile app for accessing period related information?" "What about tracking periods do you find burdensome?"* For open-ended questions, we open coded the responses and conducted thematic analysis of the same [15]. Examples of codes included *"stain stigma," "discomfort," "irregularity," and "lack of menstrual literacy."* The remaining questions were analyzed by calculating percentages and cross-tabulation [60] to view how respondent's experience affects the response. Example included cross-tabulation of *"Is sharing the menstrual tracking information with partner/parents/family members beneficial?"* with *"You are comfortable in sharing your tracking information with who among the following?"*

The adult survey was developed in English and administered online, where we recruited participants through email, WhatsApp, and Facebook. Our partner NGO helped us recruit adolescent participants as they have approval from Delhi Government to conduct surveys and workshops in government schools. The survey was developed in Hindi, administered in school and home settings in four different sites across North, South, and West Delhi. The responses were later digitized and translated into English for the analysis. We received 301 adolescent survey responses and 281 adult survey responses. We eliminated responses of prepubescent participants, unit non-response with only the demographic details, and incomplete responses using listwise deletion [62] following NMAR (not missing at random) pattern. The cleaning process resulted in a dataset of 220 adolescent responses and 210 adult responses.

Figure 1: Our team designed a Period Journal (fig. b) for cultural probe investigation with adolescent menstruators. Our participants' association with menstruation is evident in their Journals' decoration (camouflaging the statement—'my period, my friend'), including explicitly voicing their hostile feelings through text (fig. d). Later we used images in fig. (a [9]) and fig. (b) as probes during remote interviews with adults as ice-breakers and to offer a vocabulary to our participants given the topic of sensitive nature.

3.3 Cultural Probe Investigation

To understand how adolescent menstruators practice, visualize, and relate to menstrual tracking, we conducted a cultural probe investigation [41] through a workshop with ten adolescent girls (see table 1). We recruited the participants from Udayan Care, an NGO supporting several family homes, which provide shelter to adolescent girls and are responsible for their education and wellbeing [19]. We took ethical clearance from the NGO for the workshop, where we used a Period Journal as our cultural probe. The Period Journal, designed by our team, included–stickers (including sanitary products, flow, snacks, and smileys), monthly calendars, and blank pages. As shown in the fig. 1, the front cover includes a tagline 'my period my friend.' The workshop spanned four phases over four hours, with a break of 10 minutes separating each phase. We began by administering the paper-based survey, which served as an icebreaker, followed by an open discussion based on their survey responses. We primarily gauged if they have attended any educational workshop on menstrual health, access to sanitary products, and period tracking practices. We introduced the Period Journal in the second phase and asked our participants to decorate it using art and craft materials. The focus of this exercise was to instill a sense of belongingness and gauge their response to the printed tagline. In the third phase, we asked the participants to mark their period days for the last two cycles in the Journal calendar using colors/scribbling/stickers. The objective was to gauge if and how our participants remembered their period dates. Finally, we asked them to predict and mark the date of their upcoming cycle. We wanted to understand if our participants were familiar with calculating menstrual cycles and, if not, familiarise them with the steps. We (re)visited the concept of the menstrual cycle and asked our participants to re-calculate and (if required) update their predicted cycle dates. We handed the Period Journal to our participants and revisited the NGO after two months. Using semi-structured interviews, we gauged engagement with the Journal. We used a mix of Hindi and English, depending on our participants' comfort and preference. We collected data in the form of field notes and photographs of their Journals, which were analyzed using inductive thematic analysis [15].

3.4 Remote Interviews

We conducted remote interviews with 16 women following a narrative approach [28], where we aimed for a balanced sample across age groups and experiences (see table 2). These interviews aimed to understand our participants' engagement with menstrual tracking by soliciting their lived experiences across different transitions of the menstrual journey. We started by asking, *"How has been your menstrual journey up till now?"* and followed up with clarifying questions further to gauge the role of menstrual tracking throughout their journey. For example, *"When did you first realize that it is essential to track one's cycle?" "Do you feel that tracking since the early years would have made any difference to you and your menstrual journey?" "What are your thoughts on the tagline in the shared images (fig. 1 (a,b))?"* We also engaged our participants in speculating suitable tracker(s) for their lived menstrual journey transitions. For example, we asked participants in their menopausal years to reflect on the design of a menstrual tracker first for their adolescent self, then how they would change it to make it suitable for their sexually active self, and finally, to assist them in their menopausal years. Given that we were discussing a sensitive taboo topic over remote interviews, we used a set of functional features available in prevalent menstrual and menopause tracking apps (see section 3.5 and table 3) as a starting point for discussion while offering a vocabulary to our participants.

We conducted interviews in Hindi and/or English, remotely over audio/video calls, as per the participant's comfort and convenience. The interviews were audio-recorded and later transcribed in English for the analysis. We collected data in the form of notes and audio recordings. The audio data was transcribed in English and analyzed using inductive thematic analysis [15]. We read and open-coded each transcript line by line. The sample codes included: *"physiological constraints," "taboo and stigma," "irregularity," "peer support," "period companions," "mental tracking," "compromise," etc.* The open codes resulted in 46 axial codes over multiple iterations, which guided the structure of our findings section. The sample axial codes include: *"discipline the body," "body as alarm," "periods are adjustment," "experiential information is valuable," "intimate data sharing," "teens and tracking," "aspired digital tracker,"* etc.

Names	Age (yrs.)	Menopause stage	Menstrual condition	Sexually active?	Planning pregnancy?	Contraception	Using menstrual tracker?	Profession
Pihu	21	Not started yet	PCOD	No	No	NA	Used for a limited time	Student
Mahi	22	Not started yet	Not disclosed	No	No	NA	Used for a limited time	Student
Rafia	25	Not started yet	Heavy flow	No	No	NA	Yes	Student
Alia	28	Not started yet	Boderline PCOS	Yes	No	Condoms	No, never felt any need	Social worker
Diya	29	Not started yet	Irregular cycle	Yes	No	iPill/condoms	Yes	Homemaker
Baani	30	Not started yet	Irregular cycle	Yes	No	Condoms	Yes	IT Professional
Payal	30	Not started yet	Irregular cycle	Yes	No	Implant	No, but willing to try	Homemaker
Farah	34	Not started yet	Not disclosed	Yes	No	Pull-out method	No, but willing to try	Social worker
Juhi	37	Not started yet	Irregular cycle	Yes	Never	Condoms	Used for a limited time	Artist
Jasmin	38	Not started yet	Fibroids	No	No	NA	No, never felt any need	IT Professional
Priya	40	Not started yet	Not disclosed	Yes	No	Condoms	No, but willing to try	Health professional
Meenu	44	Perimenopause	Not disclosed	Yes	No	Implant	Yes	Baker
Kiran	45	Not started yet	Not disclosed	Yes	No	Never used	No, never felt any need	Homemaker
Reena	54	Perimenopause	Not disclosed	Yes	No	NA	No, never felt any need	Homemaker
Mala	61	Postmenopause	Hysterectomy	NA	NA	NA	It was unavailable	Designer
Sadhna	65	Postmenopause	Hysterectomy	NA	NA	NA	It was unavailable	Retired professor

Table 2: This table includes our interview participants' detailed demographic information, including self-described details about the menopausal stage and menstrual conditions. All names are pseudonyms.

3.5 Review of Menstrual Tracking Applications

The objective of our app review was to build a dataset of functional features available in popular mobile apps around menstrual tracking. This dataset was later used in remote interviews for probing and facilitating speculation of the design of aspired digital menstrual trackers. We conducted a systematic review of mobile apps related to menstruation available on the Android play store on February 20, 2019, as the majority of the population are android smartphone users in our study context [57]. We used eight search keywords: *"menarche," "first period tracker," "period tracker," "period cycle," "period diary," "menstrual tracker," "menstrual cycle," and "menopause."* These keywords resulted in a total hit of 1964. We included free apps designed explicitly for menstrual, fertility, ovulation, and menopause tracking and developed in English/Hindi/Indian regional languages. We excluded the apps designed for pregnancy tracking, parenting, gestacional, or iPill tracking. We identified 318 unique apps after removing redundant hits across keywords and cleaning the data using our inclusion and exclusion criteria. Next, we curated an overall list of popular period tracking apps by including the apps with 1M+ downloads and 4+ ratings, resulting in 29/318 apps. Similarly, we curated a subset of popular period tracking apps for teens (9/318) and another for menopausal years (25/318) by reading the detailed description of each of the 318 apps. We identified the top three apps in each category by calculating the cross-product of star ratings and the number of ratings for each app. We then conducted a walkthrough [66] of all the nine apps (see table 3) to extract 28 features. The sample features include *"symptom logging," "period logging," "reminders," "pattern visualization," "exporting data," "forums," "blogs," "articles," "contact experts," "reminders," "notes," "pregnancy mode," etc.* We then performed affinity mapping on these features to identify broad feature categories that we used as probes in remote interviews (see table 3).

3.6 Data Triangulation

We followed the triangulation-convergence model [27] to triangulate the learnings from multiple surveys and the menstrual tracking experiences of menstruators at different points of their menstrual journey collected and observed via interviews and cultural probe investigation. We collected and analyzed data from different methods separately before converging to the findings by comparing and contrasting the different results. The cultural probe investigation and remote interviews provided us with the data to study menstrual tracking practices taking the long view, i.e., throughout the menstrual journey (RQ1 and RQ2). We used the extracted features from the app review first to probe and later as a reference point to analyze our participants' experiences with and aspirations of digital menstrual trackers (RQ3). The responses from different surveys were mainly helpful in corroborating our findings across the methods (RQ1–RQ3). Our triangulation approach using datasets collected via various methods validated and strengthened our findings.

3.7 Positionality

All the authors are of cisgender and Indian origin and have had their own emic and etic experiences with the (partner/peer's) menstrual journey. This work is an outcome of 2.5 years of active collaboration

Application dataset	*Popular period tracking apps:* Period Tracker, Flow, and Clue *Period tracking apps for teens:* Teen Period Tracker, Oky Period Tracker App for Girls (UNICEF), and Diva App *Tracking apps for menopause:* My Luna, Hot Flash Sisters, and Menopause Tracker
Extracted features	*Physiological modes:* Basic period tracking, planning pregnancy, perimenopausal, and post-menopausal *Tracking physiological changes:* Flow, headache, mood, products, and more *Annotations:* Notes and personalized tags *Reminders and cycle patterns:* Data visualization *Buddy mode:* Sharing app with parents/partner/siblings/professional caregiver *Export data:* Share only specific data with specific person *Learn section:* Educational information through articles, daily tips, and more *Expert and community support:* Chat, forum, blogs, and more *Account creation:* Mandatory registration, onboarding, and data backup

Table 3: We identified the top three menstrual tracking apps in each category (top row) by calculating the cross-product of star rating and #user ratings for each app. We conducted a walkthrough of each of the nine apps to build our feature set.

among researchers and practitioners working on menstrual wellbeing and women's empowerment. Our team includes a gynecologist, trained menstrual educators, and HCI researchers working towards designing technology for prioritizing the interests of marginalized groups. We conducted this research leveraging an emancipatory mindset. Our data interpretation is likely to be biased by our strong desire to dismantle the social construction of the menstruating body as deficient and in need of 'control.'

4 FINDINGS

We organize our findings into four sections below. First, we take a long view of menstrual tracking practices, i.e., from early adolescence to menopausal years. Taking this view of the menstrual journey helped us to unpack evolving associations with menstrual tracking based on life choices, transitions, experiences, and access to menstrual literacy. We then discuss the innovative methods menstruators leverage to track and interpret their cycles. Next, we unpack the relationships that influence and shape their associations with their body and menstrual tracking practices throughout the menstrual journey. Our last section presents aspirations of digital menstrual trackers that emerged in our data, as participants discussed their experiences with available digital trackers.

4.1 Tracking Through the Menstrual Journey

During the initial years of the menstrual journey, menstruators primarily associate their cycles with *"discomfort", "pain,"* and *"burden"*, attributing to the lack of menstrual literacy [101]. This association was also evident in our cultural probe investigation where adolescent participants could not relate with the tagline—'my period, my friend'—printed on the cover of the Period Journal and thus covered the statement partially or entirely using craft material (see fig. 1). Only 2/10 participants used the Journal for logging their cycle, and the rest used it as their personal diary. On being probed, one of the participants described how she did not want to *"spoil"* her well-decorated diary by writing about periods as she finds them *"painful and discomforting."* We observed that the menstruators during adolescence view(ed) tracking as *"unimportant"* and *"did not take their periods seriously"* unless they are sexually active. For instance, only 10% of adolescent survey respondents reported tracking their cycles, whereas 21% said they often forget to track. Pihu (21 yrs.), reflecting on menstrual tracking during adolescences elaborated,

> *"I would have been apprehensive to do that [track] maybe because it feels like a task to have to do it, and I didn't feel it so important to do it so I would just avoid it. I think I never took them seriously enough. I think definitely when you get sexually active, that's when one starts taking it seriously."*

While reflecting on their menstrual journey, more than half (59.52%) of our adult survey participants and all our adult interview participants concurred: *"ideally tracking should be done since menarche, because you should know your cycle. Ideally, that should always be the case"* (Juhi, 37 yrs.). However, in practice, our participants did not pay much attention to their menstrual cycle, as explained by Diya (29 yrs.):

> *"There is always a rough idea, I am not particular about my dates. I think generally, we as Indian girls do not pay attention to if there is any irregularity. We are like 'ho rahi hnu na down' (I am getting my periods), that's it. We don't consider it as a big of an issue."*

Instead, menstruators adopt formal tracking if they have a specific reason—event and/or goal—including medical diagnosis, self-observed cycle irregularity, embarrassing experience, or once they are sexually active. Our data revealed that menstruators actively practice goal-driven menstrual tracking to either avoid or plan a pregnancy:

> *"Except for pregnancy, I don't think there is any value [in tracking]. In the sense of pregnancy, I mean who wants to conceive and who does not want to conceive. That is the only reason, else I don't see any logic for it [tracking]. It is normal, it is going to happen, and your body will alarm you definitely." (Jasmin, 38 yrs.)*

Self-diagnosed cycle irregularity is the second prominent motivator, with 30.95% of our adult survey respondents reported adopting tracking on observing cycle variation like Baani (30 yrs.)—*"so I keep track of my date using notes [app]. Oh, I, myself, started doing that because it was worrying me when they were irregular. So I just use to keep track like okay, let's see what is happening to me."* For a few menstruators who tracked to keep a tab on their reproductive health

and overall wellbeing, any irregularity was as a sign to reevaluate routines and habits as quoted by Pihu (21 yrs.), *"[irregularity] is indicative that you are taking too much stress and not eating right. I do keep track now so that I keep telling myself to exercise more, you are taking too much stress, you need to calm down."* Here, tracking also helped in making an informed decision about when to visit a gynecologist and (re)schedule daily routines around the bleeding days—*"I just try to avoid workload during the first two days as I just feel like resting, and I want my hot water bottle. Therefore, if I have some work, then I try to finish it before my periods start. I resume my work on the third day properly. But first two days I prefer giving my complete body rest. So tracking really helps me"* (Diya, 30 yrs.).

We observed that menstrual tracking has a deeper value and meaning associated with it beyond just tracking reproductive health. The participants' use of words like *"accepted," "adjusted," "part of life,"* and *"burden"* while reflecting on their menstrual journey indicated struggle to cope with menstrual physiology (bleeding and staining) and associated social consequences. Prior work has highlighted how menstrual mobilities are heavily shaped and affected by the prevalence and severity of stain stigma in our study context [100]. We observed menstruators (and their mothers during adolescence) taking up and relying on menstrual tracking to navigate menstruating years responsibly by being *"prepared,"* to avoid embarrassing situations or *"accidents"*, thus propagating the status quo of 'disciplining' the menstrual body in hindsight:

> *"She [mother] took it on herself to track it down, and she would say if Papa gets to know, then it's wrong. So I was always scared that if mom gets to know that I stained, she will scold me. She was so cautious that 'kisi ko pata na chal jaye' (nobody should get to know)"* (Priya, 40 yrs.).

We observed our participants saliently using tracking as a tool to practice the fundamental right to body autonomy. Building on their experience, 16.67% of survey respondents in the menopausal phase compared to 3.05% in the young adulthood phase emphasized adopting tracking once sexually active. Given the cultural expectation in India around sex without marriage, marriage and childbearing, lack of sexual education, and not easy access (finance and stigmatization) to gynecologist, we observed menstruators use menstrual tracking as a natural birth control technique—*"I need the tracking, not for conceiving, but yes, for avoiding the pregnancy"* (Jasmin, 38 yrs.). In some cases, tracking for fertility empowered our participants to achieve stability in intimate relationships:

> *"My sister-in-law wanted to conceive as soon as possible as this is her second marriage. So she was getting insecure within 3-4 months of marriage given the normal Indian mentality that 'bacha hojaega to ladki settle hojaegi ghar me' (with childbirth, the girl will get settled in the in-laws house). I recommend her an app to track ovulation. So she tried this app, and it led to a successful pregnancy." (Meenu, 44 yrs.)*

The above quote also shows that our participants were open to trying formal tracking and/or specific tracking methods recommended by someone they trusted. Among our adult survey respondents, 17.62% are following the tracking method recommended by mother, 16.67% by close friends/sister, and 4.29% by doctors. Cross-tabulation of survey responses revealed that mothers primarily promote mentally calculating the approximate dates without detailing the 'how'—the process of tracking and alternate mediums, whereas close friends primarily recommend digital trackers.

We observed that the menstrual tracking pattern did not change much with transitioning into menopausal years. 33% of menopausal survey respondents mentioned forgetting to keep track of their cycle, and 16.67% said they did not feel the need to track their cycle at all. The ones who tracked their cycle continued with their tried and tested tracking methods (see section 4.3) and did not track any additional parameters (like hot flashes) other than the date of their periods, given the sporadic nature of periods during menopausal years. For example, Reena (54 yrs.) shared, *"all these things [physiological changes] stay in my memory. Since starting, I have kept it in my mind. The only thing I struggle to remember is the exact date. That is why I mark it on the calendar. Rest I feel that feeling hot is part of the routine."*

4.2 Prevalent Menstrual Tracking Methods

The most prevalent menstrual tracking approach is informal tracking, where 61.39% menstruators across ages reported relying on their body—memory and physiology—to track the cycle. It is a common practice to retrace the start date by some occasion/event, i.e., *"if something memorable happened during my periods"* (Rafia, 25 yrs.) and lookout for bodily cues (like acne, cramps, headache, heaviness, and more) signaling the upcoming cycle:

> *"With me I believe my body gives kind of hints that you are about to get your period. Different symptoms or hints every time, it's not fixed [...] Sometimes I get severe mood swings a day or two before my periods, other times I experience pain in my leg, or sometimes I get a headache" (Rafia, 25 yrs.)*

However, only relying on the body for cues might lead to loss of health and beyond, as experienced by Priya, (40 yrs.),

> *"It is a problem, there's no [body] sign [...] I wish there was some cue. Because of this problem, I even missed my pregnancy thrice. The first time, I did not know I'm pregnant. It was like eight weeks had passed and I had not been taking any precautions as I was traveling. And whenever I'm traveling, I skipped my period. I went to the doctor only when I had miscarried. I had this pain in my stomach and went. She said, you had a miscarriage, and I said I didn't know I'm pregnant because I was traveling. Second time also I was traveling, I skipped my period, and I was pregnant. But again, I learned about my pregnancy in the seventh week because I was skipping periods while I was traveling, which is really common to me. Even third time again, I skipped [periods] and, I had a miscarriage because I didn't get to know. So, I feel helpless."*

Half of our interview participants and 95.23% adult survey respondents have tried formal menstrual tracking at some point in their journey. However, only 37.5% of interviewees reported regularly tracking their cycles, and 21.43% of survey participants acknowledge often forgetting to track their cycles. 77.61% of our adult

survey respondents mentioned that they themselves figured out the tracking methods like period tracking apps (70.55%) and devised hacks including using digital calendars (19.63%), paper-based calendars (12.88%), and notes on a diary (5.52%) to track their cycle. These menstruators rely on online spaces to seek information around menstrual tracking methods (28.22%). Although our survey showed low reliance on paper-based methods, the choice of tracking medium (paper-based or digital) is driven by convenience, comfort, and negative experiences with tracking medium. For example, Rafia (25 yrs.) shared, *"I feel like it is too much work. First, find a calendar, find a pen and then mark a circle. That is not it. Then again, go back to the calendar, especially seeing and calculating my upcoming date. So I did not do that. Then I got to know about mobile apps, and I tried using a few."* Further elaborating on her decision to switch away from mobile apps to a smartwatch based tracker, Rafia (25 yrs.) said,

> *"It [mobile app] used to ask me many questions, including about my intercourse. So I didn't find them relevant enough for me. So I just stopped using it. Now when I look back I think it's a matter of convenience [...] all I have to do now is tap on my wrist [smart watch] and answer a few questions, and my job is done."*

We observed that digital tracking is not confined to menstrual tracking apps. Some participants, including 9.05% of adult survey respondents, preferred using other apps like *"mark it in WhatsApp chat"* and Notes to log their period dates, *"so I used to, I like to keep track of my date using Notes. No, I never used to mention [the word] periods. I just used to write down the date, say 24 June, right, and the next time my periods start, I used to overwrite the previous date" (Baani, 30 yrs.)*. For traditional paper-based tracking, marking on calendars (specifically kitchen calendars) and the personal diary are two popular approaches. For example, Alia (28 yrs.) shared, *"I still stick to my diary. I mean though we have apps, I am a pen and a paper person. I am more comfortable with my diary than an app."* It was interesting to observe that different participants used different visual codes to mark (primarily) the first day of their cycle. The choice of code ranged from putting a dot, cross, and the initials of the names. Probing revealed that all our participants felt that periods are personal and thus the code is meant for them, only to remind them, as expressed by Priya (40 yrs.),

> *"So I would mark in my kitchen calendar, or my calendar diary. I would just, you know, put a dot or put a cross there. So that I remember, I did not want others to know. So I knew what a dot or a cross means. It is not like someone would see because I know it's my diary and nobody will open my diary. It was just for me."*

Different participants tracked the cycle parameter differently. Few participants logged (formally and/or informally) both the start and end date, whereas many were only interested in logging the start date—*"the main thing is to remember the start date. Suppose it was the 3rd of last month, then I mentally calculate my next cycle plus or minus 3–4 days. So, this time it might come on 30th or 31st or maybe someday between 4th–6th." (Farah, 34 yrs.)*. The others took an even more casual approach by only remembering if they had a cycle in the previous month (or not), quoting the irregularity of their cycle. Pihu (21 yrs.), shared her workaround hack for tracking her cycle given her diagnosis of PCOD/S.

> *"I never kept a proper log date-wise. It was more around months like oh happened or this month not. When this recent cycle irregularity happened, I started doing it date-wise like this date it started, and this is the end date. The next time I noticed that it happened a week later from the first date, I take that as approximately as far as I can predict [...] I use a digital notepad to note the exact start and end dates."*

Apart from the cycle date, our participants rarely tracked other parameters. In cases where they did, it was because they experienced severe physiological symptoms—*"in addition to dates, whether the cycle is regular, whether we experienced headaches, dizziness, or pain in the legs, we should note all these things if we face all such issues"* (Kiran, 45 yrs.).

4.3 Companions: Experiential Information and Care Support

> *"In your family, if you are unmarried or even married, there needs to be at least one person who knows about menstrual health and is responsible also so they can identify that if it [cycle] is abnormal and pushes to get it checked by the doctor. So, there should be one support system in the family, at least a supporting hand who is knowledgeable and cares for you." (Farah, 34 yrs.)*

With the tabooed treatment and no open conversation on the subject [101], a few relationships are vested with the power of playing a pivotal role in shaping a menstruator's menstrual journey. This section presents these relationships and the extent to which they exercise their power (intentionally and/or unintentionally).

4.3.1 Mother–The First Menstrual Companion. Since pre-pubescent years, preparing the child for menstruation is primarily seen as a mother's responsibility [101], including keeping a log of their adolescent's menstrual cycle as evident in the following quote by Diya (29 yrs.):

> *"She [mother] used to take care of my initial days. She used to track it. I am sure she did something as she remembered my dates alongside her dates [...] in school days I missed my periods for one month. So I approached her to check if there was something wrong. She was the one who would have helped me with that, maybe by taking me to the doctor. So, I have shared everything regarding the period directly with her."*

Menstruating guardians (predominantly the mother) are laden with the responsibility of playing an active caregiver for menstrual health and hygiene needs until the adolescent becomes self-reliant. For example, one of our participants shared how she was careless throughout her menstrual journey but was worried and concerned for her daughter, *"you know I was not keeping track or carrying a pad. In fact, I was more concerned when my daughter got her periods or years before [her menarche]" (Mala, 60 yrs.)*. Even in our cultural probe investigation, we observed that it was the responsibility of the home supervisor (guardian) to track every child's cycle by recording the start and end date in a logbook.

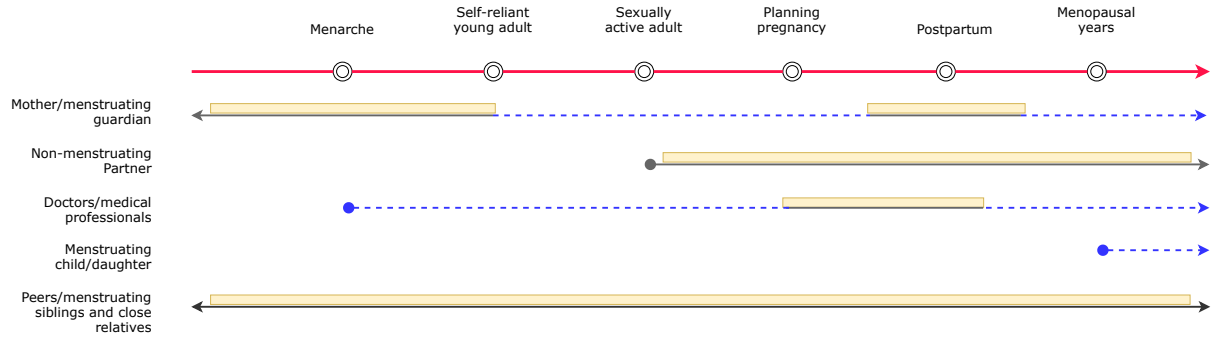

Figure 2: Menstruators engage with different stakeholders in their vicinity to seek need-based information and care support throughout their menstrual journey. Here, dashed lines represent passive need-based engagement, and the thick lines represent active engagement. The decision to involve *who, when,* and *to what extent* depends on multiple factors grounded in comfort and menstrual stigma.

With time the mother's role transitions from active to a passive caregiver, who is approached by menstruators in case of abnormality or *"issue"* with cycle and/or pregnancy. This transition is also visible in the survey data where the mother is the preferred companion for adolescents (73.18%) and young adult menstruators aged 18 to 29 years (76.83%) but is the third choice (43.47%) after the partner (71.73%) and female friends (45.65%) for menstruators aged 30 years and above. It serves as evidence that active menstrual companion(s) change through the menstrual journey, as reflected in the following survey response—*"after marriage, it is the partner only. Earlier it was mother or sister."* Sharing a mothers perspective, Mala (60 yrs.) said, *"so what happens is, if you see from the mother's perspective, slowly with time, the mothers are also maybe not keep such close tabs, because somewhere, subconsciously, you know that the child is now an adult."*

A mother plays a crucial role in developing a formative association with the body and attitude towards menstruation because she defines boundaries for a young menstruator based on culture, family traditions, and her knowledge and experience. We observed instances of menstruators celebrating their bodies and menstruation when mothers impart timely menstrual health education while offering a safe space to question and understand the body and phenomenon. For example, Alia (28 yrs.) shared, *"my mother was the sole supporter and my only goto person when it comes to it [menstruation]. There was a time my cycle was late by 20 days. My mother was very open to going to a gynae, but many of my friends told me that their mothers are not okay with them going to a gynae at such a young age. I think my mother being so comfortable about it gave me much perspective that it is not a bad thing. Like it's a natural process, and we have to treat it like any other process. If you have an infection, you go to a doctor. So, if your cycle is not constant or having a bad cycle, it is okay to consult a gynae."* Whereas, in the other instances, menstruation is initially misunderstood, seen as a burden and adjustment, until menstruators constructed their version of menstrual literacy building on their experiential information and through various resources (both online and offline). It is this self-constructed menstrual literacy that empowered our menstruators to realize their agency in pushing and challenging the boundaries set for them by their mother as described by Priya (40 yrs.):

> *"Initially, I felt like something is wrong with me. I used to feel that I am different from the rest and nobody should know about it in class. The time when I was in 6, 7, 8 grades was worst. I felt awkward throughout the month and not just when I had periods. I felt awkward within my body, and nobody explained to me. I remember nobody was talking about it. My mother would just feel upset about me getting periods so early. She did not want to talk about it. She use to feel that whatever it is, it is wrong. I got to know later this is natural, there are other people also who start early, and this is fine. It is biological. Nothing I did like playing sports would have caused me to get periods early. But that time was difficult for me [...] So in adolescence, you are dependent on your parents. I was dependent on my mother. Even if I wanted to think differently, it was very hard. When I was independent and I looked at things differently, I developed my ways."*

We also observed the power of elderly menstruating companions in shaping and influencing the menstrual journey for menstruators across generations. Elaborating on her mother, Priya (40 yrs.) further shared:

> *"My mother hasn't changed. Recently my sister told me her daughter started early (menarche) and my mother was really upset again. My mother blames, you gave her this and that to eat and because of that it started early. And I am like what? You ruined my life like this, now at least don't say all this to her."*

Interestingly, menstruators across ages reported mothers primarily instruct about menstrual etiquette and use/disposal of menstrual products but rarely share their own experiences and cycle details, as expressed by Rafia (25 yrs.):

> *"When my mother was approaching menopause, she had issues with her uterus and got it removed. Even before that, she experienced many things, but she has never talked about all this stuff with me [...] Regarding her tracking experience, she has never shared anything with me. At times, I think that if someday me and*

> *my mother sit and talk, it will be good for me because then I will know what to expect when you approach menopause. Maybe I would be better prepared for it. Like precautions to be followed or when to see a doctor."*

In rare cases when mothers did share their cycle details, they felt comfortable sharing these details only once their daughter is either married or of marriageable age, as expressed by Reena (54 yrs.), *"I have never discussed it [my cycle] with my daughter. I did not get a chance earlier as I did not find it right to talk about it when she studied [in school/college]. If a mother shares all this with her young daughter, it feels a bit shameful. Now she is married. I talk with her."*

4.3.2 Peers and Allies—The Only Constants. In our context, where menstruators receive negligible formal/informal menstrual health education [101], they seek confidants in their peers (e.g., friends and/or close relatives) and allies (e.g., doctor or/and non-menstruating allies) as explained by Pihu (21 yrs.), *"but if I don't feel comfortable in telling her [mother] because I think she won't understand or maybe she would not have a good reaction then it would really make me very uncomfortable. You know when you can not have that security from your own home then you try and search for it outside, that is when you go online or ask your friends."* Menstruators actively and constantly rely on their social circle for 'urgent need-based' information support, sharing their concerns, and seek validation of their experiences, in offline or online settings, throughout their menstrual journey. We observed a sense of solidarity among menstruators when sharing and identifying approaches to address variation in the menstrual cycle and overall menstrual wellbeing. For instance, menstruators keep returning to their support groups, specifically to the ones with more experience as they preferred and valued experiential information over expert opinion, *"elders will advise us, and it is necessary to listen to them and follow their advice as they are more experienced and have lived more days menstruating. So following their advice might help us rather than visiting a doctor. I believe we should at least try what elders say, like if they recommend any medicine or any home remedy, we should at least try it for a month"* (Reena, 54 yrs.). It was also prominent in our adult survey responses, where respondents (68.57%) who perceived value in sharing period tracking information were more comfortable and preferred sharing it with female friends (68%) over the doctor (47.22%).

In addition to peer support, our narrative data presented a salient theme where non-menstruating allies played a pivotal role in empowering menstruators to overcome their conditioning of discomfort, shame, and stigma associated with menstruating bodies: For example, Priya (40 yrs.) shared,

> *"The first empowerment in my life was when I was in grade 11. I remember going to this small karate school with a male instructor and I could openly discuss my periods with him. He was a young man of 25-26 years of age. He would openly say it in the group of boys and girls that if any one is on their first day of periods you can rest, you can sit down. So from there I learnt that its okay, I can talk about it in front of 20 people, even if they are boys and girls that I am on my periods yet I am here so I will sit and not do exercise. This karate school probably make me accept the fact that having periods is nothing to be ashamed about."*

There were also instances where medical professionals played the role of an ally (see Alia's quote below) and were the first to introduce the concept and relevance of menstrual tracking, *"my doctor familiarized me with the fertile days and how to calculate them when I visited gynae in the initial year of my marriage"* (Payal, 30 yrs.). Our data revealed that although doctors played a crucial role in (re)shaping menstruators' attitude towards menstrual tracking, they did not recommend any particular tracking mechanism.

> *"I am a 90s kid, and there were no apps that time. So I always used to mark my periods and note fluctuations [...] my friends used to think I am a big fool wasting a lot of time doing this. I used to get this a lot like 'mental hospital jao, kya karti ho ye, kyu track karti ho,' (go to a mental hospital, why do you do this?) [...] my gynae appreciated me. She said she hardly come across women who keep track of periods like this." (Alia, 28 yrs.)*

4.3.3 Partners—Companions in Menstrual Wellbeing (or Not?) [1] With time, age, and life choices (e.g., sexually active and/or married), a partner takes over the role of an active menstrual companion, a responsibility initially vested in a mother. For our survey respondents aged 30 years and above, partner (70.96%) replaced mother (48.38%) as the prominent relationship with whom they feel comfortable sharing their menstrual cycle details. Menstruators acknowledge their (non-menstruating) partners might not empathize with them entirely and primarily seek care-support and comfort from their partners throughout their journey, as Diya (29 yrs.) shared,

> *"I can share [tracking data] with both my mom and partner [...] a lady can understand what other ladies are going through. He [partner] is not going to understand up to this extent. So at max, he would see it as something that happens every month. In my case, I have observed that he acknowledges that something is happening to me so he will not impose anything. Partner become a little soft towards you during all those days, that is definitely a difference."*

However, involving a partner actively in one's menstrual journey depends on many factors, including if they are long term partners, living together, sexually active, and the partner's openness and attitude towards menstruation.

> *"I'm not married, and I am not living with anyone, so the guy I was seeing was like on and off basis. I mean, in any case, you always use a condom, so anyways, you don't give a shit to sharing these details (fertile days). I mean, that will be helpful when you start living with someone, or get married to someone, or planning a family, or deliberately avoiding starting a family." (Juhi, 37 yrs.)*

A partner's active involvement in the menstrual journey includes collectively developing a period vocabulary. For example, Mahi (22 yrs.) shared she finds texting her partner the easiest if she is not with him at the moment, but if together, *"it's better to say it verbally or sometimes just a few nods work. I mean, I might not*

[1] All our participants are heterosexual, and their interactions with their partners do not include experiences with same-sex partners. This section refers to non-menstruating partners and their involvement in their partner's menstrual journey.

have said exactly verbally, but just nods or a different expression just sends the message that I started with my periods." Additionally, non-menstruating partners develop their ways to track and identify their partner's cycle phases. Alia (28 yrs.) elaborated, *"I think he has a log in his head, so he never has to check [my diary]. He just quickly understands, which is a great thing. I get a lot of support from his side, and having a conversation about these things makes life easier because the other person understands where this is coming from. If you are having mood swings or anger, it is because of a real issue. It is a real thing. Nobody builds a castle in the air when they say they are PMSing or having mood swings."* The practice of partners collectively (albeit concurrently) tracking the menstrual cycle was acknowledged to be of value by all our interviewees *"because it is reproductive health"* (Pihu, 21 yrs.) and *"in case of unplanned pregnancy partners might end up blaming each other"* (Reena, 54 yrs.). Ironically, we also observed a pattern where menstruator did not track for themselves and rested the entire responsibility of contraception on their partner:

> *"My husband and I never really planned pregnancies ever. It was never a part of the plan. Both times I was caught unaware. So my husband was taking precautions and using condoms. So all this precaution was his, I mean job, it was never on me. Actually, I never took responsibility, although I knew that tracking should be done. He did take precautions." (Priya, 40 yrs.)*

The conversations around menstrual tracking for family planning further unpacked prevalent power structures in intimate relationships. The non-menstruating partner is in a position of power to passively make choices that (re)define and impact their menstruating partner's overall menstrual journey. On being asked if tracking would have made a difference in family planning, Meenu (44 yrs.) expressed,

> *"Ahh, different experience is not dependent on us only. It equally depends on your husband too. Even if we track but if he is unwilling to use precautions, I don't think tracking will be beneficial. It is different if you are tracking because you are conscious of your menstrual health. But if you are tracking for [avoiding] pregnancy, it is not all up to you. I mean, it also depends on the partner, whether he wants to do it or not."*

On similar lines, Payal (30 yrs.) shared that menstrual tracking data will be of no value for her husband as, *"he would not pay any attention to it. As I know, if I tell him and share with him, he will listen to it, and he does, but otherwise, he himself will not be proactive or care to know about it. Even if I would not have been comfortable talking to him about this, even then, sharing data with him through an app or any medium would have been of no use."*

4.4 Digital Trackers: Experiences, Apprehensions, and Aspirations

Our participants perceived and acknowledged the value of digital trackers in relieving them of the burden of remembering dates while emphasizing—*"I am not saying one can't stick to the traditional way of charting or tracking your period, but you should always have a choice [of medium]"* (Alia, 28 yrs.). As reported by Epstein et al. [29], our participants also felt more connected with their bodies while engaging with data visualizations being offered in digital trackers, *"in the clue app, they give, full-cycle thing. In a diagram, your entire cycle is shown. So that is just fascinating and good information to know. I could see what is happening within my body through this"* (Juhi, 37 yrs.). However, a minimal number of our participants are using digital trackers, a pattern similar to the one reported by Tuli et al. [101]. Many of our participants have tried digital trackers at least once but did not continue. This section presents the participant's reported aspirations (or not) of a digital tracker, shaped by their apprehensions and experience with different tracking methods.

4.4.1 Avenue for Seeking and Constructing Menstrual Literacy. Our participants aspired for an assistant in the form of a menstrual tracker, with whom they could discuss their issues and seek advice. In general, something to update them with menstrual and reproductive literacy they never formally received, as expressed by one of our participants:

> *"While planning and during pregnancy, I did not have much information. I would have benefited a lot from a tracking assistant at that time. I would have asked all my unanswered queries. Instead of spending time looking up books, I wish I had such an assistant [...] I can visualize myself receiving answers to all my doubts and questions I had since initial years through such an assistant. I would have discussed menstruation and pregnancy, like what should be practiced, avoided, and everything. I would have felt as if I have found a friend to discuss all this with. A friend, who would provide the information I never received." (Reena (54 yrs.)*

The most sought-after is a safe space in form of a forum to leverage peer support, where menstruators could reach out to their peers and allies, validate their experiences, and ask queries which they would not have felt comfortable asking in person given the stigma and taboo around the subject—*"if there are doctors [on forums], it would be best. Often, we cannot talk openly with male doctors during visits. Everything was new for me during my first pregnancy, but I was still hesitant to ask questions. Even if I had questions, I never asked my doctor face to face. I believe such a forum can be beneficial in these situations" (Meenu, 44 yrs.).* However, we observed apprehensions around the information exchange through such forums. Our participants believed that the full potential of the peer support could only be achieved if an expert moderates it, *"I just feel it [forum] should be controlled as in nobody should pass wrong information as it can be very harmful concerning these things because it relates to health. So the educational discussion or conversation has to be monitored probably" (Alia, 28 yrs.).*

Given the sensitive nature of the subject and cultural boundaries, the prerequisite for moderation includes revisiting the question: how much is too much information? As Pihu (21 yrs.) described, *"there are different types of people. I know people who like knowing things, but I also know people who, if given too much information, would get too worried thinking about: Is this happening to me? So sometimes too much information hurts people."* The question becomes even more relevant when designing a tracker for adolescents, as Priya (40 yrs.) elaborated in the following quote. Speculating a

menstrual tracker for adolescents while reflecting on her experience of initial menstrual years, she shared:

> *"I would like the tracker to be simple and just about my periods. There can be information about sexual health because the risk-taking tendency is so high at that age. Remembering my time, if I was told that this is a safe time [to have sex] I would have wanted to see what happens if we do it during the unsafe time! Generally, until the age of 18–19, you always want to try out things that are termed as unsafe."*

With the evolving association with menstrual tracking and menstrual data sense-making throughout the menstrual journey, menstruators seek different information support during different journey transitions. Thus, the current approach to designing menstrual trackers—'one fit for all'—falls short of offering a personalized experience, as evident in the following quote:

> *"It would be best if we can customize the tracker. I mean, there should be three options. First, married people who have a sexual partner can track for pregnancy if they want. Second, beginners who have not yet begun menstruating or are in the initial 1-2 years of their periods can track and identify abnormal cycle patterns. Third, rest for people whose cycle pattern is stable, but they are not sexually active, so they can also use tracking as per their needs." (Farah, 34 yrs.)*

Furthermore, different people like to track different parameters (like flow, clot, dietary intake, water intake, and more) in addition to dates, and some menstruators prefer to track only their dates. As reported in the survey and observed in our cultural probe, the latter was prevalent in adolescents. Even the adult menstruators suggested adolescent period trackers primarily only offering date tracking. These parameter tracking practices also offers us an opportunity to disseminate menstrual literacy by alerting about both—what is *normal* and *abnormal*, unlike the prevalent designs, which only focus on highlighting the not typical cycle pattern:

> *"It will be helpful if it alarms normal and abnormal. Like it should also tell you, these many hours have passed, please change your pad, and it has been 3-4 days, and if you still have heavy bleeding, it should indicate it as abnormal. I feel this would be brilliant." (Farah, 34 yrs.)*

4.4.2 Self-controlled Intimate Data Sharing. Overall, our participants, including 68.57% of our adult survey respondents and many interviewees, saw value in sharing their data with close relationships while acknowledging it as a subjective choice. Different menstruators prefer to selectively share their intimate data with different individuals depending on multiple factors, including comfort, age, experience, and sexual activity. For instance, for survey respondents aged 18-29 years, the mother (76.83%) was the preferred choice followed by partner (74.39%), female friend (66.46%), sister (59.15%), and doctor (53.05%). Whereas, for respondents aged 30 years and above, the reported preference is a partner (71.73%), female friend (45.65%), followed by mother (43.47%). Conversations about menstrual trackers supporting intimate data sharing emphasized the need for designing to accommodate this subjectivity as expressed by Alia (28 yrs.):

> *"Sharing cycle details is very subjective, so it would be handy for a person like me since I am very comfortable sharing my cycle details with my partner, sister, and mother [...] even people of my age might not be very comfortable with people logging into their personal info. There can definitely be a mode to switch on or off because it is subjective and differs from person to person in what we are comfortable sharing with whom."*

A few menstruators questioned altogether the need and value of sharing menstrual data through an app (or any other medium) when they can converse verbally as per their convenience—*"I can talk to my mother and sister verbally when I need to, so then why share by a formal thing?"* (Juhi, 37 yrs.). However, a 'buddy mode' to sync-share the menstrual cycle data with the doctor is perceived to be a valuable feature as it would offer a safe space to share details about the sexual activity which a menstruator, specifically adolescent/unmarried, otherwise would have avoided sharing all together given the associated stigma, as narrated by Pihu (21 yrs.),

> *"I would want a companion thing [sharing tracking data] with my doctor. I don't think they would be able to keep track of it, but it is easier to have data sync in that way so that they see the data there. But again, I would not want to share all of the data. So around the diagnosis [PCOD], I remember my boyfriend and I were always wondering should we have sex, should we not, and then I would always say no, as I was under the diagnosis. I have to go to the doctor, and I cannot say if it [sex] happened or not."*

Menstruating data is powerful and would be a valuable heirloom for future generations as recommended by Lazar et al. [64], specifically in our context with limited to little menstrual literacy [101] as expressed by Kiran (45 yrs.), *"I will definitely share my cycle details with my daughter because it is hereditary. Our cycle pattern reflects our mother's or paternal aunt's (bua) cycle pattern. So, my period diary is similar to a kundali (horoscope) for my daughter. I will carefully note all the changes I will be observing in my cycle. I will also note if any particular home remedy or medicine worked for me. It will be helpful for my daughter to know what to expect."* Further, menstrual cycle data, if shared, can also be used to offer support, allyship, and solidarity as speculated by Mahi (22 yrs.), *"so my friend can come to my profile and see my status [upcoming cycle], but only my close friends [...] My friends know that during periods I get very disheartened and am not able to do work. So maybe next month she might be prepared, and she could remind me your this [periods] is coming, and we can have fun over these days."*

With power comes great responsibility. Our narrative data highlighted multiple instances where menstrual data could be used against the menstruators. For example, we observed discomfort and apprehensions among menstruators across ages in sharing the data about sexual activity, specifically with mothers. This discomfort was rooted in fear of stigmatized identity as expressed by Baani (30 yrs.), *"from the parents' perspective, it will be helpful to know if everything is all right with their daughter. But from a girl's perspective,*

she will be more uncomfortable because she might think her parents don't trust her and are keeping track of her cycles [...] imagine if I would have been involved in relationships and then it would have been tricky for me to you know share my cycle. It could be like, this thing [physical intimacy] has happened, and my periods might get delayed. So my parents might question me." In another instance, one of the interviewees pointed at a possibility that menstrual data could restrict menstrual mobility on religious grounds. The recent movement around Sabarimala temple [76, 96] calls for careful collection and management of intimate data so it does not lead to further marginalization of menstruators as indicated by Jasmin (38 yrs.), *"I don't think anybody wants to know this thing [menstrual cycle data], until you are going to some religious thing in particular, you know, not clean or something like that, that kind of a thing."*

4.4.3 Data Logging and Privacy Concerns. Menstruators wished for a system that requires them to provide detailed information only once, followed by a bare minimum to negligible data input during each cycle. Logging detailed information every day for every cycle is considered much of an effort as expressed by Mala (60 yrs.), *"so every month, in every day of these five days, you put in flow, symptoms, moods, etc. I think that would be too much. I may have enthusiastically done it the first few times, but I don't think I would have done it after that. Especially if everything seems normal, you think it is such a waste of time to do this."* One of the prominent reasons menstruators switched away from digital trackers (or trackers in general) was forgetting to continuously log data as shared by Priya (40 yrs.),

> *"A couple of times, I felt like I needed to write and track, especially on an app. What is stopping me is the feeling that I might forget to track. This happened with me frequently. I may just forget to use the app [...] So I m not starting it again because I think I might not be able to continue tracking for too long."*

We observed that menstruaters who are using trackers (paper-based/digital) rely on them significantly to validate their physiological cues and mental calculations, *"so when I mentally note my period date using some event, then I use a calendar to cross-check the date in case I only remember the day and not the date"* (Payal, 30 yrs.). Given that trackers are being heavily utilized as confirmation tools, sporadically inputting data into a digital tracker in the long run results in inaccurate predictions causing stress:

> *"I don't mind having a tracker which basically records the date but does not send me notifications. I think that is when you start getting distressed like, Oh my god, why I am late. You start getting stressed and contemplating like what happened." (Juhi 37 yrs.)*

Although inaccurate reminders led to feeling *"something is abnormal"*, 71.9% of our adult survey respondents agreed that receiving reminders about the upcoming cycle would be helpful. However, different menstruators reported different functional and privacy expectations from reminder notifications. For instance, around 22.22% of menopausal respondents explicitly denied any reminder service where one of them believed receiving reminders and notifications *"will be a violation of my privacy."* Whereas, few preferred notifications in the form of *"some encrypted message"* and others seek multiple reminders as they approach their cycle:

> *"[Tracker] share a message that this week your period can start like tomorrow or the day after. So something that I don't need to see every day, but probably closer to the date. Then again, if I am reminded once, I might forget. So if I get reminded a couple of times, even if I close my reminder, that would be nice." (Priya, 40 yrs.)*

We observed that the need to preserve privacy was rooted in fear of creating stigmatized identity. Downloading an app especially for tracking menstruation reportedly felt like *"extra burden," "task," "time consuming,"* and a calculated risk which might lead to creating stigmatized identity given prepubescents and adolescents in our context still share mobile phones with their elder siblings and parents. In shared device scenarios, the attention-seeking look and feel of the trackers [29] makes menstruators uncomfortable in keeping such apps in their phones. Rafia (25 yrs.) shared, *"the apps I saw were mostly pink in color, flowers, basically very girly, and personally, I am not fond of such things. Second, I have nieces and nephews, too, who use my phone to play games. They might use that app, and then I have to explain what it does because they are very curious. But they are not of the age where I can explain all this to them. So such girly apps stand out and seek special attention, I do not think it is correct. I don't like it."* To avoid the risk of ending up in a vulnerable situation, our participants proposed moving these apps out of mobile phones and into something more convenient like smartwatches as proposed by Sadhna (65 yrs.), *"it will definitely help like if you have a watch on your wrist [to track periods]. If you perhaps have to look at the time, you will bring your mobile out of your purse and then see the time. Instead, a watch on your wrist is a much easier and quicker option. Similarly, if there is an app like that, it will help. It will help."* The fear of creating a stigmatized identity also shapes menstruators' concerns around leaving digital footprints of online engagement on the taboo topic, *"it feels less vulnerable to do it [posting queries] on an app anonymously because I feel like you can delete the app and forget about it forever, but it will always be there on the website. If you are a bit embarrassed to ask, I would prefer to do that on the app." (Pihu, 21 yrs.)* A similar trend was observed by Tuli et al., where the Menstrupedia forum showed prominent passive engagement (4M+ views) in contrast to active engagement (223 questions posted in 5 years) [99].

5 DISCUSSION

Nussbaum's political theory of capabilities approach [79] served as an ally to our participants as it made their struggles of navigating life as menstruators visible in a context with deep-rooted menstrual stigma. We observed that menstruators have to adjust and compromise on the pretext of their bleeding bodies to preserve the dignity of self as mirrored in the eyes of others during social interactions (see section 2.2). In this section, we begin by unpacking how menstruators are using menstrual tracking to experience liberation, calling attention to menstrual tracking as a site of intervention towards the empowerment of menstruators. For our analysis, we define *liberation* as the ability to achieve Nussbaum's central capabilities (specifically that of bodily integrity, bodily health, and control over one's environment) essential for leading a life in a dignified or worthy way [78, 79]. Leveraging the concept of central capabilities, we then discuss how digital menstrual trackers

shall be (re)designed to serve as a pathway towards period-positive ecologies. A detailed description of the capabilities approach and its interpretation for our analysis is presented in section 2.3.

5.1 Menstrual Tracking: Carving a Path to Self-Liberation

Our investigation revealed that menstrual tracking serves as a means to experience liberation in a stigma-heavy settings. In our study context, menstruators are using it to partially and indirectly operationalize a few but prominent central capabilities (e.g., bodily integrity, bodily health, and control over one's environment) critical to ensure minimal social justice in a society. It is proactively being adopted as a workaround to practice the right to bodily autonomy, which otherwise is a distant reality given the prevalent cultural stigma (around menstruation, sex without marriage, and childbearing expectations) [53]. For instance, we observed that many menstruators (both married and unmarried) primarily consumed digital menstrual trackers as natural birth control. However, our participant-reported experiences revealed that the design of prevalent digital trackers falls short of catering to evolving information needs across a menstrual journey and does not account for their life choices like abstinence, voluntary childlessness, hysterectomy, and more (also observed by Eschler et al. [30] and Epstein et al. [29]). Instead, our analysis highlighted specific scenarios in which the prevalent digital trackers might even be constraining for the menstruators. For example, our participants were apprehensive of installing menstrual tracking apps in their devices shared with and accessible to other stakeholders in their vicinity, worrying about creating stigmatized identity and restricted menstrual mobilities. We also observed that inaccurate predictions and typecasting of the menstrual cycle have made menstruators feel *"abnormal"* in their bodies in multiple instances, depriving them of their ***bodily integrity***. Our observations point attention to the potential of digital menstrual trackers to impact menstruators' capability of ***life*** profoundly, making it a suitable site for capability-building intervention to empower menstruators.

Our data shows how menstrual tracker as a capability-building tool call for designing trackers to support menstruators throughout their menstrual journey instead of the prevalent albeit narrow view of designing trackers to support a specific transition (menarche, fertility, and menopause) in isolation. Menstruation is not a one-time occurrence but an individual journey, and designing for this journey will entail designing for the subjectivity at multiple layers throughout the journey while accounting for messy and diverse associations with menstrual tracking. Further, we observed that an individual's association with menstrual tracking evolves with changing bodies and life choices across different transitions through the journey. Menstruators track per their convenience towards a goal using methods they find convenient. As observed, the goal expands beyond menstrual wellbeing, including experiencing enhanced liberation. Liberation being deeply subjective and tied to personal experiences (evident in our data), oneself (a menstruator in our case) is the best suitable designer of their liberation in a given circumstance (all through the menstrual journey) [54]. Aligning with the HCI community's call of promoting user agency, autonomy, and knowledge (e.g., [4, 54, 97, 99]) and Nussbaum's stance on giving positive freedom of agency to individuals to shape their lives by cultivating central capabilities [78, 79], we propose *designing for the self* approach to design menstrual trackers. We advocate that design should empower menstruators to (re)design their relationship with their menstrual trackers by *enabling them to first design and later tailor their tracker* throughout their menstrual journey according to where they are in their journey, experience with menstruation, and life choices. Our recommendation of facilitating *designing for the self* is a step toward supporting menstruators in exercising ***control over their environment***.

To operationalize *designing for the self,* we recommend deriving inspiration from the literature at the intersection of crafting technology, do-it-yourself (DIY) toolkits, and open-source approaches (e.g., [2, 5, 6, 18, 40, 90]). These studies project non-traditional forms of engagement and interaction with bodies as the future of intimate technologies promoting self-care and intimate wellbeing [97]. We call for ideating menstrual trackers beyond a mobile application and as a multi-modal system engaging digital and non-digital cultural artifacts. Moving menstrual trackers out of smartphones enhances the affordance of using it as a probe to nurture a safe and personal space for the menstruator to explore the menstruating body and bodily fluids via embodied interactions (e.g., [6, 8, 18, 90]). Facilitating self-designing unpacks a new site for intervention—*the process of designing, assembling,* and *tailoring* itself. The act of self-designing can be structured to promote bodily awareness, "inviting women [menstruators] to become embodied knowers" enhancing opportunities to ***sense, imagine, and think***, as exemplified by Almeida and colleagues [2, 5, 6, 97].

5.2 Digital Menstrual Trackers: A Pathway to Period-Positive Ecologies

With the central capabilities approach, Nussbaum envisions a human life where individuals are dignified free beings "who shape their lives in cooperation and reciprocity with others, rather than being passively shaped or pushed around the world in the manner of a 'flock' or 'heard' of animals" [78]. Our analysis shows that menstruators, in our study context, live an inverse of the human life envisioned by Nussbaum. Our narrative data illuminates that menstruators develop a complex and antagonistic relationship with their bodies grounded in their experience and observation of society's negative attitude, reactions to, and expectations from the menstruating body. For example, our participants used adjectives like *"dirty," "abnormal," "awkward," "different from rest,"* and *"uncomfortable"* to explain how they felt about their bodies and bodily fluids (menstrual blood and discharge). Although our participants acknowledge menstruation as a natural bodily phenomenon, their frequent use of *"adjustment"* and *"compromise"* when reflecting on their experience of living as a menstruator unpacks how the social construction of menstrual bodies makes them a site of struggle, including for individuals with menstrual literacy. Our thick and affective narrative revealed that digital menstrual trackers enable menstruators to conform to the socially constructed menstrual dignity by helping them be *"prepared to avoid accidents,"* i.e., avoid stain stigma [100], thus instilling a sense of control over their bodies. To nurture positive, just, and enabling environments for menstruators, Bobel emphasizes reallocating resources to build intellectual

infrastructure (knowledge, skill, and abilities) [13]. Taking a stance against emancipation through 'control,' we call for rethinking menstrual trackers to craft opportunities for menstrual literacy for the menstruators and the *others*, contributing to capabilities of ***affiliation*** and ***practical reason*** towards crafting period-positive futures.

Currently, the FemTech interventions approach menstrual tracking as self-care and individual-centric [29, 83]. However, as evident from our analysis, it is a highly collaborative process shaped by multiple relationships at once. Figueiredo et al. [26] present a larger ecosystem of use (in western environments) in which fertility data is embedded and reflexively shaped by different stakeholders (family, partner, peers, health practitioners, and more). Our analysis expands this understanding by unpacking close relationships influencing and shaping the menstrual journey (including their tracking practices) across generations, beginning with the pre-pubescent years and continuing till the final years of the menstrual journey (see fig. 2). In many instances, these relationships themselves lack menstrual literacy [101]. However, our data shows they are obligated to be vested in advising practices and validating experiences that lead to formative (albeit negative) associations with menstruation and menstruating body, which, in the long run, might lead to deprivation of ***bodily health, bodily integrity,*** and ***life***. These observations are reminiscent of feminist HCI's quality of ecology [11], making menstrual tracking a suitable site to reflexively design for period-positive ecologies.

An ecological approach to design in our case would entail supporting an interdependent way of life that supports capabilities of ***affiliation*** and ***practical reason*** for all stakeholders. Different relationships play a pivotal role for different menstruators with varying degrees of involvement at different points of time in a menstrual journey and might keep rotating and replacing each other with every life transition (see fig. 2). Moreover, the menstrual journey entails (re)negotiating social boundaries (set for menstruating bodies) and challenging power structures (in close relationships) towards a menstruator's liberation where liberation and its inverse meant different things to different menstruators. For example, many menstruators (and their mothers on their behalf) track to avoid stain stigma, others covertly rely on tracking as natural birth control, and few use tracking as a guide to reschedule their work to seek rest during menstruation. Thus, taking an ecological approach would entail engaging with and accounting for ever-evolving and even conflicting diversity among stakeholders including varied and evolving menstrual literacy, diverse menstrual experiences, hygiene practices, associated myths, cultural and social norms, and more. A gender justice design space (like ours) with stakeholders having conflicting goals requires fair evaluation of which and whose freedoms are harmful to menstruators' wellbeing [61, 78]. In such scenarios, Nussbaum says, it is acceptable, even essential, to limit or sacrifice the freedoms of *others* (ibid).

Digital menstrual trackers offer multiple avenues for crafting period positive futures, ranging from the act of designing to the generated intimate data. For instance, the process of *designing for the self* (see section 5.1) can be structured as a co-designing activity while preserving the agency of the menstruator to include or exclude stakeholders(s) (menstrual companions including mother, daughter, peer, sibling, partner, etc.) in the vicinity as co-designers of their trackers. Prior works like Crimson Wave [33], Ambient Cycle[51], Ovum [49], MenstrualMaze [98], HelpPinky [56], and other DIY kits (e.g.,[5, 6, 18, 90, 97]) can serve as inspiration for designing and structuring the co-designing activity. In this case, *the design process* can facilitate conversation on the subject leading to ***meaningful relations and affiliations*** by serving as an ice-breaker, offering vocabulary, and an avenue for activism by facilitating positive body association with one's body and creating body awareness of *others*. Taking such an approach would translate to supporting multiple capabilities, including bodily integrity, affiliation, senses, imagination, and thought, and control over one's environment, which collectively contribute to ***bodily health***.

We observed that the most sought-after is a digital space to construct menstrual literacy. Tuli et al. have shown how such safe spaces also offer an avenue for menstruators and their allies to support ***practical reasons***, and express their ***emotions*** around their menstrual experiences by building ***affiliations*** [99]. However, our participants described their engagement with such spaces as predominantly passive and anonymous and being carried out with utmost caution to avoid creating a stigmatized identity. Given the prevalent menstrual stigma, our participants were aware and mindful that their digital footprints and menstrual data could constrain them (literally and metaphorically), unpacking a tension between menstruators' privacy and seeking care support. For instance, a chief of an Indian temple said, "there will be a day when a machine is invented to scan if it is the 'right time' [i.e., not menstruating] for a woman to enter the temple. When that machine is invented, we will talk about letting women inside" [76]. Thus, our participants desire to firmly control menstrual data sharing starting from the initial years of the menstrual journey—what data to share, with whom, and when. Our analysis emphasizes the need to make careful considerations when designing the collection, management, storage, and sharing of intimate data in a stigma-heavy context like ours. The design of digital trackers should enhance menstruators' capacity to preserve their privacy by designing control over menstrual data sharing to ensure bodily integrity. It will entail redesigning for accountability and care at the policy level, also emphasized by Mehrnezhad and Teresa [72], in supplement to implementing privacy checks in the technological intervention.

Scholars (e.g., [26, 100]) have pointed potential of intimate data in highlighting unjust social structures, making them a prospective tool for activism. However, the literature highlights the role of the FemTech industry in defining ways of 'how' the data is collected and stored instead of accomodating *multiplicity* of practices, subtly dictating a transactional relationship with the menstruating body [37]. The first step towards activism requires redesigning digital trackers facilitating the collection of intimate data such that they do not restrict ***bodily integrity*** by reaffirming 'concealment' of the menstruating bodies. Only then will the data collected through these tools serve for activism in a true sense.

6 CONCLUSION

In this work, we use Nussbaum's central human capabilities [78] to analyze prevalent menstrual practices of Indian women menstruators throughout the menstrual journey. This approach helped us broadly unpack the struggles of experiencing life through the

menstruating body. We identified that menstruators use menstrual tracking to exercise body integrity while co-existing with the boundaries of taboo and stigma. However, the prevalent digital menstrual trackers propagate the social constructs of menstrual bodies and menstrual dignity by selling false control over menstruating bodies. Taking a stance against emancipation through 'control', we call for rethinking menstrual trackers as a capability-building tool for the self and *the others* towards period-positive futures.

ACKNOWLEDGMENTS

This work was made possible thanks to the efforts of many volunteers. We thank those who helped, collaborated, and joined us in various ways. Special thanks to our field partners—Sachhi Saheli and Udayan Care—for their support and counsel. We express gratitude to our participants who gave their pandemic hours to this study. We are immensely grateful to the external reviewers, who sharpened our contribution with their feedback and critical comments. Finally, we acknowledge Jasmeet Kaur, Kirti Dabas, Prerna Malik, and Anushka Bhandari for their efforts during the initial data collection and management. For this work, Tuli was supported partly through the Visvesvaraya Ph.D. Scheme of Ministry of Electronics and Information Technology, Government of India (2016–2020) and partly through the Google Ph.D. Fellowship Program (2021). We also acknowledge the support provided by iHub-Anubhuti IIIT-Delhi Foundation.

REFERENCES

[1] Maninder Ahuja. 2016. Age of menopause and determinants of menopause age: A PAN India survey by IMS. *Journal of mid-life health* 7, 3 (2016), 126–131.
[2] Teresa Almeida. 2015. Designing Intimate Wearables to Promote Preventative Health Care Practices. In *Adjunct Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers* (Osaka, Japan) *(UbiComp/ISWC'15 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 659–662.
[3] Teresa Almeida, Madeline Balaam, Shaowen Bardzell, and Lone Koefoed Hansen. 2020. Introduction to the Special Issue on HCI and the Body: Reimagining Women's Health. *ACM Trans. Comput.-Hum. Interact.* 27, 4, Article 20 (Aug. 2020), 32 pages.
[4] Teresa Almeida, Madeline Balaam, and Rob Comber. 2020. Woman-Centered Design through Humanity, Activism, and Inclusion. *ACM Trans. Comput.-Hum. Interact.* 27, 4, Article 27 (Sept. 2020), 30 pages.
[5] Teresa Almeida, Rob Comber, Patrick Olivier, and Madeline Balaam. 2014. Intimate Care: Exploring ETextiles for Teaching Female Pelvic Fitness. In *Proceedings of the 2014 Companion Publication on Designing Interactive Systems* (Vancouver, BC, Canada) *(DIS Companion '14)*. Association for Computing Machinery, New York, NY, USA, 5–8.
[6] Teresa Almeida, Rob Comber, Gavin Wood, Dean Saraf, and Madeline Balaam. 2016. On Looking at the Vagina through Labella. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, New York, NY, USA, 1810–1821.
[7] Karan Babbar, Jennifer Martin, Josephine Ruiz, Ateeb Ahmad Parray, and Marni Sommer. 2021. Menstrual health is a public health and human rights issue. *The Lancet Public Health* 7, 1 (2021), E10–E11.
[8] Madeline Balaam, Nadia Campo Woytuk, Marianela Ciolfi Felice, Ozgun Kilic Afsar, Anna Ståhl, and Marie Louise Juul Søndergaard. 2020. Intimate Touch. *Interactions* 27, 6 (Nov. 2020), 14–17.
[9] Ruben Banerjee. 2019. Editor's Essay: Why Menstruation is the Outlook's Issue of the Year: Menstruation . https://bit.ly/3tlKTnS. Accessed on (2019/03/06).
[10] Jeffrey Bardzell, Shaowen Bardzell, Amanda Lazar, and Norman Makoto Su. 2019. (Re-)Framing Menopause Experiences for HCI and Design. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. ACM, New York, NY, USA, Article 115, 13 pages.
[11] Shaowen Bardzell. 2010. Feminist HCI: Taking Stock and Outlining an Agenda for Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. ACM, New York, NY, USA, 1301–1310.
[12] Chris Bobel. 2018. Beyond the Managed Body: Putting Menstrual Literacy at the Center. In *The Managed Body*. Springer, New York, NY, USA, 281–321.
[13] Chris Bobel. 2018. *The managed body: developing girls and menstrual health in the global South*. Springer, New York, NY, USA.
[14] Susanne Bødker. 2015. Third-Wave HCI, 10 Years Later—Participation and Sharing. *Interactions* 22, 5 (Aug. 2015), 24–31.
[15] Braun, V. and Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (2006), 77–101.
[16] Urie Bronfenbrenner. 1979. *The ecology of human development*. Harvard university press, Cambridge, MA, USA.
[17] Nadia Campo Woytuk, Linette Nilsson, and Mingxing Liu. 2019. Your Period Rules: Design Implications for Period-Positive Technologies. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI EA '19)*. Association for Computing Machinery, New York, NY, USA, 1–6.
[18] Nadia Campo Woytuk, Marie Louise Juul Søndergaard, Marianela Ciolfi Felice, and Madeline Balaam. 2020. Touching and Being in Touch with the Menstruating Body. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–14.
[19] Udayan Care. 2020. https://www.udayancare.org/. Accessed on (01/08/2020).
[20] Chander Shekhar, Siddhardha Devarapalli, Mohan Singh, Sudhaveni Naresh, and Jitendra Gauda. 2018. Fertility preferences in India. In *Family Demography in Asia: A Comparative Analysis of Fertility Preferences*, Minja Kim Choe Stuart Gietel-Basten, John Casterline (Ed.). Edward Elgar Publishing, Cheltenham, United Kingdom, Chapter 8, 425.
[21] Shaan Chopra, Rachael Zehrung, Tamil Arasu Shanmugam, and Eun Kyoung Choe. 2021. Living with Uncertainty and Stigma: Self-Experimentation and Support-Seeking around Polycystic Ovary Syndrome. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 202, 18 pages.
[22] Marianela Ciolfi Felice, Marie Louise Juul Søndergaard, and Madeline Balaam. 2021. Resisting the Medicalisation of Menopause: Reclaiming the Body through Design. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 408, 16 pages.
[23] Mayara Costa Figueiredo. 2020. Self-Tracking for Fertility Care: A Holistic Approach. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–9.
[24] Mayara Costa Figueiredo, Clara Caldeira, Elizabeth Victoria Eikey, Melissa Mazmanian, and Yunan Chen. 2018. Engaging with Health Data: The Interplay Between Self-Tracking Activities and Emotions in Fertility Struggles. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW, Article 40 (Nov. 2018), 20 pages.
[25] Mayara Costa Figueiredo, Clara Caldeira, Tera L. Reynolds, Sean Victory, Kai Zheng, and Yunan Chen. 2017. Self-Tracking for Fertility Care: Collaborative Support for a Highly Personalized Problem. *Proc. ACM Hum.-Comput. Interact.* 1, CSCW, Article 36 (Dec. 2017), 21 pages.
[26] Mayara Costa Figueiredo and Yunan Chen. 2021. Health Data in Fertility Care: An Ecological Perspective. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 204, 17 pages.
[27] John W Creswell and Vicki L Plano Clark. 2007. Choosing a Mixed Methods Design. In *Designing and Conducting Mixed Methods Research*. SAGE publications, Los Angeles, CA, USA, Chapter 4, 64–65.
[28] Jane Elliott. 2005. *Using narrative in social research: Qualitative and quantitative approaches*. SAGE publications, Los Angeles, CA, USA.
[29] Daniel A. Epstein, Nicole B. Lee, Jennifer H. Kang, Elena Agapie, Jessica Schroeder, Laura R. Pina, James Fogarty, Julie A. Kientz, and Sean Munson. 2017. Examining Menstrual Tracking to Inform the Design of Personal Informatics Tools. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. ACM, New York, NY, USA, 6876–6888.
[30] Jordan Eschler, Amanda Menking, Sarah Fox, and Uba Backonja. 2019. Defining Menstrual Literacy With the Aim of Evaluating Mobile Menstrual Tracking Applications. *CIN: Computers, Informatics, Nursing* 37, 12 (2019), 638–646.
[31] Ilker Etikan, Sulaiman Abubakar Musa, and Rukayya Sunusi Alkassim. 2016. Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics* 5, 1 (2016), 1–4.
[32] Breanne Fahs and Milena Bacalja Perianes. 2020. Transnational Engagement: Designing an Ideal Menstrual Health (MH) Curriculum—Stories from the Field. In *The Palgrave Handbook of Critical Menstruation Studies*. Palgrave Macmillan, Singapore, 449–465.
[33] Margaret Flemings, Shanzay Kazmi, Rachel Pak, and Orit Shaer. 2018. Crimson Wave: Shedding Light on Menstrual Health. In *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction* (Stockholm, Sweden) *(TEI '18)*. ACM, New York, NY, USA, 343–348.

[34] Sarah Fox. 2017. Casting a Feminist Eye on Public Infrastructure. In *Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (Portland, Oregon, USA) *(CSCW '17 Companion)*. Association for Computing Machinery, New York, NY, USA, 61–64.

[35] Sarah Fox and Daniel A Epstein. 2020. Monitoring Menses: Design-Based Investigations of Menstrual Tracking Applications. In *The Palgrave Handbook of Critical Menstruation Studies*. Palgrave Macmillan, Singapore, 733–750.

[36] Sarah Fox, Noura Howell, Richmond Wong, and Franchesca Spektor. 2019. Vivewell: Speculating Near-Future Menstrual Tracking Through Current Data Practices. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (San Diego, CA, USA) *(DIS '19)*. ACM, New York, NY, USA, 541–552.

[37] Sarah E. Fox, Amanda Menking, Jordan Eschler, and Uba Backonja. 2020. Multiples Over Models: Interrogating the Past and Collectively Reimagining the Future of Menstrual Sensemaking. *ACM Trans. Comput.-Hum. Interact.* 27, 4, Article 22 (Sept. 2020), 24 pages.

[38] Sarah E. Fox, Rafael M.L. Silva, and Daniela K. Rosner. 2018. Beyond the Prototype: Maintenance, Collective Responsibility, and Public IoT. In *Proceedings of the 2018 Designing Interactive Systems Conference* (Hong Kong, China) *(DIS '18)*. ACM, New York, NY, USA, 21–32.

[39] Sarah E. Fox, Kiley Sobel, and Daniela K. Rosner. 2019. Managerial Visions: Stories of Upgrading and Maintaining the Public Restroom with IoT. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–15.

[40] Andrew Garbett, Rob Comber, Edward Jenkins, and Patrick Olivier. 2016. *App Movement: A Platform for Community Commissioning of Mobile Applications*. Association for Computing Machinery, New York, NY, USA, 26–37.

[41] Bill Gaver, Tony Dunne, and Elena Pacenti. 1999. Design: Cultural Probes. *Interactions* 6, 1 (Jan. 1999), 21–29.

[42] William W Gaver, Andrew Boucher, Sarah Pennington, and Brendan Walker. 2004. Cultural probes and the value of uncertainty. *interactions* 11, 5 (2004), 53–56.

[43] Rose George. 2013. *Celebrating womanhood: how better menstrual hygiene management is the path to better health, dignity and business*. Water Supply and Sanitation Collaborative Council, Geneva, Switzerland.

[44] Thomas E. Hill. 2014. Kantian perspectives on the rational basis of human dignity. In *The Cambridge Handbook of Human Dignity: Interdisciplinary Perspectives*, Marcus Düwell, Jens Braarvig, Roger Brownsword, and DietmarEditors Mieth (Eds.). Cambridge University Press, Cambridge, England, UK, 215–221.

[45] Rafaela Hillerbrand. 2018. Why affordable clean energy is not enough. A capability perspective on the sustainable development goals. *Sustainability* 10, 7 (2018), 2485.

[46] Sarah Homewood. 2018. Designing for the Changing Body: A Feminist Exploration of Self-Tracking Technologies. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI EA '18)*. ACM, New York, NY, USA, DC11:1–DC11:4.

[47] Sarah Homewood. 2018. Reframing design problems within women's health. In *Design as a catalyst for change-DRS International Conference 2018*, C Storni, K Leahy, M McMahon, P Lloyd, and E Bohemia (Eds.). Design Research Society, Limerick, Ireland, 507–517.

[48] Sarah Homewood. 2019. Inaction As a Design Decision: Reflections on Not Designing Self-Tracking Tools for Menopause. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI EA '19)*. ACM, New York, NY, USA, Article alt17, 12 pages.

[49] Sarah Homewood, Laurens Boer, and Anna Vallgårda. 2020. Designers in White Coats: Deploying Ovum, a Fertility Tracking Device. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–13.

[50] Sarah Homewood, Amanda Karlsson, and Anna Vallgårda. 2020. Removal as a Method: A Fourth Wave HCI Approach to Understanding the Experience of Self-Tracking. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 1779–1791.

[51] Sarah Homewood and Anna Vallgårda. 2020. Putting Phenomenological Theories to Work in the Design of Self-Tracking Technologies. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 1833–1846.

[52] Ismael Ibarra-Nava, Vikas Choudhry, and Anette Agardh. 2020. Desire to delay the first childbirth among young, married women in India: a cross-sectional study based on national survey data. *BMC Public Health* 20, 1 (2020), 1–10.

[53] UNFPA India. 2021. UNFPA Launches the State Of World Population Report, 2021: My Body Is My Own. https://bit.ly/3yd4hV6. Accessed on (2021/05/25).

[54] Margaret Jack and Anupriya Tuli. 2021. Designing for Liberation: Our Lives, Mobility, and Technology. *Interactions* 28, 2 (March 2021), 34–41.

[55] Nora Jacobson. 2007. Dignity and health: a review. *Social science & medicine* 64, 2 (2007), 292–302.

[56] Minal Jain and Pradeep Yammiyavar. 2015. Game Based Learning Tool Seeking Peer Support for Empowering Adolescent Girls in Rural Assam. In *Proceedings of the 14th International Conference on Interaction Design and Children* (Boston, Massachusetts) *(IDC '15)*. ACM, New York, NY, USA, 275–278.

[57] Arundhati Kanungo. 2017. Smartphone Penetration in India. https://bit.ly/3pMHNsv. Accessed on (01/08/2020).

[58] Os Keyes, Burren Peil, Rua M. Williams, and Katta Spiel. 2020. Reimagining (Women's) Health: HCI, Gender and Essentialised Embodiment. *ACM Trans. Comput.-Hum. Interact.* 27, 4, Article 25 (aug 2020), 42 pages.

[59] Dorothea Kleine. 2009. ICT4what? - Using the Choice Framework to Operationalise the Capability Approach to Development. In *Proceedings of the 3rd International Conference on Information and Communication Technologies and Development* (Doha, Qatar) *(ICTD'09)*. IEEE Press, New York, NY, USA, 108–117.

[60] Klaus Krippendorff. 2004. *Content Analysis: An Introduction to Its Methodology*. SAGE Publications, Thousand Oaks, Calif.

[61] Neha Kumar, Naveena Karusala, Azra Ismail, and Anupriya Tuli. 2020. Taking the Long, Holistic, and Intersectional View to Women's Wellbeing. *ACM Trans. Comput.-Hum. Interact.* 27, 4, Article 23 (July 2020), 32 pages.

[62] Paul J Lavrakas. 2008. *Encyclopedia of survey research methods*. Sage Publications, California, USA.

[63] Iain Law and Heather Widdows. 2008. Conceptualising health: insights from the capability approach. *Health Care Analysis* 16, 4 (2008), 303–314.

[64] Amanda Lazar, Norman Makoto Su, Jeffrey Bardzell, and Shaowen Bardzell. 2019. Parting the Red Sea: Sociotechnical Systems and Lived Experiences of Menopause. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. ACM, New York, NY, USA, Article 480, 16 pages.

[65] Mirim Lee, Bon-chang Koo, Hee-seok Jeong, Joongsin Park, Juhee Cho, and Jundong Cho. 2015. Understanding Women's Needs in Menopause for Development of MHealth. In *Proceedings of the 2015 Workshop on Pervasive Wireless Healthcare* (Hangzhou, China) *(MobileHealth '15)*. Association for Computing Machinery, New York, NY, USA, 51–56.

[66] Clayton Lewis and Cathleen Wharton. 1997. Chapter 30 - Cognitive Walkthroughs. In *Handbook of Human-Computer Interaction (Second Edition)* (second edition ed.), Marting G. Helander, Thomas K. Landauer, and Prasad V. Prabhu (Eds.). North-Holland, Amsterdam, 717–732.

[67] Ian Li, Anind Dey, and Jodi Forlizzi. 2010. A Stage-Based Model of Personal Informatics Systems. In *Proceedings of the 2010 CHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. Association for Computing Machinery, New York, NY, USA, 557–566.

[68] Deborah Lupton. 2015. Quantified sex: a critical analysis of sexual and reproductive self-tracking using apps. *Culture, health & sexuality* 17, 4 (2015), 440–453.

[69] Sydney Lutz and Gayathri Sivakumar. 2020. Leaking the secret: women's attitudes toward menstruation and menstrual-tracker mobile apps. *Gender, Technology and Development* 24, 3 (2020), 362–377.

[70] Christopher McCrudden. 2008. Human dignity and judicial interpretation of human rights. *european Journal of international Law* 19, 4 (2008), 655–724.

[71] Joselyn McDonald, Siyan Zhao, Jen Liu, and Michael L. Rivera. 2018. MaxiFab: Applied Fabrication to Advance Period Technologies. In *Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems* (Hong Kong, China) *(DIS '18 Companion)*. ACM, New York, NY, USA, 13–19.

[72] Maryam Mehrnezhad and Teresa Almeida. 2021. Caring for Intimate Data in Fertility Technologies. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 409, 11 pages.

[73] H.R. Moody. 1998. Why dignity in old age matters. *Journal of Gerontological Social Work* 29, 2-3 (1998), 13–38.

[74] United Nations. 1948. Universal Declaration of Human Rights. https://www.un.org/en/universal-declaration-human-rights/. Accessed on (2020/11/15).

[75] United Nations. 2015. Transforming our world: The 2030 Agenda for Sustainable Development. https://bit.ly/3gYScwk. Accessed on (25/12/2021).

[76] BBC News. 2015. Why are Indian women 'Happy to Bleed'? https://bbc.in/2wxqkbN. Accessed on (2022/3/6).

[77] Sarah Ng, Shaowen Bardzell, and Jeffrey Bardzell. 2020. The Menstruating Entrepreneur Kickstarting a New Politics of Women's Health. *ACM Trans. Comput.-Hum. Interact.* 27, 4, Article 21 (Aug. 2020), 25 pages.

[78] Martha C Nussbaum. 2001. *Women and human development: The capabilities approach*. Vol. 3. Cambridge University Press, Cambridge, England, UK.

[79] Martha C Nussbaum. 2011. *Creating capabilities*. Harvard University Press, Cambridge, MA, USA.

[80] Ministry of Statistics and Programme Implementation Government of India. 2018. Women and Men in India: A statistical compilation of Gender related Indicators in India . https://bit.ly/2OVmPFF. Accessed on (2019/12/06).

[81] Ilse Oosterlaken. 2009. Design for development: A capability approach. *Design issues* 25, 4 (2009), 91–102.

[82] Ilse Oosterlaken. 2012. The capability approach, technology and design: Taking stock and looking ahead. In *The capability approach, technology and design*.

Springer, New York, NY, USA, 3–26.
[83] Laura R. Pina, Sang-Wha Sien, Teresa Ward, Jason C. Yip, Sean A. Munson, James Fogarty, and Julie A. Kientz. 2017. From Personal Informatics to Family Informatics: Understanding Family Practices around Health Monitoring. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (Portland, Oregon, USA) *(CSCW '17)*. Association for Computing Machinery, New York, NY, USA, 2300–2315.
[84] Thomas Pogge. 2010. A critique of the capability approach. *Measuring justice: Primary goods and capabilities* 17 (2010), 17–60.
[85] Ingrid Robeyns. 2003. Sen's capability approach and gender inequality: selecting relevant capabilities. *Feminist economics* 9, 2-3 (2003), 61–92.
[86] Michael Rosen. 2012. *Dignity: Its history and meaning*. Harvard University Press, Cambridge, MA, USA.
[87] Sachhi Saheli. 2020. http://sachhisaheli.org/. Accessed on (01/08/2020).
[88] Marie Louise Juul Søndergaard, Marianela Ciolfi Felice, and Madeline Balaam. 2021. Designing Menstrual Technologies with Adolescents. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. ACM, New York, NY, USA, Article 260, 14 pages.
[89] Marie Louise Juul Søndergaard and Lone Koefoed Hansen. 2016. PeriodShare: A Bloody Design Fiction. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction* (Gothenburg, Sweden) *(NordiCHI '16)*. ACM, New York, NY, USA, Article 113, 6 pages.
[90] Marie Louise Juul Søndergaard, Ozgun Kilic Afsar, Marianela Ciolfi Felice, Nadia Campo Woytuk, and Madeline Balaam. 2020. Designing with Intimate Materials and Movements: Making "Menarche Bits". In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 587–600.
[91] Katta Spiel. 2021. The Bodies of TEI – Investigating Norms and Assumptions in the Design of Embodied Interaction. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Salzburg, Austria) *(TEI '21)*. ACM, New York, NY, USA, Article 32, 19 pages.
[92] Paola Spinozzi and Massimiliano Mazzanti. 2017. *Cultures of Sustainability and Wellbeing: Theories, Histories and Policies*. Routledge, London, UK.
[93] Courtenay Sprague. 2018. Assessing Equity in Health and Women's Opportunities to Be Healthy. In *Gender and HIV in South Africa*. Springer, New York, NY, USA, 289–318.
[94] Nithin Sridhar. 2019. Hindu View of Menstruation. In *The Sabarimala Confusion: Menstruation Across Cultures*. Vitasta, New Delhi, India, 1–72.
[95] Hindustan Times. 2019. Delhi's first 'Pad Yatra' busts stigma around menstruation. https://bit.ly/3fjn4UX. Accessed on (01/08/2020).
[96] The New York Times. 2018. Religion and Women's Rights Clash, Violently, at a Shrine in India. https://nyti.ms/2CwwJYR. Accessed on (08/28/2019).
[97] Giulia Tomasello and Teresa Almeida. 2020. Empowerment and Self-Care. In *Crafting Anatomies: Archives, Dialogues, Fabrications*, Amanda Briggs-Goode Katherine Townsend, Rhian Solomon (Ed.). London: Bloomsbury Visual Arts, London, United Kingdom, Chapter 9, 171–188.
[98] Bonnie Tran and Lee Na Choi. 2018. Menstrual Maze: A Toy Exploring Public Engagement in Menstrual Health Education. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI EA '18)*. ACM, New York, NY, USA, Article SDC10, 6 pages.
[99] Anupriya Tuli, Shaan Chopra, Neha Kumar, and Pushpendra Singh. 2018. Learning from and with Menstrupedia: Towards Menstrual Health Education in India. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW, Article 174 (Nov. 2018), 20 pages.
[100] Anupriya Tuli, Shaan Chopra, Pushpendra Singh, and Neha Kumar. 2020. Menstrual (Im)Mobilities and Safe Spaces. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–15.
[101] Anupriya Tuli, Shruti Dalvi, Neha Kumar, and Pushpendra Singh. 2019. "It's a Girl Thing": Examining Challenges and Opportunities around Menstrual Health Education in India. *ACM Trans. Comput.-Hum. Interact.* 26, 5, Article 29 (July 2019), 24 pages.
[102] Agatha Tutia, Kelda Baljon, Lan Vu, and Daniela K. Rosner. 2019. HCI and Menopause: Designing With and Around the Aging Body. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI EA '19)*. ACM, New York, NY, USA, Article CS23, 8 pages.
[103] UNICEF. 2020. Mitigating the impacts of COVID-19 and menstrual health and hygiene. https://uni.cf/3I4b6xV. Accessed on (25/12/2021).
[104] WASH United and Human Rigts Watch. 2017. Understanding Menstrual Hygiene Management & Human Rights. https://bit.ly/3hdsfZb. Accessed on (2020/11/15).