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Ethical perspectives on femtech: Moving from concerns to capability-sensitive designs

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Abstract

Femtech is the collective name for technologies that address female health needs. Femtech applications can help women digitally track their period, manage their fertility, and support their pregnancy. Although femtech has beneficial potential, there are various ethical concerns to be raised with current femtech apps. In this article, we discuss three of the main ethical concerns with femtech apps regarding (1) medical reliability, (2) privacy, and (3) gender stereotyping and epistemic injustice, and we explore how Capability Sensitive Design, a novel design framework for health and well-being technologies, is able to mitigate these concerns and help create morally sensitive femtech.

KEYWORDS

Capability Sensitive Design, digital health technology, ethics by design, femtech, fertility apps, period tracking

1 | INTRODUCTION

There is a new type of digital health technology on the rise and it is called *femtech*—short for *female technology*. These technologies address female health needs and include different types of products. In this article, we focus on apps that assist users with tracking their menstrual cycle, fertility, or pregnancy. Currently, femtech apps are the fourth most popular type of apps among adults and the second most popular type of apps among female adults, and it is projected that the femtech market will reach a share size of 50 billion U.S. dollars by 2025.[1]

The greatest benefit of the fast-growing development and popularity of femtech is that it is putting women's health on the agenda. Traditionally, medicine and medical research has largely focused on the health conditions of men: using the male body as the "human standard" from which findings and therapies were generalized.[2] This resulted from a traditional androcentric perspective that regards men to be more central than women, to the extent that "men" seem "gender-neutral, capable of representing humanity as a whole"[3] and women, in contrast, are treated as peripheral and distinctly gender-marked.[4] Such an androcentric perspective in medicine and healthcare has serious consequences, such as the tendency to overgeneralize research findings solely based on men. In addition to the androcentric focus of medicine and healthcare, women were largely excluded from clinical trials from the 1970s onwards after the tragical occurrences with the drug Thalidomide that was widely prescribed to (pregnant) women at the time.[5] This

[1]Taylor, A. M. (2021). Fertile ground: Rethinking regulatory standards for femtech. *UC Davis Law Review*, *54*, 2269–2299.

[2]Cleghorn, E. (2021). *Unwell women, misdiagnosis and myth in a man-made world*. Dutton; Criado Perez, C. (2019) *Invisible women, exposing data bias in a world designed for men*. Vintage Books; Dusenbery, M. (2019) *Doing harm, the truth about how bad medicine and lazy science leave women dismissed, misdiagnosed, and sick*. HarperCollins Publishers Inc.

[3]Bailey, A., LaFrance, M., & Dovidio, J. F. (2019). Is man the measure of all things? A social cognitive account of androcentrism. *Personality and Social Psychology Review*, *23*, 307–331.

[4]Ibid.

[5]Hendl, T., Jansky, B., & Wild, V. (2019). From design to data handling. Why mHealth needs a feminist perspective. In J. Loh & M. Coeckelbergh (Eds.), *Feminist philosophy of technology*

has left the woman's body mainly under-researched, with imbalances and inequalities in medical and health-related knowledge as a result.[6] Proponents of femtech like to point to the potential of femtech to bridge this gender data gap that currently still exists in medicine and healthcare practices. Users of the app *Clue*, for example, contribute to a large data set on female health that the creators of the app together with various research institutes and clinicians use to come to a better understanding of female bodies.[7] Furthermore, proponents of femtech like to point to the potential of femtech to be an empowering practice as it helps users to become more informed about their reproductive health.[8] Many femtech apps explicitly aim to empower women with self-knowledge and the information needed to make smart and informed decisions about their (reproductive) health. The app *Glow*, for example, advertises with the slogan that users can "simply be in control" of their fertility when they use the app,[9] and the app *Clue* advertises that it helps women to "demystify" their menstrual cycle.[10] By providing users information and insights into their menstrual cycle and fertility, these apps allow women to become more informed about their own health and help them take charge over their own bodies and health outcomes. In addition, femtech apps can serve as an affordable and convenient option for women in places where birth control is hard to access or not accessible at all.[11] In a time when access to abortion is becoming more restricted in various places in the world,[12] proponents of femtech like to point out that femtech apps may provide affordable, convenient, and accessible tech-based contraceptive options.[13]

But despite its beneficial potential, femtech has received severe criticism in recent years. Scholars have criticized femtech applications for reproducing and reinforcing

dominant social inequalities, including troubling binary sex-gender norms and sexist stereotypes.[14] Furthermore, the promise of empowerment advertised by femtech has been disputed by authors pointing out that the discourse of empowerment promoted through the majority of femtech apps is grounded in exclusionary and oppressive conceptualizations of normative embodiment, gender, and sexuality, which contradicts the promise of empowerment.[15] Authors have also pointed out the many privacy violations committed by femtech apps.[16] Also, various studies have shown that many femtech apps provide users with inaccurate and unreliable medical information about their reproductive health.[17]

In this article, we briefly discuss what we identify as the three main ethical concerns with femtech: (1) medical reliability, (2) privacy, and (3) gender stereotyping and epistemic injustice. We subsequently explore how Capability Sensitive Design (CSD),[18] a novel design framework for health and well-being technologies, might be able to mitigate these concerns and help create morally sensitive femtech. The article proceeds with a brief introduction into CSD, followed by an elaboration on the three main ethical concerns with femtech and how CSD can help femtech creators to mitigate these concerns and create morally sensitive femtech applications.

The purpose of this paper is to contribute to the bioethical debate on femtech. So far, the ethical debate on femtech has foremost focused on pointing out and analyzing the various ethical concerns that arise with femtech apps. This paper aims to contribute to the debate by providing designers of femtech apps with ethics-by-design tools derived from the CSD framework (Jacobs, 2020), in order for them to gain ethical guidance to design morally sensitive femtech apps that are medically reliable, privacy-sensitive, and avoid gender stereotyping and the infliction of epistemic injustice. We aim to show that CSD is a valuable approach for designers to design morally sensitive femtech. Please note, however, that this particular paper discusses the theoretical underpinnings of the CSD framework and illustrates the potential contribution that CSD can make to femtech design from a theoretical point of view. The paper, thus, does not consist of an actual application of the CSD framework in the design context of femtech. As will be explained in the next section of

(pp. 77–98). Springer Nature; Wild, V. (2012). How are pregnant women vulnerable research participants? *IJFAB: International Journal of Feminist Approaches to Bioethics*, *5*(2), 82–104.

[6]Zimmerman, M. K., & Hill, S. A. (2000). Reforming gendered health care: An assessment of change. *International Journal of Health Services: Planning, Administration, Evaluation*, *30*(4), 771–795; Hendl, T., et al., op. cit. note 5.

[7]Druet, A. (2018). *Scientific research at Clue: How tracking your cycle advances female health*. Retrieved January 5, 2022, from https://helloclue.com/articles/about-clue/scientific-research-at-clue

[8]Levy, J., & Romo-Avilés, N. (2019). "A good little tool to get to know yourself a bit better": A qualitative study on users' experiences of app-supported menstrual tracking in Europe. *BMC Public Health*, *19*, 1–11.

[9]www.glowing.com

[10]www.helloclue.com

[11]Taylor, op. cit. note 1.

[12]See, for example, de Vogue, A., & Sneed, T. (2021). Supreme Court lets Texas abortion law continue but says providers can sue. *CNN*. Retrieved January 5, 2022, from https://edition.cnn.com/2021/12/10/politics/texas-abortion-law-scotus/index.html; *BBC*. (2021). Poland enforces controversial near-total abortion ban. Retrieved January 5, 2022, from https://www.bbc.com/news/world-europe-55838210

[13]Taylor, op. cit. note 1; Hendl, T., & Jansky, B. (2021). Tales of self-empowerment through digital health technologies: a closer look at 'Femtech'. *Review of Social Economy*, *80*(4), 29–57. https://doi.org/10.1080/00346764.2021.2018027; Woodford, I. (2018). Digital contraceptives and period trackers: The rise of femtech. *The Guardian*. Retrieved January 5, 2022, from https://www.theguardian.com/technology/2018/oct/12/femtech-digital-contraceptive-period-trackers-app-natural-cycles

[14]Hendl & Jansky, op. cit. note 13; Corbin, B. (2020). Digital micro-aggressions and discrimination: FemTech and the "othering" of women. *Nova Law Review*, *44*, 1–28; Hendl, T., et al., op. cit. note 5; Kressbach, M. (2019). Period hacks: Menstruating in the big data paradigm. *Television & New Media*, *22*(3), 241–261; Epstein, D., Lee, N. B., Kang, J. H., Agapie, E., Schroeder, J., Pina, L. R., Fogarty, J., Kientz, J. A., & Munson, S. A. (2017). Examining menstrual tracking to inform the design of personal informatics tools. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, *2017*, 6876–6888; Tiffany, K. (2018). *Period-tracking apps are not for women*. Retrieved January 5, 2022, from https://www.vox.com/the-goods/2018/11/13/18079458/menstrual-tracking-surveillance-glow-clue-apple-health; Delano, M. (2015). *'I tried tracking my period and it was even worse than I could have imagined'*. Retrieved January 5, 2022, from https://medium.com/@maggied/i-tried-tracking-my-period-and-it-was-even-worse-than-i-could-have-imagined-bb46f869f45

[15]Hendl & Jansky, op. cit. note 13; Corbin, op. cit. note 14.

[16]Taylor, op. cit. note 1; Privacy International. (2020). *No body's business but mine: How menstruation apps are sharing your data*. Retrieved January 6, 2022. https://privacyinternational.org/taxonomy/term/676; Gross, M., Hood, A., & Corbin, B. (2021). Pay no attention to that man behind the curtain: An ethical analysis of monetization of menstruation app data. *IJFAB*, *14*(2), 144–156; Shipp, L., & Blasco, J. (2020). How private is your period?: A systematic analysis of menstrual app privacy policies. *Proceedings on Privacy Enhancing Technologies*, *4*, 491–510.

[17]Moglia, M., Nquyen, H., Chyjek, K., Chen, K., & Castaño, P. (2016). Evaluation of smartphone menstrual cycle tracking applications using an adapted applications scoring system. *Obstetrics & Gynecology*, *127*(6), 153–1160; Freis, A., Freundl-Schütt, T., Wallwiener, L.-M., Baur, S., Strowitzki, T., Freundl, G., & Frank-Herrmann, P. (2018). Plausibility of menstrual cycle apps claiming to support conception. *Frontiers of Public Health*. https://doi.org/10.3389/fpubh.2018.00098; Gross, M., et al., op. cit. note 16; Corbin, op. cit. note 14.

[18]Jacobs, N. (2020). Capability sensitive design for health and wellbeing technologies. *Science and Engineering Ethics*, *26*, 3363–3391.

this paper, the CSD framework is an inductive and empirically informed framework with a strong participatory nature and there thus exists a gap between the theoretical outlining of the framework, as is done in this paper, and the actual application of the framework that is empirically informed and participatory in nature. What we aim to show here is the promising potential of CSD in the design context of femtech and we do this by discussing the theoretical workings of the framework in the femtech design context. An important next step, then, for future research is to actually apply the CSD framework in close collaboration with femtech designers, potential users, and other stakeholders to the femtech design context to obtain empirical and participatory-informed insights on how CSD is best put to practice in the femtech design context. This empirical application of CSD is saved for future work.

2 | CSD

A femtech app consists of the solidification of hundreds -even thousands- of design decisions. These decisions concern, for example, what data are worthwhile to collect as well as how that collected data should be quantified and in what ways it should be interpreted and subsequently displayed to the users. All of these decisions somehow affect what the technology is able to do and what not, how these options will be available to users, and for who they will be available. Design decisions made during design processes therefore impact not only the functionality, usability, or esthetics of a technology but also reflect and impact the broader social context and dominant moral views. With conscious design decisions, designers can influence—to a certain extent—what moral values might be represented, supported, or undermined through the technology design.[19] The increasing awareness that technology designers can actively and deliberatively "design for values" has led to the development of multiple "ethics-by-design" approaches.[20] One such novel ethics-by-design approach is CSD[21] for the particular context of health and well-being technology design. CSD combines the method of Value Sensitive Design with the capability theory by Martha Nussbaum.[22]

CSD is based on the idea that all people are morally equal and deserve a life worth living, which entails that everyone is entitled access to 10 basic capabilities in order to live a worthy life. These ten basic capabilities, as identified by Nussbaum, include

(1) being able to live a normal length of lifespan;
(2) having good health;
(3) maintain bodily integrity;
(4) being able to use the senses, imagination, and think;
(5) having emotions and emotional attachments;
(6) possess practical reason to form a conception of the good;
(7) have social affiliations that are meaningful and respectful;
(8) express concern for other species;
(9) being able to play; and
(10) have control over one's material and political environment.[23]

The primary aim of CSD is to design technology that enhances and expands these capabilities for people.[24] Designers working with CSD, together with the intended user-group and other relevant stakeholders, jointly select one or more capabilities from the list of ten basic capabilities as to have specific moral value in the technology design context at hand. The selection of these capabilities from Nussbaum's list, thus, ideally takes place in close collaboration between designers, intended users, and other relevant stakeholders involved. This process can be supported by the set of "capability cards" developed by Marc Steen,[25] who developed a set of cards based on Nussbaum's 10 capabilities as a tool to support discussions about human capabilities, to articulate shared goals, and to align ambitions. The selected capabilities and their enhancement then form the starting point of the design process.[26]

A unique strength of CSD is the emphasis it places on people's *conversion factors*, that is, those factors that determine the degree to which a person is able to transform a resource, a technology in this case, into a capability. Such conversion factors can be either personal, for example, your physical condition, or social, for example, the social norms or societal hierarchies or power relations at play, or environmental, for example, the physical or built environment one finds oneself in. All these factors determine a person's abilities to convert a technology into capabilities. It is important to note that every person has a unique profile of conversion factors at play and this makes humans so diverse. In practice, this means that designers should employ empirical research methods, such as, for example, user focus groups and stakeholder interviews, to find out what personal, social, and environmental conversion factors play a role for their intended users. This empirical investigation, then, informs designers what design requirements are needed to enable their intended users to ultimately make use of the technology design in such a way that the design enhances the selected capabilities for all of the intended users. By doing this, designers account for the human diversity among their intended user group. Moreover, CSD is able to explicitly signal to designers if a new technology design does *not* take into account the diverse conversion factors of its intended user group,

[19]Friedman, B., & Hendry, D. (2019) *Value sensitive design, shaping technology with moral imagination*. The MIT Press; Lupton, D. (2013). Quantifying the body: Monitoring and measuring health in the age of mHealth technologies. *Critical Public Health*, *23*(4), 393–403.
[20]Friedman & Hendry, op. cit. note 19; Hoven, Van den, J., Vermaas, P. E., & Van de Poel, I. (2015). *Handbook of ethics, values and, technological design. Sources, theory, values and application domains*. Springer.
[21]CSD originated by Oosterlaken, I. (2013) *Taking a capability approach to technology and its design* [PhD thesis, TU Delft]. https://repository.tudelft.nl/islandora/object/uuid%3Adf91501f-655f-4c92-803a-4e1340bcd29f. CSD has been further developed by Jacobs, op. cit. note 18 for the context of health and well-being technologies.
[22]Nussbaum, M. (2000). *Women and human development: The capabilities approach*. Cambridge University Press; Nussbaum, M. (2011). *Creating capabilities*. Harvard University Press.
[23]Nussbaum, op. cit. note 22.
[24]Jacobs, op. cit. note 18.
[25]Steen, M. (2016). Organizing design-for-wellbeing projects: Using the capability approach. *Design Issues*, *32*, 4–15.
[26]It exceeds the scope of this article to discuss the CSD framework in full depth here. We refer to Jacobs, op. cit. note 18 for a detailed elaboration on CSD.

since the technology would then fail to enable and enhance the selected capabilities for (some of) the intended users. This, then, will not only result in an inadequate technology that (partly) fails to function but it will also risk being a socially unjust technology since (some) of the intended users are denied (full) access to the capabilities that are identified as to be relevant and morally valuable for *all* intended users of the technology. In the history of technology design as well as the history of medicine and healthcare, there have been numerous examples wherein the needs of either whole population (sub)groups have been neglected, as well as individual differences within populations. Think, for example, of the historical neglect in medicine and healthcare on how cardiovascular diseases in women differ from men,[27] or how for many decades cars have been designed with the male body as standard and thereby putting women at greater risk of injury when involved in a car crash than men.[28] Or think of the example of pulse oximeters—simple technological devices that measure oxygen levels in the blood—that turned out to be less accurate for black people than they are for white people.[29] CSD's strong focus on conversion factors and human diversity is a much-needed response to the neglect of diversity in medicine, healthcare, and technology design. In the context of femtech, accounting for human diversity and (epistemic) justice is very relevant, as will become clear in Section 3 of this article. Therefore, we deem CSD a particularly well-suited ethics-by-design framework to apply to the context of femtech.

Now, although CSD is certainly not the only promising ethics-by-design framework developed recently, we set out to explore CSD's potential for mitigating some of the main ethical concerns that femtech applications presently face. This is because CSD has been specifically developed for health and well-being technologies, a category of which femtech is part, and because of CSD's explicit focus on supporting human diversity and accounting for equal opportunity and justice in technology design, which, as we will argue, is of great importance to femtech. It is important to note, however, that Nussbaum's theory has been critiqued by various feminist scholars as to be either ethnocentric, individualistic, or coming short of responding to the needs of those who are oppressed through intersecting identity categories.[30] An extensive discussion of these critiques is beyond the scope of this paper, but we would like to refer to Jacobs (2020)[31] for a discussion of these first two critiques.

With regard to the latter point of critique, we want to argue that Nussbaum's theory is actually indeed able to account for equality and human rights in intersectional terms. Intersectionality refers to the concept that there are various ways in which the categories race, gender, class, caste, religion, sexual orientation, disability, age, and so forth, are interrelated and reciprocally constructing one another, which in turn shape power relations that influence social relations and individual experiences.[32] With the capability theory's emphasis on the importance of taking into account people's diverse conversion factors, we interpret the theory as giving explicit notice to the idea that structures of oppression do not exist independent of each other but are an interplay of personal, social, and environmental factors. By stressing the importance of conversion factors, the capability theory then enables us to envision what a person—or group—needs in order to enhance and expand their capabilities.

Relatedly, some ethicists have argued that the concerns of the most marginalized and structurally vulnerable populations are most weighty and should be prioritized.[33] The CSD framework in itself does not prescribe which needs of which users should be prioritized. However, as the above account shows, within the CSD framework, designers should account for diverse conversion factors and enhance capabilities for all intended users equally and inclusively.[34] Thus, femtech design should explicitly consider the needs and interests of vulnerable or marginalized users,[35] and if a femtech design fails to bring a particular user group to the threshold level of the mentioned capabilities, then the design is inadequate and possibly morally unjust.[36] We understand the question whose needs are most weighty and how to account for that within the CSD framework to be an important topic for future work.

Furthermore, we want to stress once more that CSD is a new framework that up till now has only been developed theoretically and has not yet been applied in practice. There are thus not yet examples to be given of technologies to which the CSD framework was successfully implemented. The endeavor of this paper is thus a theoretical exploration of the promising potential that CSD could have for the design of femtech applications. Future empirical research on the implementation of CSD to an actual design context of femtech will ultimately have to prove whether CSD is able to realize its potential. Furthermore, we do not aim to argue that CSD is

[27]Gao, Z., Chen, Z., Sun, A., & Deng, A. (2019). Gender differences in cardiovascular disease. *Medicine in Novel Technology Devices*, *4*. See also Cleghorn, op. cit. note 2.

[28]Criado Perez, op. cit. note 2.

[29]Sjoding, M., Dickson, R., Iwashyna, T., Gay, S., & Valley, T. (2020). Racial bias in pulse oximetry measurement. *The New England Journal of Medicine*, *383*, 2477–2478.

[30]Atrey, S. (2018) Women's human rights: From progress to transformation: (an intersectional response to Nussbaum). *Human Rights Quarterly*, *40*, 859–904; Charusheela, S. (2009). Social analysis and the capability approach: A limit to Martha Nussbaum's universalist ethics. *Cambridge Journal of Economics*, *33*, 1135–1152.

[31]Jacobs, op. cit. note 18.

[32]This definition follows Collins, P. H., & Bilge, S. (2016). *Key concepts: Intersectionality*. Polity Press; Collins, P. H. (2017). Intersectionality and epistemic injustice. In I. J. Kidd, J. Medina, & G. Pohlhaus Jr. (Eds.), *The Routledge handbook of epistemic injustice* (pp. 115–124). Routledge. 'Intersectionality' was first used as a metaphor by Kimberlé Crenshaw, who built upon extensive black feminist work and race, class, and gender studies, such as the work done by bell hooks and the Combahee River Collective. (Crenshaw, K. W. (1989). Demarginalizing the intersection of race and sex: A Black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, *1989*(1), article 8; Crenshaw, K. W. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, *43*(6), 1241–1299; Hooks, B. (1981). *Ain't I a woman*. South End Press; Combahee River Collective. (1995). A Black feminist statement. In B. Guy-Sheftall (Ed.), *Words of fire: An anthology of African-American feminist thought*. The New Press (Original work published 1977).

[33]For an overview, see Hendl, T., Chung, R., & Wild, V. (2020). Pandemic surveillance and racialized subpopulations: Mitigating vulnerabilities in COVID-19 apps. *Bioethical Inquiry*, *17*(4), 829–834; Pratt, B., Wild, V., Barasa, E., Kamuva, D., Gilson, L., Hendl, T., & Molyneux, S. (2020). Justice: A key consideration in health policy and systems research ethics. *BMJ Global Health*, *5*(4), e001942.

[34]A mere enhancement of the capabilities of young, fertile, sexually active, abled-bodied, partnered, heterosexual ciswomen would not be sufficient, in this sense.

[35]Jacobs, N. (2020). Two ethical concerns about the use of persuasive technology for vulnerable people. *Bioethics*, *34*, 519–526.

[36]Jacobs, op. cit. note 18.

able to solve all of the ethical concerns that arise with femtech entirely, simply because not all ethical concerns can be solved by solely making changes in technology designs. Instead, many ethical problems require structural and systematic societal changes as well as fundamental changes in the business models behind femtech apps. We do, however, think that CSD has the potential to provide ethical guidance to femtech designers in order for them to be more attuned to the moral aspects of their designs, and thereby help them mitigate some of the ethical concerns that femtech technologies currently give rise to.

3 | ETHICAL CONCERNS AND CAPABILITIES

3.1 | Medical reliability and the capability of having good health

Various studies on the medical reliability of fertility apps have shown that many femtech apps provide inaccurate medical information[37] and that only a few apps cite medical or health literature used, or are developed or recommended by reproductive health experts.[38] What most femtech apps actually offer users are generalized predictions based on learning algorithms, not comprehensive, individualized, transparent, and explainable analyses of complex medical and psychological aspects of their menstruation and fertility.[39] Despite this, most femtech apps position themselves as "authorities on women's bodies and unique facilitators of user self-knowledge".[40] This is problematic since the often misleading and unreliable information provided by femtech apps can lead to, for example, unwanted pregnancies and cause great health risks for users. At a time when abortion regulations are becoming stricter in many parts of the world[41] and femtech apps are at the same time gaining popularity as the primary method of contraception for many women, it is of utmost importance that the information provided by these apps is medically reliable, transparent, and easily understandable for users.

A well-known example of a femtech app that provided inaccurate and misleading health information to its users is Natural Cycles, a nonhormonal birth control app.[42] The Natural Cycles app works with an algorithm that combines a user's temperature, period, and cycle data to predict a user's fertility status. Using the app correctly is time consuming and requires heavy user involvement, since users need to measure their temperature every day at the same time in order to achieve perfect use of the app. Research into the Natural Cycles app suggests that this might explain the high discontinuation rate (54% at 12 months) of the app,[43] as well as the low proportion of women contributing to the "perfect use" analysis (less than 10%) of the app.[44] The difference between "perfect use" and "typical use" of the app has been shown to be a crucial difference, where typical use of Natural Cycles reflects how an average person uses the app, while perfect use requires correct and consistent use throughout the menstrual cycle. Typical use of the Natural Cycles app amounted to a failure rate of 6.9 pregnancies per 100 women per year, while perfect use of the app amounted to a failure rate of 1 pregnancy per 100 women per year,[45] a significant difference. However, Natural Cycles has based their accuracy claims on the "perfect-use" rates and advertises its birth-control method as "highly accurate", although the level of perfect use by users has always been very low (<10%) and the difference between the effectiveness of the app when in perfect use and in typical use is significant. At the start of 2018, a hospital in Stockholm, Sweden, alerted national authorities that 37 women who had sought abortions in a four-month period had all become pregnant while using Natural Cycles as their primary form of contraception.[46] During the same period, research showed that the studies upon which Natural Cycles relies are funded and run primarily by the company itself.[47] Furthermore, research showed that Natural Cycles is primarily marketed on social media through endorsements from trendsetting influencers who vouch for the apps' dependability.[48] This advertising technique, along with the apps' esthetically pleasing interfaces, makes them especially appealing to young women looking for a chic, tech-savvy solution for monitoring their bodies.[49] Femtech such as Natural Cycles are by appearance "approximating, and *perhaps impersonating*, healthcare".[50] However, these apps are not qualified healthcare providers; their only reliable function is to convert individuals' health needs and bodily data into profit.[51]

The short-term gains that femtech apps make by converting users' bodily data into monetary profit are rather obvious. However, we may assume that this will not be profitable in the long run simply because studies have shown that users abandon unreliable and inaccurate tracking apps and search for more accurate alternatives.[52] Let us therefore assume that it is both in the interest of users as well as of creators of femtech to ultimately design medically reliable applications. Now, CSD may assist designers to create such medically reliable femtech applications. Starting from the idea that it is important to design technology that enhances one or more of the

[37]Gross, M., et al., op. cit. note 16; Corbin, op. cit. note 14; Freis, A., et al., op. cit. note 17.
[38]Moglia, M., et al., op. cit. note 17.
[39]Hendl & Jansky, op. cit. note 13.
[40]Ibid: 17.
[41]de Vogue & Sneed, op. cit. note 12; *BBC*, op. cit. note 12.
[42]Hough, A., Bryce, M., & Forrest, S. (2018). Social media and advertising natural contraception to young women: The case for clarity and transparency with reference to the example of 'natural cycles'. *BMJ Sexual Reproductive Health*, *44*, 307–309.
[43]Ibid.
[44]Berglund Scherwitzl, E., Lundberg, O., Kopp Kallner, H., Gemzell Danielsson, K., Trussel, J., & Scherwitzl, R. (2017). Perfect-use and Typical-use Pearl Index of a contraceptive mobile app. *Contraception*, *96*(6), 420–425.
[45]Ibid.
[46]Altman, A. (2018). The unlike politics of a digital contraceptive. *The New Yorker*. Retrieved January 6, 2022, from https://www.newyorker.com/tech/annals-of-technology/the-unlikely-politics-of-a-digital-contraceptive
[47]Ibid.
[48]Hough, A., et al., op. cit. note 42; Taylor, op. cit. note 1.
[49]Taylor, op. cit. note 1.
[50]Gross, M., et al., op. cit. note 16.
[51]Ibid.
[52]Epstein, D., et al. op. cit. note 14.

ten basic capabilities as defined by Nussbaum as to contribute to a worthy life for everyone, designers of femtech should select, in close collaboration with intended users and other stakeholders involved, one or more capabilities relevant to the femtech context. In light of the just discussed importance of medical reliability, it is likely that designers together with intended users and other stakeholders would select the capability of having good health as to be relevant to this context.[53] Furthermore, it is also important for CSD designers to gain clarity on the issue what conversion factors play a role for future potential users of the femtech application. For example,[54] some users might have the personal conversion factor of being very punctual and having lots of discipline, while others do not. Also, where some users might have the social conversion factor of living in a society with social norms that accept the choice for abortion, others might live under social (and perhaps legal) norms that condemn abortion. Furthermore, some potential users may have the environmental conversion factor of having nearby access to high-quality health care services, while others may not. These diverse conversion factors should all inform the eventual design choices made for the femtech app, so that the design and functionality of the app ultimately facilitate the diverse needs of its users.

So, how can the capability of having good health together with the information on the relevant conversion factors of potential users inform what tangible design requirements should be met in a femtech app in order to be medically reliable? We propose to apply a capability hierarchy, which is a tool to help translate abstract capabilities into tangible design requirements.[55] Such a capability hierarchy aims to assist designers to translate an abstract capability into prescriptive norms and from there into concrete design requirements. Taking into account that femtech apps can only offer users generalized predictions instead of highly accurate, individualized, and comprehensive analyses of their reproductive health, as well as the fact that not all potential users have the personal conversion factor of being a "perfect user", a capability hierarchy for the capability of having good health[56] may look like Figure 1.[57]

The translation from the abstract capability into prescriptive norms and into more concrete design requirements requires the methodological tool of specification, which adds context- and domain-specific content to the abstract capability.[58] With the help of the capability hierarchy, designers can translate the capability of having good health into several prescriptive norms and from there into concrete design requirements that ultimately contribute to increasing the medical reliability of a femtech app. Subsequently, based on these design requirements, designers should build several prototypes of the femtech app and empirically test with the potential future users whether the prototype sufficiently facilitates the capability of having good health and therefore is indeed sufficiently medically reliable, as well as whether the prototype sufficiently accounts for the relevant conversion factors at stake for the potential users involved.

3.2 | Privacy and the capability of maintaining bodily integrity

Users of a femtech app are requested to enter various kinds of personal data into the app in order for the app to provide calculations and predictions on, for example, the starting date of their next period or fertile window. The personal data that users are asked to enter into these apps are of the most intimate sorts; involving information about what days one menstruates, whether one experiences bloating, whether one experiences skin problems such as acne, what the smell and texture is of one's vaginal discharge, when one has sex and in what position, whether one had an orgasm, and whether one experiences constipation or diarrhea, among other things. Despite the highly intimate nature of these personal data, the U.S. Food and Drug Administration has taken a largely "hands-off" approach to regulating femtech apps.[59] In Europe, reports by Privacy International have shown that many popular femtech apps are not in compliance with the EU's General Data Protection Regulation (GDPR).[60] Instead, many femtech apps regularly share the personal and intimate data of users with third parties, among which Facebook is one. Almost all femtech apps work with a profit-making mechanism that relies on users entering very personal and sensitive information into the app, which is subsequently used to characterize users and draw up user category lists. These lists are then sold to third parties, who use it for more precise targeting of their audiences with personalized advertisements.[61]

Given the very sensitive nature of the personal data that femtech apps handle, privacy breaches could lead to various unwanted consequences for femtech users.[62] In light of this, designers could

[53]Please note that this paper is not based on an actual CSD analysis conducted in the context of Femtech design but is presenting the workings of CSD from a theoretical point of view; the proposed capabilities are selected by the authors based on ethical concerns that were highlighted in the aforementioned literature.

[54]What follows are examples of potentially relevant conversion factors identified by the authors of this paper based upon the aforementioned literature. In a full CSD analysis, which is beyond the scope of this article, conversion factors are identified with the help of empirical research methods in close consultation with potential user groups. The examples are thus not an exclusive list nor are they based on insights gained by following the proposed bottom-up process.

[55]Jacobs, op. cit. note 18; Van de Poel, I. (2013). Translating values into design requirements. In D. P. Michelfelder, N. McCarthy, & D. E. Goldberg (Eds.), *Philosophy and engineering: Reflections on practice, principles and process* (pp. 253–266). Springer.

[56]Please note that this capability hierarchy is created by the authors of this paper as a theoretical illustration based on the aforementioned literature. When an actual CSD analysis is conducted, the capability hierarchy and the following concrete design requirements are the result of close collaboration between the (technical) designers involved, potential future users, and other relevant stakeholders.

[57]With regard to the norm 'provided information should provide probabilities', we mean that instead of providing unreliable binary predictions, the app interface could present *probabilities* of, for example, ovulation and period arrival as an alternative (Epstein, D., op. cit. note 14).

[58]Jacobs, op. cit. note 18.

[59]Taylor, op. cit. note 1.

[60]Privacy International, op. cit. note 16.

[61]See, for example, FTC. (2021). *Developer of popular women's fertility-tracking app settles FTC allegations that it misled consumers about the disclosure of their health data*. Retrieved January 6, 2020, from https://www.ftc.gov/news-events/news/press-releases/2021/01/developer-popular-womens-fertility-tracking-app-settles-ftc-allegations-it-misled-consumers-about

[62]Shipp & Blasco, op. cit. note 16.

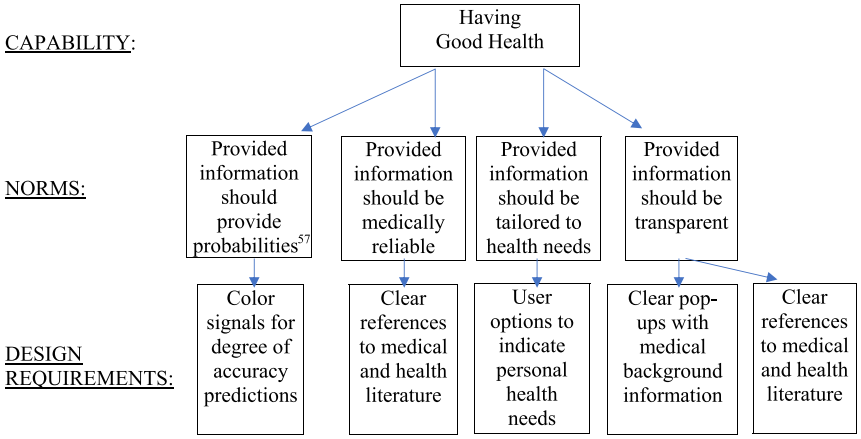

FIGURE 1 A capability hierarchy for the capability of having good health.

select the capability of maintaining bodily integrity as to be relevant here, which can be understood as maintaining the right to self-determination and having one's body protected against unwanted external influences. Protection of one's body, or bodily privacy,[63] is a type of privacy closely connected to decisional privacy—being able to make one's own decisions about one's body, relations, and lifestyle—[64] and informational privacy.[65] As such, (all types of) privacy protect the ability to lead an autonomous life.[66] Decisional and informational privacy are often mutually reinforcing one another, for example, where information about the user could be used to influence their decisions.[67]

Personal conversion factors of potential users that are relevant to take into account include, for example,[68] whether users have the ability to understand complex privacy policies and consent forms and whether they have the ability to understand and grasp the potential consequences of privacy breaches. Social conversion factors relevant here are social and political norms regarding sexual and gender identity, women's rights and reproductive rights, and discrimination. Privacy plays a pivotal role here, as it protects against interferences with someone's sexual and gender identity, and protects reproductive rights, such as abortion. In a social and political context in which, for example, transgender identity is not accepted or in which reproductive rights are limited, these people might be at greater risk of having their privacy breached and their bodies unprotected against unwanted external influences. An example of this, in light of the recent overturning of *Roe v Wade* in the United States and the subsequent implemented abortion bans, is the fear that menstrual tracking apps could be used to punish people seeking an abortion. Although other (digital) evidence, such as text messages, search histories, or location data, would probably be a primary form of evidence, app companies might have to comply with requests or subpoenas to disclose users' data from authorities.[69] This can be aggravated by discrimination, for example, when black people with the capacity for pregnancy would be disproportionately affected.[70]

A capability hierarchy for the capability of maintaining bodily integrity, and thereby mitigating the concern of privacy violations,[71] may look like Figure 2.[72]

3.3 | Gender stereotyping, epistemic injustice, and the capability of having control[73]

A glance at the design of currently available femtech apps shows a uniform picture: almost all femtech apps are designed in the colors

[63]Koops, B. J., Newell, B. C., Timan, T., Škorvánek, I., Chokrevski, T., & Galič, M. (2017). A typology of privacy. *University of Pennsylvania Journal of International Law*, *38*(2), 483–576.
[64]Decew, J. W. (2016). Connecting informational, fourth amendment and constitutional privacy. In A. D. Moore (Ed.), *Privacy, security and accountability: Ethics, law and policy* (pp. 733–788). Rowman and Littlefield International.
[65]Koops, B. J., et al., op. cit. note 63.
[66]Rössler, B. (2004). *The value of privacy*. Polity Press; See also Lanzing, M. (2018). 'Strongly recommended': Revisiting decisional privacy to judge hypernudging in self-tracking technologies. *Philosophy and Technology*, *31*(3), 549–568.
[67]Ibid.; Lanzing, op. cit. note 66.
[68]See note 54.
[69]See Garamvolgyi, F. (2022, June 28). Why US women are deleting their period tracking apps. *The Guardian*. Retrieved 25 October, 2022, from https://www.theguardian.com/world/2022/jun/28/why-us-woman-are-deleting-their-period-tracking-apps; Albert, K., Delano, M., & Weil, E. (2022, June 28). Fear, uncertainty and period trackers. *Medium*. Retrieved October 25, 2022, from https://medium.com/@Kendra_Serra/fear-uncertainty-and-period-trackers-340ab8fdff74; Hill, K. (2022, June 30). Deleting your period tracker won't protect you. *New York Times*. Retrieved October 25, 2022, from https://www.nytimes.com/2022/06/30/technology/period-tracker-privacy-abortion.html
[70]Roberts, D. (1998). *Killing the black body: Race, reproduction and the meaning of liberty*. Vintage Books; See on the argument that rights are not bestowed equally, so that marginalized populations have no privacy rights, Bridges, K. M. (2017). *The poverty of privacy rights*. SUP.
[71]See footnote 56.
[72]With regard to the norm 'provided information should be transparent', we mean that the information that the app provides to its users should be clear and understandable, that is: it should be made understandable to the user how their personal data is being used by the app to create predictions and calculations for the user. This should be communicated back to the user in a clear and understandable way, so that users are well-informed and can decide themselves how to act upon the provided information.
[73]The capability of maintaining bodily integrity is also of great relevance to mitigate the concerns of gender stereotyping and epistemic injustice, as well as the capability of having good health and the capability of being able to live a normal length of lifespan. When CSD would be applied in an actual design context, designers would ideally discuss multiple capabilities here in close consultation with intended users and other relevant stakeholders. With the help of, for example, the earlier mentioned capability cards, they then jointly select the capabilities to focus on in the design context at hand. As we have limited space, we only discuss the capability of having control. The reason we focus on the capability of control and not one of the others is because the capability of control can be understood here as to have agency and control over one's own body, to have one's voice heard and experiences

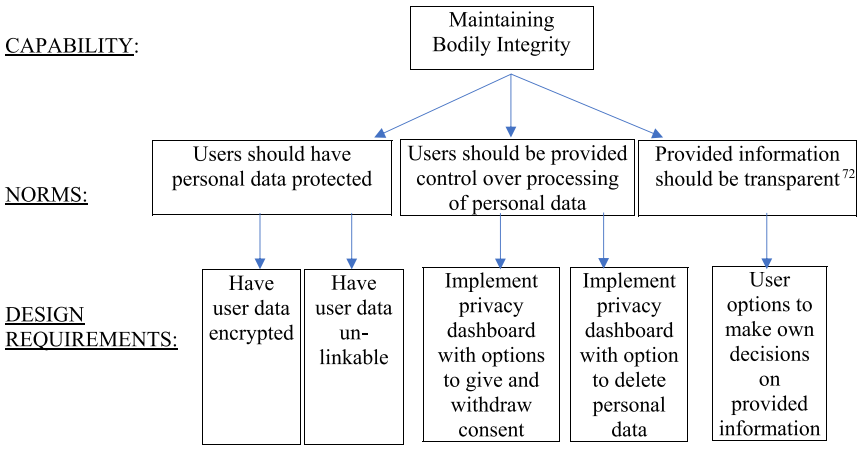

FIGURE 2 A capability hierarchy for the capability of maintaining bodily integrity, thereby mitigating the concern of privacy violations.

pink and purple and make use of stereotypically feminine design elements such as floating clouds, hearts, and superfluous flowers, often combined with iconographic assumptions of cisgender heterosexuality. Various authors have criticized this obsessive focus on stereotypical feminine cisgender heterosexuality in the design of femtech apps[74] and a comprehensive study showed that many users of femtech apps find the overly feminine design "insulting" or "condescending".[75]

In a popular piece on period tracking, scholar Maggie Delano wrote about her experience with the app Clue, which would not let her remove the algorithmically generated "fertile window" from the app's calendar, despite the fact that it would take "a miracle of biblical proportions" for her to get pregnant with her partner, who was also a woman.[76] As Delano pointed out, the assumptions made by the app about fertility and reproduction are not just "a matter of having a few extra annoying boxes on the in-app calendar that one can easily ignore". Instead, they are telling app users that:

> the only women worth designing technology for are those women who are capable of conceiving and who are not only in a relationship, but in a sexual relationship, and in a sexual relationship with someone who can potentially get them pregnant. Read: straight, sexually active, partnered, cis women with enough money for a smartphone to run the app.[77]

But not only young, fertile, heterosexual, abled-bodied, cisgender women benefit from tracking their cycles for the purpose of either avoiding or achieving pregnancy. People may have various reasons to track their menstrual cycles, such as women in lesbian relationships who benefit from tracking their cycle for purposes of health and self-knowledge independent of achieving or avoiding pregnancy, or transgender users who track their cycle to be informed, or users nearing menopause, to name only a few examples. Femtech designs should therefore support the multiple and varied reasons people track their menstrual cycles. Otherwise, femtech apps risk coming short of providing health services equally to all people who might benefit from tracking their menstrual cycle and reproductive health.

Furthermore, femtech apps risk causing epistemic injustice to users who fall outside the stereotypical category of young, fertile, abled-bodied, heterosexual cisgender women. As argued by Miranda Fricker, epistemic injustice occurs when someone is wronged in their capacity as a knower. This could either occur by *testimonial* injustice when prejudice causes a hearer to give a deflated level of credibility to a speaker's word. This could have, for example, the form of not taking a speaker serious, dismissing what someone says, or it could take the form of not wanting to hear what someone says and not acknowledging what someone shares. Epistemic injustice could also occur by *hermeneutical* injustice, when a gap in collective interpretive recourses puts someone at an unfair disadvantage when it comes to making sense of their social experience.[78] Epistemic injustices where someone is ingenuously downgraded or disadvantaged in respect of their status as an epistemic subject, are, fundamentally, a form of discrimination, as Fricker clarifies.[79]

respected and credited, and to have equal access to the health practice of femtech, which are all highly relevant aspects for mitigating the concern of gender stereotyping and epistemic injustice.

[74]Delano, op. cit. note 14; Epstein, D., et al. op. cit. note 14; Tiffany, op. cit. note 14; Hendl, T., et al., op. cit. note 5; Corbin, op. cit. note 14; Gross, M., et al., op. cit. note 16; Hendl & Jansky, op. cit. note 13.

[75]Epstein, D., et al. op. cit. note 14.

[76]Delano, op. cit. note 14.

[77]Ibid.

[78]Fricker, M. (2007). *Epistemic injustice: Power and the ethics of knowing*. Oxford University Press.

[79]Fricker, M. (2017). Evolving concepts of epistemic injustice. In I. J. Kidd, J. Medina, & G. Pohlhaus Jr. (Eds.). *The Routledge handbook of epistemic injustice* (pp. 53–60). Routledge, p. 53; An example of a discriminatory form of testimonial injustice describes sociologist Tressie McMillan Cottom: When she was pregnant, she did not receive proper healthcare and lost her baby, as the existence of her pain was denied. That is, as a black woman, she was ignored and neglected, and thus downgraded as an epistemic subject—even though she was highly educated, spoke in the way one might expect of someone with a lot of formal education, had health insurance, was married, and in all respects "competent"; McMillan Cottom, T. (2019). Dying to be competent. In *Thick and other essays* (pp. 73–97); The New Press. An example of a discriminatory form of hermeneutical injustice happens when, for example, ill persons' experiences are not recognized by the epistemically dominant medical professions, but which are essential to understanding the experience of illness; Carel, H., & Kidd, I. J. (2017). Epistemic injustice in medicine and healthcare. In I. J. Kidd, J. Medina, & G. Pohlhaus Jr. (Eds.), *The Routledge handbook of epistemic injustice* (pp. 336–346). Routledge. This is what happened to McMillan Cottom when her pain was not read as

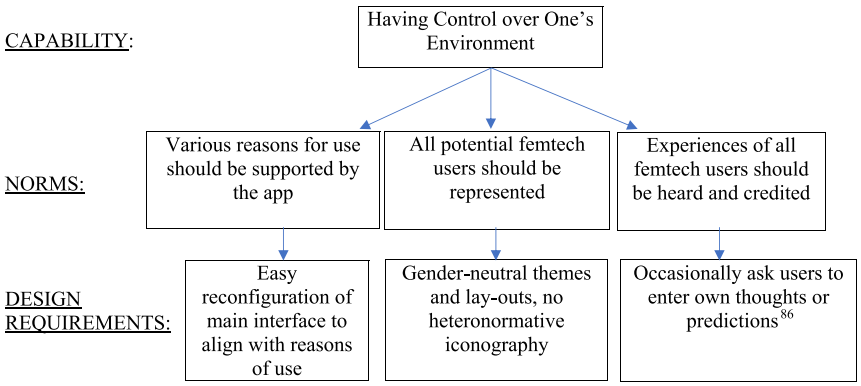

FIGURE 3 A capability hierarchy for the capability of having control over one's environment, and thereby mitigating the concerns of gender stereotyping and epistemic injustice.

Both testimonial and hermeneutical epistemic injustices apply to the context of femtech apps. The experiences of people who fall outside of the stereotypical category of users do not "fit" the design and functionalities of most of these apps either because, for instance, a lesbian woman is not able to remove the fertile window from the app's display, or because queer, nonbinary or transgender people do not feel included by the overly feminine designs, or because these apps do not give credibility to users' experiences of, for example, miscarriage or abortion in the sense that the apps are designed in such ways as *not* wanting to hear, credit, and acknowledge that these are realistic experiences. The latter happened to journalist Kaitlyn Tiffany, who was unable to explain to the "ad-riddled, ultra-pink" app that she had been using since she bought her first smartphone in 2014 that "something out-of-the-ordinary had happened" to her body.[80] The app stated that she had undergone a cycle more than twice as long as usual and adjusted all her averages, rendering all of its future predictions completely useless to her. A testimonial injustice can be observed here: the credibility of Tiffany's experience is being dismissed and her bodily self-knowledge is being undermined by the design and (limited) functionalities of the app.

The apparent structural identity prejudice that only young, fertile, sexually active, abled-bodied, partnered, heterosexual cis-women with a very narrow set of "reproductive health experiences"[81] should be understood as users of femtech apps leads to a deflated level of credibility given to anyone who does not meet this conforming picture and has different health experiences. This deflated level of credibility is apparent in femtech designs that do not want to hear, credit, or acknowledge that certain experiences, such as abortion or miscarriage, are also part of life and therefore do not include these experiences in their app designs. That is, prejudice on behalf of many femtech designers, in combination with a firm belief that a stereotypical feminine user base yields the most commercial profit, causes femtech designers and developers to give a deflated level of credibility to the words and sharing of experiences of those users whose experiences differ from the standard and stereotypical picture, and thereby, those users are confronted with testimonial injustice.[82] The structural identity prejudice occurrent in many femtech apps obscures the menstrual and reproductive health experiences of anyone who identifies differently or has different health experiences. This prejudicial exclusion in the design of these apps toward anyone "other",[83] as a result, causes a hermeneutical marginalization of these people: by design, they are excluded from full participation in the creation and spread of knowledge about their menstrual experiences and reproductive health, and as such, they are confronted with hermeneutical injustice. Thus, (discriminatory) exclusionary mechanisms form the basis of both testimonial and hermeneutical injustices.

In light of the gender stereotyping and epistemic injustices caused by current femtech apps, the capability of having control over one's environment, both materially and politically, appears of relevance here. The capability of having control over one's environment can be understood in this context as to have agency and control over one's own body as well as over one's personal data, to have one's voice heard and experiences respected and credited, and to have equal access to -for all who might benefit from- the health practice of femtech. Personal conversion factors of potential users that are relevant to take into account could include, for example,[84] gender, sexual orientation, bodily abilities, and reproductive health conditions. Social conversion factors could include social norms regarding queerness, transness, or homosexuality, as well as social and legal norms regarding abortion. Environmental conversion factors could include access to health care services, such as abortion clinics.

A capability hierarchy for the capability of having control over one's environment, and thereby mitigating the concerns of gender stereotyping and epistemic injustice,[85] may look like Figure 3.[86]

contractions—being in labor, for over three days. See, for similar examples, Cleghorn, E., op. cit. note 2, 313–318.

[80]Tiffany, op. cit. note 14.

[81]That is, not having the experiences of an abortion, miscarriage, or early menopause symptoms, among others.

[82]Hendl & Jansky, op. cit. note 13.

[83]Corbin, op. cit. note 14.

[84]See footnote 54.

[85]See footnote 56.

[86]With regard to the design requirement 'occasionally ask users to enter own thoughts or predictions', we mean that the app design could occasionally request users to log their own thoughts, experiences, or predictions concerning their reproductive health and use that opportunity to identify necessary changes; see Epstein, D., et al. op. cit. note 14.

4 | CONCLUDING REMARKS

The solution to the ethical problems currently attached to femtech requires fundamental and structural societal changes to ensure full representation and inclusion of all users of femtech, as well as fundamental changes in the business models behind femtech that currently still understand users' health needs and bodily data foremost as monetary profit. One way of contributing to this necessary societal shift is by actively envisioning what an ethical design of femtech should look like and stimulating femtech designers to create such morally sensitive applications. In this article, we have presented the CSD framework and explored how femtech designers with the help of CSD could create applications that mitigate the ethical concerns currently attached to femtech and can proactively design morally sensitive femtech.

CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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