Knowing Pregnancy
A qualitative study of the (non-)use of fertility and pregnancy smartphone applications by women in the UK

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A qualitative study of the (non-)use of fertility and pregnancy smartphone applications by women in the UK

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Abstract

In this thesis I investigate the use of smartphone applications (apps) related to fertility and pregnancy, and consider how the dynamics of women's use, partial use, and non-use of such apps relate to how they experience and make sense of their bodies before and during pregnancy. Drawing upon data from 24 semi-structured, qualitative interviews with 13 women and an analysis of smartphone apps, I contribute to the existing literature on fertility and pregnancy apps by adding empirical data on the experiences of women based in the UK, and extend discussions on practices of self-monitoring specific to the case study of fertility and pregnancy. I explore the use of fertility and pregnancy apps across four key categories of functionality: tracking fertility; monitoring the maternal body; understanding fetal development; and monitoring fetal movement. I analyse women's motivations for and patterns of use of fertility and pregnancy apps, and consider how practical considerations of user availability, app design, and user self-awareness can limit the utility of such technologies. Monitoring fetal movement is a particularly rich example of app functionality to explore, as current clinical practice guidelines and National Health Service advice for women in the UK advise against formal fetal movement counting, yet many apps encourage and facilitate this practice. I unpack the interplay between what has been termed subjective maternal perception of fetal movement, and quantifiable measures based on specific alarm limits that serve as a measure of fetal wellbeing. Through my analysis, I uncover themes related to bodily awareness and ways of knowing, risk and reassurance, and further examine the role of external tools and sources of data in the embodied experience of pregnancy.

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Introduction

Introduction

In this chapter I explain my research aims and how my thesis contributes to the existing literature. I present my research questions, and give a short summary of the research methods I used to address these questions. I describe my theoretical approach, and explain my understanding of the key terms that I use, as well as establishing my choices for particular terminology. Due to the limited scope of a thesis project I identify some areas that are not covered by my thesis but that require attention. I indicate the structure of the remainder of the thesis, and summarise my key findings and arguments.

Background

With the growing use of digital technologies for health purposes, the role of apps and other forms of digital technology in women's contemporary experiences of pregnancy is increasingly significant. In an Australian study of pregnant women's use of digital technology, almost three-quarters of the 410 women surveyed used at least one pregnancy app, and the majority of them found the apps helpful (Lupton and Pedersen, 2016). This suggests that pregnancy apps and other forms of digital technology play a role in the experiences of many pregnant women, but there is a lack of research that explores this in depth, and a lack of research conducted in the UK. Through my PhD project, I produce empirical research that addresses this gap.

In some respects, the use of the internet and smartphone apps to share and obtain information about pregnancy can be seen as an extension of more traditional forms of information seeking and knowledge sharing, such as intergenerational advice, books, and leaflets (O'Higgins *et al.*, 2014). However, central to the small existing literature on digital technology use in pregnancy, notably pregnancy apps, is the notion that the use of technology represents more than just a new

delivery format for information during pregnancy. Women's use of the internet has been noted to align with changing social structures; while women may still use family and friends as sources of advice, a lack of geographical proximity to family members caused by increased migration and mobility means pregnant women may use online discussion forums and social media to reduce isolation and find support (O'Higgins *et al.*, 2014). Furthermore, Johnson argues that smartphone apps are fundamentally different to static sources of information, as they "prompt or provoke" women to engage in certain practices, particularly through push notifications (Johnson, 2014, p. 333).

While much of the written information within pregnancy apps is similar in both content and tone to popular pregnancy books, the delivery format has some differences. I characterise these differences across three areas: presentation, personalisation, and integration. The first is presentation. Having drawn some comparisons with pregnancy books, for example the popular book *What to Expect When You're Expecting*, I found that the illustrations of fetal development appear less frequently (Murkoff and Mazel, 2008). They are more likely to appear monthly, rather than weekly, and tend to appear less 'human'. They are less interactive than the animations available on pregnancy apps, particularly those which can be manipulated and moved by the user using the touch screen. Books also do not offer the same level of personalisation as apps, which can be tailored to at least present the appropriate date, name and sex of the fetus within the development updates. This may have implications for how the user processes this information. Finally, there is likely to be a greater level of integration into daily life with pregnancy apps. Several participants reported checking their apps multiple times a day, including while at work. This is a more discreet means of reading pregnancy information than through a book, and is delivered on a device that is more likely to already be integrated into daily habits. Therefore the frequency of consumption of information delivered in this way is likely to be somewhat different. I do not intend to argue that pregnancy apps represent an unprecedented disruption in

how pregnant women consume information. However, I do argue that an analysis of these apps is justified by the differences in both user habits and the delivery of information, and the need to understand the processing of information as it exists and is used now. There is a need for a thorough investigation of the role of fertility and pregnancy apps in the UK, with a particular focus on the perspectives and experiences of users. This study contributes an interrogation of the experiences, perspectives, and ultimately agency of users, delving more deeply into the use as well as the content of apps. The thesis adds value in the form of a richer picture of the use of digital technology related to fertility and pregnancy in the UK.

Existing research and knowledge gap

Much of the existing literature on fertility and pregnancy apps (which I explore in depth in the literature review chapter) is based on app content analysis or on quantitative surveys. There is a need for in-depth qualitative work to develop this, as there can be a tendency for content analyses to lose sight of the lived experience of app use. I bring this to the forefront of the conversation. I consider the use of fertility apps in one chapter, with my primary focus in the remainder of the thesis being on pregnancy apps, which have been paid less attention than fertility apps in the existing literature.

Only a limited body of empirical research has been conducted on women's experiences of using fertility and pregnancy apps, and with the exception of three recent studies, very little has taken place in the UK. A small number of recent UK qualitative studies on fertility and pregnancy apps have been published since I started this project, highlighting the pertinence of projects like these (Hamper, 2020; Grenfell *et al.*, 2021; Hamper and Nash, 2021) – as well as building upon this work, my research offers some original content not explored in these studies. My thesis incorporates the first interview study on women's perspectives on and/or experiences of using

apps for monitoring fetal movement, and the first analysis of app functionalities for monitoring fetal movement. Unlike Grenfell and colleagues I focus on a variety of fertility apps, rather than their focus on the one app Natural Cycles, and unlike Hamper and Nash my participants are drawn from across the UK, rather than solely London. Being based on new empirical data I offer new findings, and my own analysis of this includes developing emerging concepts to help explain some of the dynamics of app use I observed in the data.

Research questions

I set out to study app use in pregnancy, and later app use for fertility purposes, and did not include non-users in my sample in order to limit my remit to a realistic scope for a PhD project. But in studying use, I also found out about the complexities of how women negotiated app use, what app use meant for them, and where it might and might not be relevant, useful, or meaningful. Therefore non-use was clearly significant even among a sample of what could broadly be defined as users. Participants' usage of apps often reflected the ways in which they made sense of and experienced their pregnancies.

In this thesis I therefore address the following research questions:

1. How and why do women use, or choose not to use, fertility and pregnancy smartphone applications before and during pregnancy?

2. How does the (non-)use of fertility and pregnancy smartphone applications relate to the ways in which women understand and experience their bodies before and during pregnancy?

A supplementary research question is addressed in Chapter 4, which focuses on app features for fetal movement monitoring. In Chapter 4 I analyse the features and content of apps, and align

this analysis with women's experiences as explored throughout the thesis[1]. Through this chapter I consider:

3. How do fertility and pregnancy smartphone applications shape women's knowledge and/or understanding of pregnancy?

Research methods

The core of this thesis is based on 24 qualitative, semi-structured interviews with 13 participants which I conducted between September 2017 and July 2019. Participants took part in one to three interviews at different points during pregnancy, or during the stage of trying to conceive. I analysed this data inductively through a process of thematic analysis. In addition, I conducted an analysis of 20 pregnancy apps, with a focus on fetal movement monitoring features. Together this mixed methods approach allowed me to explore similar themes from the perspective of users and directly from the content of apps, offering some comparisons of intended use and user practices.

Theoretical approach

Rather than applying a single theoretical framework, here I establish my epistemological and conceptual commitments. I approached this project from a non-foundationalist perspective, not assuming that there is one objective reality to be unravelled (Gray, 2009). Starting from this overall theoretical approach, I then used a variety of concepts from existing theory in making sense of the data, which features where I offer analysis in my findings chapters and in the

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[1] This is particularly the case in Chapter 5 on women's experiences of using apps for monitoring fetal movement.

discussion chapter. I draw upon theory from science and technology studies – in particular critical digital health studies – sociology of health/medical sociology, and philosophy.

Definitions/terminology

- *Knowledge*

In understanding knowledge or knowing I refer to Polanyi's work on tacit and explicit knowledge. Polanyi writes that "…what is usually called knowledge is structurally similar to the knowledge of a problem. Knowledge is an activity which would be better described as a process of knowing" (Polanyi, 1969, p. 132). His theory of knowing involves two dimensions of knowledge – tacit knowledge and explicit knowledge.[2] Tacit knowledge is impossible to communicate to others as it is based on subsidiary awareness. Explicit knowledge is based on what he describes as focal awareness, and is knowledge that can therefore be communicated and shared (Polanyi, 1969, p. 128). I return to this in the discussion chapter.

- *Users*

I frequently use the term "user" – there are different approaches to conceptualising users from a variety of perspectives. These include (but are not limited to) the social construction of technology approach, which focuses on the role of particular social groups in constructing technology; the "script approach" used by some scholars of STS that emphasises the role of users in developing technology; attention paid to the links between technology use and consumption; and feminist approaches that underlines the involvement of non-expert actors in technological development, including "end users" (Oudshoorn and Pinch, 2003). Rather than providing a single definition of a user, I agree with Wyatt and colleagues' assertion that "…users

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[2] This theory has been subject to critique over the years, for example sociologist Collins' critique of Polanyi's understanding of tacit knowledge in his own work on the same subject (Collins, 2010). I do not engage with these critiques here as it is beyond the remit of this thesis, and I find Polanyi's conceptualisation of tacit knowledge sufficient as an explanatory tool.

are not simply the passive recipients of technology but that they are active and important actors in shaping and negotiating its meanings" (Wyatt, Thomas and Terranova, 2002, p. 25). They also emphasise that individuals are not only producers or users of technology, but that non-users are also an important group to consider, which I do in this thesis.

- ***Fetus***

In this thesis I predominantly use the term "fetus", though at times I also refer to the unborn, or baby. I acknowledge biomedical terminology that defines a fetus as existing from 10 weeks (first being described as a blastocyst, then an embryo), then a neonate or baby at birth (Moore, Persaud and Torchia, 2016) but for simplicity's sake I refer to fetus during pregnancy without specifically differentiating between fetuses and embryos. This is, however, a complex and political issue. It is beyond the remit of this chapter to explore this in depth, but studies have demonstrated that the language used in abortion discourse reflects and shapes attitudes towards abortion, with the anthropomorphising language of "unborn child" as opposed to "fetus" being used in anti-abortion rhetoric (Bilewicz, Mikołajczak and Babińska, 2017). As Han argues,

> the fact of a fetus is the ground on which claims for its moral significance as a human person are built. Yet, "embryos" and "fetuses" are not biological facts of human ontogeny, but historical, cultural, and social constructions of "human" and "person"… (Han, 2013, p. 20).

I do not therefore suggest that "fetus" is a neutral, objective term and that only "baby" is socially constructed, but "baby" as a concept is nonetheless loaded with more emotional significance (Han, 2013). In my study, I found that some participants used both the terms fetus and baby, but most often found that they referred to themselves as being pregnant with a baby, or if they knew the sex of the baby, he/she. I include the term baby when quoting directly, but generally refer to

fetus in my analysis of participants' statements. However, I recognise that as Rothman argues, if pregnant women define the fetus as a baby they thus enact this reality: "if a woman defines the products of conception within her as accidental, then that is what they are to her. If she defines it as her baby, then she treats it as her baby" (Rothman, 1988, p. 6). For simplicity and because this study included only singleton pregnancies[3], I use the singular to refer to "fetus", though of course some pregnancies are multiple.

- ***Women***

I use the terms woman and women as opposed to gender neutral language such as pregnant individual or birthing people, as to my knowledge the participants in this study identify as women as they responded to a recruitment advert that called for pregnant women. Additionally, the existing research I cite also refers to women and I follow suit when referring to these studies. However I acknowledge that not all people who are pregnant and give birth identify as women or mothers (Karaian, 2013).

- ***Self-monitoring***

I use self-monitoring – or self-tracking – to refer to individuals recording and analysing data about themselves, with or without digital devices that can help mediate this practice (Neff and Nafus, 2016). Self-monitoring is commonly linked to the potential to reflect upon, improve upon, or control particular aspects of life (Rettberg, 2014). Like Weiner and colleagues, I understand the terms self-tracking and self-monitoring to be largely similar (Weiner *et al.*, 2020), and I tend to use the term self-monitoring. Lupton delineates five modes of self-monitoring: "…private, pushed, communal, imposed and exploited" (Lupton, 2014d, p. 5). While these

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[3] This was not a criterion for participation, but only women with singleton pregnancies participated, which is relatively unsurprising given that only around 1 in 60 pregnancies are multiple (Royal College of Obstetricians and Gynaecologists, 2021a).

categories intersect – and do so in the case of fertility and pregnancy apps – in this thesis I would generally characterise participants' app use as private self-monitoring, which as Lupton writes "…is undertaken for purely personal reasons and the data are kept private or shared only with limited and selected others" (Lupton, 2014d, p. 6). While the extent to which the use of self-monitoring technologies is truly voluntary is debatable given that social expectations surrounding personal responsibility for health may compel individuals to self-monitor (a far wider conversation that I do not engage with here, but briefly address in the literature review chapter), I do not consider for example self-monitoring that is pushed by health insurance companies or workplace health schemes, and study what could at a basic level be understood as voluntary self-monitoring.

While I do explore self-monitoring in this thesis, not all aspects of fertility apps, and even more so pregnancy apps, encompass what I would consider self-monitoring. Most pregnancy apps allow users to follow the progression of their pregnancy, with the days of pregnancy increasing over time in the app. Many pregnancy apps refer to the fetal development updates they provide as "tracking", with app features commonly being named with variations of "pregnancy tracker". Apps offer various opportunities for self-monitoring, such as the user logging their weight as it changes across pregnancy, but the fetal development updates are also sometimes described by apps as an aspect of their tracking capabilities. This thesis contributes to the existing literature on modalities of self-monitoring, but this is a dimension of tracking or monitoring that is slightly different in character. It could reasonably be considered tracking in the sense of following the progression of fetal development week by week, which is initially based on the user entering the data point of their pregnancy due date[4] into the app. But when compared with other apps that offer self-monitoring functionalities, such as heart rate tracking apps, the nature of the tracking is

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[4] Or the date of their last menstrual period which the app uses to calculate the due date.

less closely tied in its relation to the tracked subject, as the app user is not the fetus, which itself draws into question the "self" in self-monitoring and how this particular aspect of pregnancy app use is relevant to conversations on self-monitoring. Furthermore, the forms of app use for self-monitoring generally studied within the literature on this practice describe a person using an app to record data and track these data points and gain insights into their practices or health status. In this use of pregnancy apps, the user enters no further data specific to the fetus, and the apps provide generic updates on fetal development that are delivered temporally. I therefore primarily refer to fetal development updates, rather than using the term self-monitoring when discussing this particular feature.

- *Digital health technologies*

Digital health technologies is a term that has been applied in a variety of ways. As Petersen identifies,

> digital health may be conceived or defined narrowly in terms of one domain of application, such as electronic health records, or widely to encompass a vast range of concepts and technologies, such as telehealth and telemedicine, personalized medicine, medical imaging, e-health and e-patient, mobile health, wearable computing, connected health, and health information technology (Petersen, 2019, p. 9).

I do not seek to provide a complete definition here; my study focuses on fertility and pregnancy apps, and in my recruitment materials and interviews I also referred to digital technologies without offering a specific definition, leaving this open to participants' interpretation.

- *Fertility app*

Existing studies of fertility apps are quick to note that menstrual and fertility tracking do not

represent new practices, with the fertility awareness method upon which they are generally based being a well-established means of supporting conception and contraception (albeit not the most reliable form available) (Gambier-Ross, McLernon and Morgan, 2018). Fertility apps are however increasing the reach of the fertility awareness method (Hamper, 2020). The fertility awareness method is a process for identifying potentially fertile days of the menstrual cycle through following the dates of cycles, observing physical signs – notably cervical secretions – and tracking changes to basal body temperature (Grimes *et al.*, 2004). Fertility apps enable users to record some or all of these elements, in addition to recording a variety of factors that the apps might suggest are related to hormonal fluctuations and could therefore be linked to fertility (Hamper, 2020). The apps use this data to make predictions about when the user might be most likely to become pregnant, often using charts, graphs, calendars, and other visualisations to demonstrate this. Some fertility apps are also marketed as period tracking apps, and may be used by individuals who wish to track their menstrual cycles without an interest in ovulation, as well as those who aim to use this data to avoid or achieve pregnancy. I suggest there may be some differentiation between fertility apps and some period tracking or menstrual tracking apps that do not incorporate information on ovulation, but I did not set clear parameters of what constituted a fertility app in interviews and allowed participants to decide the relevance of the apps they used to our conversations. There are a number of apps on the market that pair with wearable fertility monitoring devices that automatically monitor the user's basal body temperature, for example Ovusense. I do not examine these in this thesis, but this exclusion is solely because none of my participants reported using them.

- *Pregnancy app*

The primary focus of my research is on pregnancy apps, which are among the most prevalent types of mHealth apps (Tripp *et al.*, 2014). Pregnancy apps broadly defined are apps related to pregnancy. They serve a variety of functions, including functionalities for self-monitoring, for

example recording symptoms and food intake; for following the progression of pregnancy in days and weeks; and for advice or information on pregnancy related topics (Tripp *et al.*, 2014). There are several apps that appear in app stores if searching for the term "pregnancy", including photo editing apps aimed at pregnant users, games, and baby name generators (Thomas and Lupton, 2016). While I did not offer a singular definition of pregnancy apps when recruiting or in interviews, the use of apps as participants described it influenced the focus of this study, which focuses on pregnancy information, fetal development information, and self-monitoring functionalities (including fetal monitoring), as opposed to games or apps that would be primarily categorised as for entertainment purposes. Pregnancy apps that offer doppler functionalities or compatible hardware for listening to fetal heartbeats have been subject to some controversy. The Royal College of Gynaecologists Obstetricians has advised pregnant women that home dopplers can be misleading if operated without professional expertise, as the user might not know what they are looking for, or mistake their own heartbeat for that of the fetus and be falsely reassured (Royal College of Obstetricians and Gynaecologists, 2021b). This is not something I have explored in this thesis only because my participants did not report using these technologies. One participant reported once trying a heartbeat listening app based solely on her phone's inbuilt microphone, which she was doubtful worked effectively, but as she described it this was for entertainment, rather than as a diagnostic tool.

- *Embodied knowing*

I make several references in this thesis to embodied knowing or bodily knowing, based on theories of embodiment. My understanding of embodiment is grounded in the influential work of Merleau-Ponty and Csordas. Merleau-Ponty reasoned that perception is situated in the body, what he described as embodiment, and in doing so he challenged the supposed distinction between mind and body established in the work of Descartes (Merleau-Ponty, 2013). Csordas writes that:

…the body is a biological, material entity, while embodiment can be understood as an indeterminate methodological field defined by perceptual experience and the mode of presence and engagement in the world… (Csordas, 1993, p. 135).

Therefore the body is not an object to be studied, but the point from which humans experience, understand and know the world. By this token, embodied or bodily knowing (I use the two interchangeably) refers to knowledge gained by or through the body.

Scope

There are a number of issues that are relevant to discussions of self-monitoring, and to fertility or pregnancy apps, that I do not include as part of my analysis but that I wish to acknowledge. It is necessary to limit the scope of a PhD thesis in order to deal with the ideas raised in depth, and additionally there are some areas where my data did not offer sufficient basis to explore particular topics. First, there are some key areas of research in the existing literature on self-monitoring that I do not give significant attention. There are important conversations that surround the political economy of self-monitoring apps and the data that apps collect, explored in the work of scholars such as Zuboff on surveillance capitalism (Zuboff, 2019) and Birch on data assetization (Birch, 2017) that I do not explore in this thesis. Additionally, I do not enter into discussions of data privacy and security, which have been addressed in much of the literature on self-monitoring (see for example Ajana, 2018), but are not my focus here.

Moreover, there are some potential uses of pregnancy apps that I do not consider in this thesis. First, I do not discuss pregnancy apps produced by hospitals or National Health Service (NHS) trusts that may be used for information specific to the services they offer, as electronic patient

records, or for more general pregnancy information. I asked participants open questions about the apps they used and a small number mentioned that they had been asked to download an electronic patient record app, but this would be an outlier in my analysis as I focus on voluntary app use. Second, I do not explore the use of apps in labour and delivery, such as contraction timers. These were not excluded from the original scope of my study and I did ask participants about using apps during labour, bur I did not have sufficient data to explore this in depth, in part because a smaller number of participants (six) took part in an interview after giving birth. Finally, I restricted my remit to fertility and pregnancy apps, and do not discuss the use of parenting apps in the thesis, which have been demonstrated to be an interesting area of study in the existing literature (see for example Thornham, 2019). I discussed parenting apps and technologies such as baby monitors with some participants in interviews conducted after they had given birth, but ultimately limited my scope to fertility and pregnancy apps as this is a wider topic than I had the data to discuss.

Structure

Following this introductory chapter, I review the literature on digital health technologies, paying particular attention to existing research on fertility and pregnancy apps. I then describe my methodology, followed by my findings. I present my findings in five thematic chapters organised by the functionality or purpose of app use. In the first chapter I discuss women's experiences of fertility tracking. In the second chapter, I consider the use of pregnancy apps for self-monitoring and information seeking, with a focus on diet and pregnancy symptoms. In the third chapter I describe how participants and their partners used pregnancy apps to inform their understanding of fetal development. In the fourth chapter I present the results of my analysis of fetal movement monitoring apps. In the fifth chapter I examine this same topic from the perspective of participants, and study their fetal movement monitoring practices that did or did not involve

the use of apps. These findings chapters are somewhat chronological in their organisation, starting with fertility and ending with fetal movement (though chapters two and three span across pregnancy). I acknowledge that some scholars have criticised understandings of pregnancy based on linear time as potentially disempowering to women by constraining their choices into a defined model of medical time management (Simonds, 2002), but ultimately feel this is a coherent thesis structure despite this potential critique. Following the findings chapters, I draw the arguments of the thesis together in a discussion chapter, then offer my conclusions.

Key arguments and significance

Overall, in exploring the question of how and why women use fertility and pregnancy apps my thesis highlights the agency of women. Participants were thoughtful in how they approached app use, and used apps selectively in the ways that they felt were useful to them. Many participants were critical of the apps they used and were clearly able to reflect on their own usage, and change their usage patterns as they felt appropriate, including at different points in pregnancy as their needs and experiences changed. For example, some participants felt that some app features were not relevant or useful; some participants altered their usage practices if they felt they had become obsessive, or the self-monitoring induced anxiety and fear, like one case of a participant having emotional associations of self-monitoring data with a previous miscarriage experience; and some participants chose to prioritise their intuitive, embodied knowing over using an app to record data. These findings also demonstrate the emotional resonance of self-monitoring, and complement the findings of existing research on self-monitoring. My thesis adds new emphasis to this in the context of fertility and pregnancy app use, something that has not been considered in depth in much of the literature given that content analysis has often been the primary research method. A notable aspect of selective use of apps is that while most participants used fertility apps for self-monitoring, many participants did not go on to use pregnancy apps for this

purpose. I develop an overall argument that the use of apps for self-monitoring is context-specific. There were some participants who used pregnancy apps for self-monitoring, notably for tracking their food intake. Additionally, I add new insights into the use of pregnancy apps for monitoring fetal movement, a type of self-monitoring that some participants used apps to facilitate. I describe the ways in which participants used these apps, which generally fell into two categories: the first is the use of apps to augment a short period of heightened awareness of fetal movement after a user had intuited a possible change in fetal movement; and the second as a tool to record fetal movement over a longer period time, with the app forming a type of external memory. By considering both app content and user experiences, I offer a new conceptualisation of the role of pregnancy apps for fetal movement monitoring as gatekeepers.

While the model of usage that most participants described for using fertility apps fits relatively neatly into existing understandings of self-monitoring, the type of pregnancy app usage that several participants engaged in can be better described as information seeking, though with a temporal, semi-personalised dynamic, and still forming part of practices of self-management when not enacted as quantified self-monitoring. I argue that while the level of personalisation that pregnancy apps offer is limited, they nonetheless offer users reassurance, including on fetal development through the updates on fetal development that the apps offer users as a way to "track" the progression of their pregnancies. This is an interesting finding, as some participants suggested that this generic advice gave them insight into their own pregnancies. I conceptualise the virtual pregnancy that develops on a pregnancy app in parallel to a user's pregnancy as a counterpart pregnancy. I argue that this is a helpful concept for explaining this practice, including occurrences such as discrepancies between the development of the counterpart pregnancy and the user's physical pregnancy. Many participants valued using this aspect of pregnancy apps as the limited amounts of information they included in their updates was easier

to process than the sometimes overwhelming amounts of pregnancy advice participants reported consuming, particularly online.

The weekly updates on fetal development were a feature where the role of partners in app use emerged, with some partners showing limited interest in pregnancy apps, while others chose to download them independently, which I also analyse using the concept of the counterpart pregnancy. One aspect of the counterpart pregnancy relates to my second research question of how the use of fertility and pregnancy apps relates to the ways in which women understand and experience their bodies before and during pregnancy. I suggest that the counterpart pregnancy influenced how users understood their bodies and how the fetus within developed during their pregnancies, all while emphasising their own understanding and feeling of being pregnant. This also related to physical sensations or symptoms of pregnancy, with the temporal updates on pregnancy leading some participants to focus their bodily attention on these experiences. However, once again user agency is important, as participants were aware of where the advice of the apps did not align with their own bodily experience. In particular, fetal movement monitoring was an area where some participants specifically rejected app use as they trusted their bodily, intuitive knowing. I suggest that there is a two-way dynamic whereby apps can play a role in influencing how users understand and experience their bodies, but the ways that users understand their bodies in turn influences how they choose to use, or not use, apps for self-monitoring. This develops existing literature on self-monitoring, but I also draw greater attention to types of knowledge that cannot be quantified. Additionally, my analysis of apps nuances some of the existing literature on pregnancy apps. Some scholars have suggested that pregnancy apps position metric knowledge and data as superior to embodied knowledge, but I find that several apps emphasise the compatibility of these ways of knowing. I also consider these ideas in relation to fertility apps. I argue that fertility apps categorise particular aspects of the body and of practices as related to fertility, sometimes using gamification to embed this, which potentially

influences how users understand their own fertility. Some participants' self-monitoring practices aligned with a broader understanding of fertility as related to a wider range of factors, while others had a narrower view of what constituted fertility, and therefore what data points were relevant. Fertility apps also defined fertility in specific metrics, with particular measures being used to indicate ovulation, and I consider how users trusted this measure against their own bodily experiences. In the same way that pregnancy apps could make participants more physically aware of their bodies by suggesting symptoms may arise at particular stages, fertility apps increased the physical awareness of some participants in looking for potential signs of ovulation.

This thesis extends existing research on self-monitoring practices with new empirical data from the UK. I contribute to literature on everyday, ordinary (Han, 2013) experiences of pregnancy, and offer new understandings and emerging concepts to help understand contemporary practices of digital health technology use in pregnancy. One participant shared towards the end of our interview "I just found it weird that my body is not my own anymore … it's just kind of like everything that you know about yourself, you start to question" (Julie).

She explained how she did not particularly enjoy being pregnant, and it had disrupted her sense of self. She had to reckon with a new understanding of what physical sensations meant for her body. She could not move like she used to move; sitting up took new effort, and a different amount of momentum. Feeling fetal movement was a sensation that she previously would have related to feeling sick. As she described it, her body was not her own anymore, in the sense that it partly belonged to the fetus, a living thing inhabiting and part of her body, but also in the way that she no longer knew her body as *hers* as she had previously known it. In this thesis I examine the role that apps have to play in how women come to understand these new versions of themselves during pregnancy. This dovetails with existing ideas surrounding how technology use

shapes ways of knowing. I argue that women merge their own embodied and experiential knowing with how apps know their bodies, in not so much a contrast than an active process of bringing different ways of knowing together – therefore this thesis is titled "Knowing Pregnancy"[5].

Conclusion

In this introductory chapter I have presented my overall research aims, study design, theoretical approach, and definitions of how I understand some of the key terminology I use. I have detailed the key arguments of the thesis, and indicate how I have structured the thesis. In the following chapter, I situate my study in the existing literature.

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[5] This is a phrase also used by Ross as a subtitle in her 2019 article on women's accounts of sensing fetal movement (Ross, 2019).

Literature review

Introduction

Having established the aims of my research in the introduction, in this chapter I position my study in the existing literature. I begin by briefly reviewing the literature on digital health technologies, and describe critical approaches that have drawn attention to the potential consequences associated with their use as part of health care provision. I focus in particular on self-monitoring technologies, and offer an overall view of some of the key literature on this topic rather than a comprehensive review, instead turning specifically to considering the existing research on fertility and pregnancy apps as this is the focus of this study. Much of the existing literature on fertility and pregnancy apps has established that they emphasise a need for self-surveillance in pregnancy, which I go on to contextualise by explaining some of the wider debate surrounding the medicalisation of pregnancy and birth, and narratives surrounding risk and the associated expectations on the restriction of certain behaviours in pregnancy. I describe some of the parallels between the use of pregnancy apps and longstanding critiques of technology use in pregnancy that developed in response to the increased use of technology in pregnancy care, such as ultrasonography. I then turn to how the existing literature has considered the use of fertility and pregnancy apps in relation to understanding the body, and in particular the interactions between different ways of knowing the body that scholars have identified in the use of quantified data and embodied knowing. Stepping back from the focus on fertility and pregnancy apps, I then consider the wider literature on self-monitoring that also explores these issues of quantified knowing and embodied knowing, and how empirical research suggests that the use of self-monitoring technologies does not necessarily supersede embodied knowing in the way that some critics have proposed. I suggest that this is a particularly interesting area to consider in the case of pregnancy, as there are changes to embodied knowing brought about by pregnancy itself, and

the ideas of pregnant embodiment and technology and embodiment intersect. Finally, I position my study as contributing to current discussions of fertility and pregnancy app use by adding new empirical data gathered in a UK context based on in-depth, qualitative interviews, and a focus on fetal movement monitoring that has not been sufficiently considered in existing research. My thesis also adds to discussions of self-monitoring more broadly by offering new insights into how users of digital health technologies negotiate and blend different ways of knowing.

Digital health technologies

The opportunities that digital technologies may offer for health purposes have been lauded by some policymakers and industry actors as potentially transformative to the structure of health care systems and the role that individuals play in the management of their own health (Swan, 2012; Topol, 2015). Catalysed by Apple's launch of the first iPhone in 2007, there has been a surge in the availability of products that fall under the broad umbrella of digital health technologies (West *et al.*, 2012). These include smartphone health apps and other tools such as wearable monitors, which may be products such as Fitbits and the Apple Watch used to track factors such as heart rate and activity, as well as more specialised devices designed for use by people living with particular conditions, for example blood glucose monitors for use by people living with diabetes. The term digital health technologies can also include in its remit digitally facilitated tools for health care at a distance, for example smartphone cameras for taking photographs of moles for remote skin cancer screening by a physician (Lucivero and Jongsma, 2018). My focus in this thesis is on the use of smartphone applications for health purposes, sometimes referred to as mobile health or mHealth (World Health Organization, 2011). From what has been termed a "techno-utopian" perspective (Lupton, 2014a), the use of personal digital tools for self-monitoring and even self-diagnosis has the power to shift the dynamics between health care professionals and patients, who are empowered with the ability to take

greater ownership and responsibility for their health (Swan, 2012; Topol, 2016). From a policy and public health standpoint, digital health technologies have been praised for the potential to facilitate relatively low-cost interventions that can enable easier access to underserved populations, for example individuals living in rural areas (World Health Organization, 2011).

Scholars in the social sciences – for example in science and technology studies and within the sub-field of critical digital health studies – have examined and interrogated these claims surrounding digital health technologies (Lupton, 2014b; Grenfell *et al.*, 2021, p. 117). Some of this literature positions digital health technologies and associated self-monitoring practices as part of a historical trajectory towards individualised responsibility for health. Among others, Lupton – a sociologist who has published widely on self-monitoring technologies – uses a Foucauldian perspective to characterise the use of digital health technologies for self-monitoring as an activity of medical self-surveillance, with individuals internalising societal demands to take responsibility for their own health (Lupton, 2012, 2014c). This is also influenced by Armstrong's work on surveillance medicine, in which he argues that changing boundaries between health and illness are normalised and voluntarily taken on by individuals who become complicit in their own surveillance, extending the influence of the medical realm into their own lives (Armstrong, 1995). Given this longer history, this dynamic is not exclusive to digital health technologies, but due to the resonance of these ideas Lupton and others have explained self-monitoring technologies as an aspect of this. From this standpoint, Lupton suggests that some of the problematic potential of digital health technologies lies in the finding that not all individuals wish to be empowered in this way, and furthermore, digital health technologies also create and extend obligations for self-surveillance (Lupton, 2012; Ajana, 2017; Sanders, 2017). While these technologies may create some opportunities for empowerment – for example Nafus and Sherman suggest that taking ownership of self-monitoring data can be a practice of "soft resistance" when compared with the lack of control afforded by structures associated with Big Data (Nafus and Sherman, 2014) – the

potential benefits are distributed inequitably. As Fiske and colleagues argue, existing research on digital health technologies has found that they "…both empower and disempower patients: they increase possibilities for some (often, the healthier and wealthier) while limiting control and agency for those who are excluded from using these technologies due to economic or social barriers" (Fiske, Buyx and Prainsack, 2020, p. 2). Individuals may be excluded from using technologies, or choose not to use them, which Oudshoorn explores in her work on telecare (Oudshoorn, 2008). It is important therefore to recognise patterns of exclusion with the proliferation of digital health technologies, especially if they are adopted as part of health care delivery. Owens and Cribb argue that the use of health promoting wearable technologies is likely to reproduce existing health inequalities, which they suggest is particularly problematic given the limitations they have in substantively improving health outcomes (Owens and Cribb, 2019). Other research has also challenged the supposed benefits of such tools in terms of a possible lack of efficacy. For example, studies have demonstrated that there are problems of accuracy with apps and wearable fitness devices (Feehan *et al.*, 2018; Millenson *et al.*, 2018), and furthermore, the assumption that using such tools actually leads to better health has been challenged by empirical evidence (see for example Jo *et al.*, 2019). A focus on cost-saving digital health technologies is problematic if used to justify reduced investment in health care, as "…merely having access to data does not imply that people have an increased control over their behaviour and health outcomes, as for behavioural change to happen the intervention of a health professional or counsellor is often necessary" (Lucivero and Jongsma, 2018, p. 687). Fiske and colleagues describe this type of issue as a "double-edged sword of digital self-care" – patients may become more engaged and be enabled to take more ownership of their health care and wellbeing, but "…individualized practices of empowerment cannot be a substitute for a shrinking provision of high-quality medical services available to all" (Fiske, Buyx and Prainsack, 2020, p. 8). In this thesis I focus on the lived experience of individuals using fertility apps and pregnancy apps voluntarily alongside their use of formal health care, and do not consider the

institutional or political background to their use – but as this literature demonstrates, the use of digital health technologies is not apolitical.

The above is far from a complete account of the literature on self-monitoring and digital health technologies. Instead I intend to provide some of this wider context on the use of digital health technologies and self-monitoring, and in line with the focus of my research I wish to give greater attention to the literature specific to fertility and pregnancy apps. There are several other issues that are important in the literature on self-monitoring that I do not cover here, such as the dynamics between individuals/patients and health care professionals influenced by the use of digital health technologies (Ruckenstein, 2015; Neff and Nafus, 2016), the commodification and appropriation of personal health data, data privacy, surveillance, and markets (Pantzar and Ruckenstein, 2014; Ajana, 2017; Williams *et al.*, 2020). I return to more of the literature on self-monitoring later in this review, primarily on the impact of personal health data on how the body is perceived and understood. This body of literature on user practices adds an important contribution, as it emphasises the agency of users and "…helps to complicate narratives about the disciplining and normalising power of self-monitoring practices and about the flows of self-monitoring data related to the potential for surveillance and/or commodification" (Weiner *et al.*, 2020, p. 2). For now, I will turn specifically to literature that considers fertility and pregnancy apps.

Uses of fertility and pregnancy apps

As discussed more generally above, digital health technologies have been positioned as a way to reduce the cost of antenatal care by reducing the need for professional care and enabling patient empowerment (Tripp *et al.*, 2014). Most existing studies of fertility and pregnancy apps are conducted from a public health standpoint (Johnson, 2014; Lupton, 2015) and tend to explore

their effectiveness as a health care intervention, such as the use of apps to manage gestational diabetes, and issues surrounding the accuracy of information fertility and pregnancy apps provide (Derbyshire and Dancey, 2013; Overdijkink *et al.*, 2018; Skar *et al.*, 2018; Bland *et al.*, 2020; Sandborg *et al.*, 2021). A far smaller body of literature examines the social and cultural aspects of fertility and pregnancy app use, which provides a deeper understanding of the significance and meaning surrounding the use of fertility and pregnancy apps than is possible through a solely public health oriented approach. Similar issues in the wider literature as mentioned above are also seen here, including concerns around data privacy, and equitable access to technology (Kruk *et al.*, 2016; Hughson *et al.*, 2018; Daly *et al.*, 2019; Bland *et al.*, 2020).

A basic starting point to draw upon from the existing literature on fertility and pregnancy apps is the motivations that women share for why they use such apps. The reasons women use fertility apps may change over time based on their reproductive intentions (i.e. whether they use them with hopes of avoiding pregnancy or becoming pregnant) (Earle *et al.*, 2021). Here I focus primarily on the use of fertility apps among women trying to conceive as well as the use of pregnancy apps among pregnant women. Participants in Gambier-Ross and colleagues' study of fertility apps – a mixed methods study comprising qualitative interviews and a survey – valued the constant access to fertility apps enabled by the proximity they had to their phones and the relative ease of entering data compared with using a paper chart (Gambier-Ross, McLernon and Morgan, 2018). In Hamper's interview study of fertility apps, she found that many women used fertility apps in an attempt to exercise some control over what was an otherwise uncertain bodily process (Hamper, 2020). Lupton found a similar phenomenon in an online survey of pregnancy and parenting and app use, and women reported that pregnancy apps offered them knowledge – particularly on fetal development – and reassurance (Lupton, 2017). In a UK study the majority of women surveyed reported referring to online sources of information – for some this included pregnancy apps – to increase their understanding of pregnancy related concerns (Mackintosh *et*

al., 2020). The knowledge and reassurance offered by digital sources may be valued by women in the context of relatively infrequent antenatal care appointments. In Kraschnewski and colleagues' focus group in the US on internet use in pregnancy they found that most women reported following the progress of their pregnancy using a pregnancy app, and that alongside internet use more broadly, pregnancy apps help fill a perceived gap in antenatal care in terms of providing women with a resource to seek answers to questions, particularly given that women reported their antenatal care began later than the point at which they needed advice (Kraschnewski *et al.*, 2014).[6] Other studies also confirm the use of pregnancy apps as being partially motivated by the relative infrequency of antenatal care appointments, or the initial gap between taking a positive pregnancy test and attending an appointment, that is likely to be several weeks (Hearn, Miller and Fletcher, 2013; Peyton *et al.*, 2014). This perceived gap in care relates back to the use of digital technologies changing health care dynamics, though this clearly will differ widely given the variation in the provision of antenatal care between regions, particularly in lower-resource settings.[7]

Further to the motivation of using pregnancy apps to gain knowledge and reassurance, in Hamper and Nash's interview study of pregnancy apps they found that many women used pregnancy apps as a tool to engage partners with their pregnancies, in what they characterise as an attempt to encourage paternal bonding[8] and therefore investment in the practical responsibilities of parenting (Hamper and Nash, 2021, p. 595). They explore the role of partners in the use of pregnancy apps, and examine how pregnancy apps are a factor in forming intimate relationships, both between the expectant parents and the fetus through the visual images of

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[6] The first antenatal appointment in the UK, known as the booking appointment, is recommended by NICE guidelines to occur before 10 weeks of pregnancy, and is usually offered from the eighth week of pregnancy (NICE, 2021).

[7] I focus on the UK in this study and do not go into depth in discussing the use of fertility and pregnancy apps in lower-resource settings.

[8] All participants in the study reported being in heterosexual relationships (Hamper and Nash, 2021).

fetal development shown on pregnancy apps, and intergenerational relationships with other family members (Hamper and Nash, 2021). Several other studies also explore the role of partners, most commonly fathers, in relation to pregnancy apps. A number of content analysis studies of pregnancy apps identify the lack of opportunities for meaningful engagement for partners in the design of pregnancy apps, with Thomas and colleagues arguing that pregnancy apps, and particularly those geared towards men, trivialise the role of fathers, and make assumptions about the heteronormativity of user relationships (Johnson, 2014; Ley, 2016; Thomas, Lupton and Pedersen, 2018; Peyton and Wisniewski, 2020).

Risk and maternal sacrifice

While trivialising the role of partners and minimising their responsibilities, existing studies have demonstrated that fertility and pregnancy apps simultaneously put many obligations and expectations on women for self-surveillance.[9] While fertility tracking is sometimes marketed using discourse of feminist empowerment (Healy, 2021), critical studies of fertility and pregnancy apps echo much of the literature on digital health technologies more broadly surrounding self-surveillance as discussed earlier in this review, and discuss how these technologies can also be constraining (see for example Doshi, 2018). There is also a gendered dimension when considering apps tailored towards female reproductive health. Women face pressure from cultural and historical narratives surrounding risk, often enacted through medical services, to conform with medical surveillance of their pregnancies, lest they be blamed for any adverse outcomes that could be seen to result from their failure to comply (Coxon, Sandall and Fulop, 2014). Lupton's work on the use of apps for women's reproductive health highlights how fertility and pregnancy apps emphasise risk, and she argues that they "medicalise" women's bodies (Lupton, 2015, p. 449; Lupton, Pedersen and Thomas, 2016). I do not engage with the

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[9] Partners of women who are pregnant or trying to conceive may of course themselves also be women.

concept of medicalisation in depth across this thesis, but there is a significant debate surrounding the medicalisation of pregnancy and birth and that is interlinked to the risk narratives I do discuss – I therefore give some background here.

Historically, in the UK birth most commonly took place in the home, but the establishment of the UK National Health Service (NHS) in 1948 accompanied a shift in social values that emphasised the risk involved in childbirth and the relative safety afforded by medical monitoring and intervention (Clews, 2013). This was epitomised in the *Peel Report*, a 1970 Department of Health publication that recommended that hospitals were the most appropriate location for birth (Clews, 2013). Alongside changes in the spaces that surround childbirth, hospital births are associated with an altered manner of birth, notably through an increase in medical interventions (Walsh, 2009). The increasing use of medical intervention in birth has sparked criticism, embodied in such campaigns as the Royal College of Midwives *Campaign for Normal Birth*, which advocated for minimal intervention in childbirth, and the promotion of a view of birth that highlights its normality (Steel and Jomeen, 2015). Critics of the routine use of medical interventions, such as Walsh, consider medical interventions, notably epidural pain relief, to interfere with the "natural", physiological process of birth (Walsh, 2009). This concern with the overuse of medical intervention in pregnancy and childbirth is not a new phenomenon. Criticisms of the medicalisation of pregnancy and childbirth emerged in the late 1950s through user activism, which predated academic work that became influential in the 1970s, through the work of sociologists such as Oakley (Oakley, 2016).

In many contemporary and historic critiques of the increased role of medicine in childbirth, a contrast that often verges on a sharp dichotomy is drawn between medicalised birth on one side, and natural or normal birth on the other (Clews, 2013; Steel and Jomeen, 2015). Within some popular natural birth narratives there is an emphasis on self-knowledge, empowerment, and a

woman's intuition surrounding her own bodily processes (Cheyney, 2008; Mansfield, 2008). This is often framed in terms of women regaining control from a domineering, (at least historically) male, medical establishment, which "(over)medicalises" a natural process (Cheyney, 2008). There are, however, inherent weaknesses in the use of the term medicalisation as a critique, recognised by Rose. Rose notes that while medicalisation may be a useful neutral term to designate a change, (for example, the move of childbirth from the home to the hospital), it is incomplete as a critique, and holds methodological problems, such as a lack of a single, comprehensible medical entity that has a remit to medicalise something (Rose, 2007). Furthermore, when medicalised birth is contrasted with natural or normal birth, there remain ontological problems, as the meaning of what constitutes a natural birth is poorly defined, and at times, contradictory.

A basic definition of a natural birth is one with minimal medical intervention. This is detailed in the UK Department of Health's definition of normal birth, which "…excludes epidural or spinal anaesthetic, induction of labour, forceps or ventouse, caesarean section (CS) and episiotomy" (Walsh, 2009). In other definitions of natural or normal birth, there are references to different aspects of the process, with some suggesting that a birth is natural even when medical interventions are used, provided the woman is in "control" (Brubaker and Dillaway, 2009). This lack of a singular definition of a natural birth is further complicated by the apparent contradictions within natural birth narratives. Through an analysis of popular pregnancy books, Mansfield explores how within the discourse of natural birth, there are paradoxical ideals about how birth must be controlled in line with particular values in order to be natural, while simultaneously rejecting intervention which interferes with the natural process of birth (Mansfield, 2008). In light of this lack of clarity of what constitutes a natural birth, some work recognises that the parameters of natural and medicalised birth are complex. Brubaker and Dillaway argue that forms of birth must be considered on a continuum, rather than a dichotomy (Brubaker and Dillaway, 2009). This is perhaps a more productive approach to take; however,

whether or not this is a better way to frame the discourse, the natural/medicalised dichotomy continues to shape discussion surrounding birth and the decisions that women make (Coxon, Sandall and Fulop, 2014).

In addition to this emphasis on medicalisation in childbirth and the avoidance of risk, women's behaviour in pregnancy is also subject to judgement and restriction. There is a broad spectrum of areas where women are advised to take caution in pregnancy, including (but not limited to) exercising, taking medication, consuming alcohol, tobacco, and particular foods (Burton-Jeangros, 2011). Risks can relate to both the mother and to the fetus, including prematurity; conditions associated with alcohol consumption such as fetal alcohol syndrome and chromosomal abnormalities in the fetus; and postpartum haemorrhage and diabetes for the mother (Lennon, 2016). As well as causing anxiety, these risk narratives mean that the fetus can be prioritised, even where the health of the woman is in question. For example in a survey on hyperemesis gravidarum (a condition that involves what can be extremely debilitating vomiting) participants reported doctors denying their requests for medication or pharmacists refusing to fill their prescriptions, despite the use of medication being in line with clinical guidelines for treating the condition (Hsiao *et al.*, 2021). Alcohol consumption in pregnancy is also controversial, and continues to be subject to heated debate. In the economist Oster's pregnancy book *Expecting Better* she suggested from her analysis of the available literature on alcohol consumption in pregnancy that there is no evidence to suggest that light to moderate drinking leads to worse pregnancy outcomes (Oster, 2013). However, this was met with some sharp criticism, with critics challenging her findings as well as her credentials (Soh, 2013). Like Oster, other scholars have argued that pregnancy guidelines often include what some judge to be overly cautious recommendations, not trusting women to interpret the nuances of the available evidence and make their own risk assessments, expecting a blanket level of what Lowe describes as "maternal sacrifice" (Lowe, Lee and Yardley, 2010; Oster, 2013; Lowe, 2016). This is inherent in guidance

like the United States Centers for Disease Control and Prevention's recommendations on alcohol that suggest that not only should pregnant women avoid alcohol, all sexually active women of reproductive age who are not taking hormonal contraceptives should avoid drinking alcohol in the event that they might inadvertently fall pregnant and cause harm to a potential fetus (Centers for Disease Control and Prevention, 2016; Khazan and Beck, 2016). Burton-Jeangros highlights how the responsibility for negotiating these risks is often individualised (Burton-Jeangros, 2011). For example, suggestions that pregnant women should avoid chemical exposure in food and beauty products, as MacKendrick and Cairns rightly argue, place further personal responsibility on women rather than on regulatory control (MacKendrick and Cairns, 2018).

This background is related to the use of fertility and pregnancy apps, as arguments in the existing literature suggest that fertility and pregnancy apps accentuate risk and sustain obligations for self-surveillance on women. Lupton has published widely on digital health technologies and self-monitoring, and her work includes research on fertility, pregnancy, and parenting app use. Lupton, along with colleagues Pedersen and Thomas, has conducted a number of studies of women's use of digital media in pregnancy and early parenting, drawing upon discourse analysis of apps, focus groups and online surveys (Lupton and Pedersen, 2016; Thomas and Lupton, 2016; Lupton, 2017). As mentioned above, Lupton's work on the use of apps related to women's reproductive health highlights how pregnancy and fertility apps emphasise risk and encourage self-surveillance (Lupton, 2015; Thomas and Lupton, 2016). Thomas and Lupton go on to argue that the focus most pregnancy apps place on fetal development characterises the unborn as an infant and a social being, separate to the pregnant woman, with its own corresponding rights (Thomas and Lupton, 2016). Ley also highlights the responsibilities that pregnancy apps entrench, reasoning that the focus on the minutiae of fetal development that pregnancy apps encourage emphasises fetal personhood, and underscores the need for women to engage in

healthy behaviours and avoid risk in order to protect the unborn (Ley, 2016). As Lupton and Thomas note, similar critiques have been made of fetal visualisation technologies (Lupton and Thomas, 2015). Feminist scholars such as Petchesky, Oakley and Duden, and several others, developed such arguments in light of the increased use of ultrasonography for fetal imaging that proliferated from the 1980s (Petchesky, 1987; Duden, 1993; Oakley, 1993). As Petchesky contends when considering a series of week by week images of fetal development printed in a book titled *The First Nine Months of Life* published in 1962, "from their beginning, such photographs have represented the fetus as primary and autonomous, the woman as absent or peripheral" (Petchesky, 1987, p. 268). By focusing on the fetus as an entity, a subject in itself, imaging technologies construct a division between fetus and the pregnant woman. Petchesky argues that this visual focus on the fetus catalyses a focus on fetal rights that is used to justify limits to women's reproductive and other freedoms by ascribing an obligation to protect the unborn – as seen for example in the aforementioned refusal of some doctors to prescribe women with medications that have the potential to harm the fetus (Hsiao *et al.*, 2021). Furthermore, while a focus on fetal development is pervasive and far from being unique to pregnancy apps, as Duden argues, pregnancy has not always been understood in these terms. Fetal imaging technologies provide access to knowledge of the fetus that was previously accessible only to the pregnant woman through their embodied knowing, for example through experiences of fetal movement, known as "quickening" (Duden, 1993). Prior to the introduction of such technologies, the embodied experience of the expectant mother was of primary significance, and pregnancy was not necessarily focused on the physical progression of fetal development (Duden, 1993). Pregnancy apps generally contain fetal images like those that appeared in 1960s popular pregnancy books, albeit updated based on more recent imaging technologies, but they also offer new opportunities for both understanding and experiencing fetal development. Johnson highlights pregnancy app features that enable users to imagine the experience of the fetus in the womb. For example, users can take images and record audio clips

that will be played back to them distorted to represent how a fetus might experience them from within the womb. In this way, she argues that "…the mother is encouraged to embody the foetus from a sensory perspective" (Johnson, 2014, p. 339). Johnson contends that pregnancy and parenting apps increase the "responsibilisation" of pregnant women, imploring them to take responsibility for their own health and that of the fetus, and to avoid behaviours which could risk harm to the fetus (Johnson, 2014). As a parallel to pregnancy apps emphasising this risk and a need for women to engage in self-surveillance, she argues that for users, some of the appeal of using pregnancy and parenting apps may lie in the social expectation of what Hays terms "intensive mothering", with women expected to uphold many responsibilities for child wellbeing (Hays, 1996; Johnson, 2014). Johnson argues that apps may be seen as a way to outsource some of the mental load of these obligations, as "…these technologies allow for the possibility of delegating responsibility for certain calculations, reminders and tasks" (Johnson, 2014, p. 346). This suggests that pregnancy apps create demands, but also have the potential to help users manage such demands. Segers and colleagues point out that pregnancy apps are overdemanding – they argue that this is even more problematic if they do not actually improve pregnancy outcomes (Segers, Mertes and Pennings, 2021). A number of other criticisms have been levelled at pregnancy apps. Peyton and Wisniewski note that pregnancy apps focus on the physical health of the pregnant woman and the fetus, offering little in the way of opportunities for leveraging social support (Peyton and Wisniewski, 2020). Additionally, pregnancy apps have been criticised for assuming pregnancies are wanted (Hamper and Nash, 2021), yet are generally poor at accounting for pregnancy loss (Andalibi, 2021). A particular aspect of the existing literature on fertility and pregnancy apps that I develop in this thesis is how these apps relate to different ways of knowing the body.

Embodied and quantified knowing

In Lupton's analysis of fertility and pregnancy apps, she argues that the portrayal of self-monitoring in public health literature, as well as the content of the apps themselves, suggests that women's embodied knowing and subjective experiences of their own bodies are less valuable than the more "objective" accounts of the body developed through the use of quantified digital data (Lupton, 2015).[10] The notion of data and technology potentially devaluing the knowledge women have of their own bodies has also been made regarding fetal imaging technologies, as mentioned earlier in this review (Young, 1984; Duden, 1993; Oakley, 1993). Duden argues that the value of sensory knowing is reduced through the use of technology (Duden, 1993). Young contends that ultrasound and fetal heart rate monitoring technology shift the dynamics of observation of pregnancy and birth away from the woman to the professional making use of the technological tools, and thereby "the woman's experience of these processes is reduced in value, replaced by more objective means of observation" (Young, 1984, p. 58). Oakley develops a similar line of argument, and has also written about the impact this has on clinical interactions by placing less importance on patient-generated information and less time being spent on speaking with patients (Oakley, 1993). These critiques were posed of technologies that were used in clinical settings, but there are comparisons to be made with the use of personal digital health technologies. Parallels exist between data and technologically informed assessments of the body in pregnancy being juxtaposed against bodily knowing.

The relationship between technology and quantified data, and bodily experience is complex and has been explored in the existing literature on fertility apps (less so in existing research on pregnancy apps), and digital health technologies more broadly. Two similar but slightly different phenomena are at work here regarding the use of digital health technologies – the use of sensors

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[10] Lupton's own position on the relationship between quantified and embodied data does not appear to reflect this observation she makes on how self-monitoring technologies portray their utility – elsewhere in her work on self-monitoring she explores the meaning that users make with data, and the complexities of interpreting data on bodily processes (see for example Pedersen and Lupton, 2018).

(either personal ones such as thermometer and biosensors, with the data stored in an app, either entered manually or automatically linked; and professionally operated technologies such as ultrasound and fetal heart rate monitoring), and a user of an app making their own bodily observations and using the app to record and interpret the data they generate. Initially it may seem that technological sensors are further removed from embodied sensory experience, while sensory observation is involved in more proactive self-monitoring where the user enters data based on their bodily experience, rather than a measurement taken; however studies have shown how even biosensing and embodied knowing can relate and coexist. For example, in Wilkinson's study of ovulation biosensing she found that "…women developed greater knowledge of the ovulatory cycle, but they also began to feel and 'sense' this, and continued to do so once biosensing practices had ceased… Technology does not automatically displace women's own sensing knowledge but instead can support and help develop this" (Wilkinson, 2020, p. 1608). Similarly, in Grenfell and colleagues' study on the use of the fertility app Natural Cycles among women trying to conceive, they found that while many participants did interpret their own bodies using data, "…some emphasised what bodily processes and sensations told them, and believed these over apps (and health professionals) in certain circumstances, thus (re-)centring embodied and intuitive knowledge"(Grenfell *et al.*, 2021, p. 127). Hamper's study of fertility apps also demonstrates that they "… have the potential to subtly intensify certain aspects of embodied reproductive experience, awareness and knowledge and change the ways in which women relate to and know their bodies through data" (Hamper, 2020, p. 23). Together these studies suggest that while fertility apps may in some cases contribute to the devaluing of quantified data over subjective bodily experience, the process is better characterised as a shift in self-awareness and how the body is perceived and understood, than a habitual preferencing of one form of knowledge over another.

Returning to my earlier discussion of literature outside of the fertility and pregnancy field, researchers have developed similar arguments about self-monitoring with digital health technologies for other purposes.[11] In response to what they describe as a "data fetishist critique" posed by scholars such as Morozov who (in the words of Sharon and Zandbergen) suggest that "…a trust in numbers will trump other forms of subjective, intuitive and embodied knowledge…", Sharon and Zandbergen demonstrate that rather than prioritising digital data over their embodied knowledge, "the self-trackers whom we listened to often spoke about this relationship as a tension, or a negotiation, that produces meaning" (Sharon and Zandbergen, 2017, p. 1699). They found that many users of self-tracking technologies described becoming more aware or mindful of their bodies and habits, and using technology was a reflective practice, rather than an activity of detached data analysis (Neff and Nafus, 2016; Sharon and Zandbergen, 2017). Nafus and Sherman draw a similar conclusion from their study of users of self-tracking technologies, and argue that

> …most self-trackers in no way cede authority to the supposed objectivity of devices or the quantitative nature of sensor data. Instead, they traverse between what is inside and outside the body. They put things out in the world (software, reminders, routines, and sensors) in order to reflect on, and reorder, what is inside the body (the sensation of energy, mood, or productivity) (Nafus and Sherman, 2014, p. 1789).

Ruckenstein emphasises that the ways in which individuals engage with their data is as significant as the technology in itself. She argues that the interactions users have with what she describes as their "data doubles" is impactful as a means of knowing themselves and reflecting on their lives (Ruckenstein, 2014). In this sense, digital health technologies are not always tools that provide

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[11] Some of this literature has focused on the Quantified Self movement. Founded in 2007, the Quantified Self movement comprises a network of local groups of individuals engaged in self-tracking practices, who communicate online and meet to discuss their experiences (Nafus and Sherman, 2014).

data that are then simply interpreted by the user to be a more "objective" account of their bodily process or their practices, but are tools that can be used to change the way in which they understand and experience their bodies. One aspect of this is the use of external technology to develop internal bodily awareness, which is also evident in Mol and Law's study of individuals with hypoglycaemia and their use of blood-sugar measurement tools. They describe the "dualism" of internal, subjective knowing, and objective knowing measured from the outside, as the use of measurement tools for blood sugar encourages users to practice self-awareness and "train inner sensitivity" (Mol and Law, 2004, p. 48). Lupton too found that users described an increased self-awareness to be a consequence of self-monitoring, be that through the use of digital tools, or by "…taking notice of one's body and attempting to remember details from day-to-day…" (Lupton, 2019, p. 71). Pantzar and Ruckenstein highlight that the use of self-monitoring technologies enable aspects of the body to become visible that would otherwise be undetectable, adding new dimensions to self-knowledge, and elsewhere in their work, that self-monitoring technologies may encourage greater reflective thinking (Pantzar and Ruckenstein, 2014, 2017). In summary, this literature suggests that using technology as part of knowing and understanding the body is a complex process. Taking and recording measurements of bodily factors can inform how users know, and become part of what they know, and in doing so the boundaries of the body and what counts as sensing are permeable (Mol and Law, 2004). The use of digital health technologies for self-monitoring and the role they may play in increasing bodily awareness is an interesting dynamic to explore in the case of pregnancy, where pregnancy itself may engender increased self-awareness.

In pregnancy the notion of embodied knowing is uniquely complicated. Physical experience, bodily sensations and ultimately self-knowledge developed across an individual's life to the point of becoming pregnant are altered through pregnancy. This in part is rendered by the physical changes to the body, such as the size of the body moving through the world, the effort and

necessary motions taken to perform certain actions, and the development of new health conditions or deficiencies (Guenther, 2013, p. 102). As Young states, this also involves understanding one's own body as in some way connected to another entity: "I experience my insides as the space of another, yet my own body" (Young, 1984, p. 49). A similar statement about unfamiliar changes to the body could be made regarding those brought about by chronic illness or injury (Wilde, 2003), but in pregnancy, not only are there changes to the functioning and configuration of the body of the individual, a fetal body is gestated by the pregnant woman, which as Young describes, takes up space in the individual's body, both literally and figuratively. The extent to which the fetus constitutes a separate entity is of social and political significance due to potential restrictions to the bodily autonomy of the pregnant woman, and is debated in the literature as briefly discussed above. The full extent of this debate, as well as a wider account of women's experiences of the embodiment of pregnancy, is beyond the scope of this review, but philosophers such as Kingma explore the relationship between the fetus and the maternal organism, for example with Kingma arguing that the physical bonds between the fetus and pregnant woman, and the utter dependency of the fetus on the pregnant woman for survival meaning that it cannot be considered separate or have claims to its own rights (Kingma, 2020). Suffice it to say for my purposes here, alongside the interconnectedness in pregnancy, a separate being is ultimately being developed, which is in the UK at least a common cultural understanding that it is a future child, with pregnant women – including all of those interviewed in this study – often referring to their pregnancy as a future baby (see for example Rothman, 1988). Some studies have found that pregnant women describe having heightened bodily awareness during pregnancy (Ross, 2019). Therefore considering the interactions between quantified and embodied knowing as explored in the literature on self-monitoring is particularly interesting in this context.

Research gaps

Having provided a summary review of the literature on self-monitoring and fertility and pregnancy apps in particular, I will now identify where my study is positioned and what I contribute. Some existing studies of women's internet use in pregnancy refer to smartphone apps, but not as their central focus, and they do not explore these apps in depth, or are based on surveys (Rodger *et al.*, 2013; Mackintosh *et al.*, 2020).[12] Of the several studies that do consider fertility or pregnancy apps in more detail, many of their methods are based on analysing reviews of apps, as well as the apps themselves (Johnson, 2014; Ley, 2016; Lupton and Pedersen, 2016; Barassi, 2017; Doshi, 2018; Peyton and Wisniewski, 2020; Andalibi, 2021; Healy, 2021). This is an effective way of attaining a broad range of perspectives on pregnancy apps. Reviews are often posted with a level of anonymity, and can produce insights into how users perceive the utility of apps, and their dislikes and frustrations. However, this breadth needs to be supplemented by depth, which a study using additional qualitative methods, such as interviews as this study does, is more likely to obtain. As Johnson remarks, most existing research on the use of pregnancy apps fails to consider the "…lived experiences associated with apps…", and there is a need for more research that focuses on the choices and experiences of users (Johnson, 2014, p. 346). Some studies address this through focus groups or surveys, but there is a much more limited range of research based on in-depth qualitative interviews. Some existing studies have considered these in different contexts. Only a small number of recent studies in the UK are notably similar to my work. Geographers Hamper and Nash's work on fertility and pregnancy apps most aligns with my research, with two recent publications being based on a qualitative interview study conducted in the UK (Hamper, 2020; Hamper and Nash, 2021); alongside Grenfell and colleagues who have recently published qualitative work on the fertility app Natural Cycles (Grenfell *et al.*, 2021).

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[12] A full analysis of the literature on internet use and information seeking in pregnancy is beyond the remit of this review, which focuses more specifically on smartphone apps.

My study offers an in-depth qualitative analysis of fertility and pregnancy apps specifically, in a UK context, drawn primarily from original empirical interview data, complemented by a focused analysis of one feature of apps, fetal movement monitoring, which has not been explored in depth in any of the existing social science literature on pregnancy apps. While several studies mention that fetal movement monitoring is a feature (see for example Mackintosh *et al.*, 2020), I am aware of only one study that focuses on the use of pregnancy apps for fetal movement monitoring, and this is a content analysis focused on the accuracy of information the apps provide, not women's experiences of using them (Daly *et al.*, 2019).

In pursuing this I aim to contribute to existing literature on mundane, everyday experiences of digital health technology use (not limited only to self-monitoring, as fertility and pregnancy app use also involves information seeking and other uses), as well as everyday experiences of pregnancy (Oakley, 2016). Han rightly emphasises the value of studies that consider "ordinary" pregnancies, as meaningful and important to study as well as novel reproductive technologies (Han, 2013).

Conclusion

In this chapter I have provided a review of the literature on self-monitoring technologies, and focused on existing research on fertility and pregnancy apps. I gave particular attention to the existing literature on the relationship between quantified and embodied knowing, and the emphasis of risk and self-surveillance inherent in the use of fertility and pregnancy apps. I have established some research gaps that my study seeks to address, and in the following chapter, explain the research design and methodology of my study.

Methodology

Introduction

In this chapter I present my methodology for the study. My data collection involved two phases: a series of qualitative interviews, and an analysis of pregnancy apps focused on fetal movement monitoring features which I conducted after having completed the interview phase of the project. In addition to having produced this analysis of pregnancy apps which directly informs my findings, I performed a general background review of pregnancy and fertility apps to develop my knowledge base, and to provide context for interviews. In this chapter I begin by restating my research aims and research questions. I then explain the methodology of my background app review, app analysis, and qualitative interviews. I give an account of my approach to data analysis, and how I developed the themes for my findings. I then turn to the ethical considerations of this study, and within the chapter I consider some limitations of my approach.

Research aims

Through this study I aim to contribute new empirical data to existing discussions of fertility and pregnancy app use, and self-monitoring more broadly. Through my initial review of the literature I noted a lack of qualitative studies on fertility and pregnancy apps conducted in the UK. With this in mind I address the following research questions, combining content analysis methods with in-depth qualitative interviews:

1. How and why do women use, or choose not to use, fertility and pregnancy smartphone applications before and during pregnancy?

2.   How does the (non-)use of fertility and pregnancy smartphone applications relate to the ways in which women understand and experience their bodies before and during pregnancy?

In Chapter 4 I address the following supplementary research question:

3.   How do fertility and pregnancy smartphone applications shape women's knowledge and/or understanding of pregnancy?

Background app review methodology

At the outset of the study I conducted a background review of pregnancy apps to familiarise myself with the field, and to gain a basic understanding of the apps before developing interview materials and conducting interviews. I did not intend for this to be a systematic review, but aimed to consider a broadly representative sample of commonly downloaded apps in the UK. 15 apps was an appropriate sample size to build this general view, and is consistent with the scope of some existing app content analyses of pregnancy apps (see for example Ley, 2016; Barassi, 2017). In order to identify a sample of 15 pregnancy apps, I conducted keyword searches on App Annie, an app analytics search tool that emulates the results returned by a keyword search on a smartphone user's app store. Searches were based on UK data for both iOS (apps for iPhone, excluding iPad) and Google Play. Searches are not device-specific, but generally refer to phones and tablets using an Android operating system. I used both an iPhone (manufactured by Apple) and a smartphone with an Android operating system (manufactured by Vodafone) to analyse apps, allowing me to access the apps that are available on only one of the two operating systems. The 15 apps I selected were an amalgamation of the top 10 ranked search results for iOS and Google Play for the keyword search term "pregnancy app" on 15th July 2017. I also conducted keyword searches for "pregnancy", "pregnancy tracker", and "pregnant" which produced largely

similar results, with changes generally focused on those in the lower end of the rankings, confirming the apps chosen as sufficiently representative search results for the sample.

I included apps from the Health & Fitness, Medical, and Parenting categories. One app that appeared in the top 10 for iOS was excluded, a "pregnancy test" app classed under entertainment. Both paid and free apps were included, and within the free categories there are often paid premium upgrades offered that provide access to additional features. I chose three apps for longitudinal analysis which were those that appeared within the top two ranked apps for the "pregnancy app" keyword search for each platform (the app Pregnancy + appeared in the top two for both platforms, resulting in three top apps).

Pregnancy app sample

(Name in parentheses refers to parent company/developer – apps in bold selected for longitudinal analysis)

1. BabyBump Pregnancy Pro (with Baby Names) (Alt12)

2. Bounty Pregnancy, Birth & Baby (Bounty (UK) Ltd)

3. Glow Nurture – Pregnancy Tracker, Baby Calendar (Glow Inc)

4. I'm Expecting – Pregnancy App (Aptus Health)

5. iPregnancy (Gregory P . Moore, MD)

6. Ovia Pregnancy & Baby Tracker (Ovuline/Ovia)

7. Pregnancy & Baby Tracker/What to Expect (Everyday Health)

8. **Pregnancy + (Health & Parenting)**

9. **Pregnancy App & Baby Tracker (BabyCenter)**

10. Pregnancy Calendar (Vladimir Fedrushkov)

11. Pregnancy Today – Progress Countdown & Tracking (Mushroom Apps)

12. **Pregnancy Week by Week (Amila/Jollymobi)**

13. Pregnancy Week by Week (Rusakov77)

14. Sprout Pregnancy (Med ART)

15. The Bump (XO Group)

Having initially chosen to limit the scope of my inquiry to pregnancy specific apps, in the course of interviews I quickly found that many participants used fertility apps and that I would also incorporate these in my thesis. In order to understand the context of fertility apps I reviewed five fertility apps. I selected this sample by choosing the five apps most frequently mentioned by interview participants, which was sufficient as an approach as I aimed to conduct a broad review that would inform my understanding of the apps that my participants used, rather than establish a systematic analysis of fertility apps.

Fertility app sample

(Name in parentheses refers to parent company/developer)

1. Natural Cycles (NaturalCycles AG)
2. Ovia Fertility (Ovia Health)
3. Clue (BioWink)
4. Flo (Flo Health, Inc)
5. Glow Fertility (Glow Inc)

Analysis and researcher pregnancy

As my intention was to understand the apps as users experience them, I reviewed the content of apps within the apps without extracting data, and tested out the features they offered. I used three of the apps over a period of multiple months to experience the content as would a user of the apps. Having initially used the apps with fictious data of a hypothetical pregnancy, I later used them during an actual pregnancy. Two years into this project in November 2018 I became pregnant myself. I chose not to include my own experiences of using fertility and pregnancy apps in this study, largely because I do not consider my usage of apps to be typical by nature of it

having been informed by my conducting this research project, and this project is not designed as an autoethnography. Nonetheless, it is important to note that my having tested these apps for fertility and pregnancy is likely to have shaped my thinking, and therefore here I disclose my pregnancy, as well as the apps that I used. I used the fertility app Clue when trying to conceive, and two pregnancy apps for the duration of my pregnancy. One was an app that was the most used by my participants and that I had already included in my earlier review so was familiar with, Ovia (produced by Ovuline), and the app Bump Buddy (developed by the charity Best Beginnings), which one participant had reported using. I was interested to use this as it was developed by a charity rather than a corporate developer. I also used the contraction timer app Freya during labour. I do not explore contraction timers in this study as only two participants reported using them, and I did not have sufficient data to write about birth experiences given that only six interviews were conducted after birth.

Interview methodology

Interview study design

I designed a condensed longitudinal study with the aim of recruiting a cohort of around 15 pregnant women, and intended to recruit women at around three months into their pregnancies, and conduct qualitative interviews at various intervals over the subsequent six months to explore their experiences at different stages. The first interview was anticipated to take place at around three months of pregnancy, the second in the period of six to nine months of pregnancy, and if possible a third optional interview within six months of giving birth. These parameters were expected to be flexible based on the availability of participants. I later added fertility apps to the scope of the study, and aimed to interview participants using fertility apps once with the option of a follow up interview. In the case of participants withdrawing from the study after only one interview, I planned to include these interviews in my analysis as appropriate in order to give sufficient value and purpose to my participants' time.

Recruitment and sample

My inclusion criteria were pregnant women who lived in the UK who used pregnancy apps, and women who were not pregnant, but were using fertility apps with the aim of becoming pregnant (I offered no specific definition of what constituted a fertility or pregnancy app and allowed participants to determine this themselves). My exclusion criteria were women under the age of 18; individuals with an acute physical or mental health condition; individuals who would not be willing and able to give informed consent for participation in the study; and women who could not speak English; as well as standard exclusion criteria. I aimed to recruit women who used digital technology, particularly fertility or pregnancy apps, at least at the time of recruitment, and decided that interviewing women who actively avoided these apps would provide too much variation in my small sample to develop the issue sufficiently.

I conducted a pilot interview with a participant recruited through convenience sampling in order to test and develop my topic guide (Weiss, 1995, p. 52). I included the pilot interview in the overall sample as it was rich data, and my relationship with the participant was as an acquaintance, such that I did not feel it had impacted on the validity of the interview data. I then recruited for participants online, including posting on pregnancy and parenting forums and social media groups, in-app discussion boards, and snowball sampling (see Appendix 1 for a template recruitment advert). Snowball sampling was initiated by asking interview participants if they would be willing to post a recruitment advert in any online groups or forums they were a part of, thus acting as a gatekeeper. Recruitment adverts were posted in 14 different online spaces or apps, and I contacted a further 8 forum moderators, pregnancy related organisations with social media reach, and some pregnancy and fertility app companies, who either declined my request or did not respond. I either posted adverts myself with the permission of moderators, or they were posted on my behalf by a moderator (or in the case of snowball sampling a group member).

Using online recruitment tools was particularly appropriate for this project, as I aimed to reach users of digital technology, and this was a direct form of access to potential participants who actively used digital technology, such as online pregnancy forums. I also hoped that the use of online tools would enable me to reach a more varied sample as it is not location-specific. Participants self-selected in response to these adverts. Had a sufficient number of participants expressed interest in participating I would have used maximum variation sampling to gain a diversity of ethnicities and socio-economic backgrounds, but ultimately the response rate did not permit this. I excluded only three potential volunteers who responded to adverts and expressed an interest in participating as they were not based in the UK.

Self-selection sampling with online recruitment adverts was an appropriate approach to access users of online resources, and was cost-effective and feasible for a limited-resource PhD project. However, self-selection sampling can lead to a lack of diversity (Sharma, 2017), which was the case with my sample which was majority white and middle class. My research aims were not to explore questions based on these demographic factors, and as a small-scale qualitative study I did not aim to make generalisable claims, but I openly acknowledge the lack of diversity in the sample as a significant limitation of this study. Addressing the underrepresentation of socioeconomically disadvantaged and ethnic minority groups in social science research involves engaging with many factors, including methodological considerations such as accurately representing the diversity within groups, and valid concerns that individuals may have around participating in research given experiences of exploitation and abuse (Knight, Roosa and Umaña-Taylor, 2009). While I held the rationale of using online recruitment tools to reach users of technology, some existing research has suggested that middle class, white women are the primary users of online parenting forums, and I did ultimately find this to be reflected in my sample (Plantin and Daneback, 2009). If designing a future study I would consider some alternative

approaches for recruitment to help mitigate this, such as using gatekeeper organisations and some in-person recruitment in less-advantaged areas.

I recruited 13 women to take part in the study, which was close to my original intended sample size. I conducted interviews over a period of 22 months between September 2017 and July 2019, and closed recruitment when I had reached saturation (Glaser and Strauss, 2017). As is typical of qualitative research, the intention of this study was not to find generalizable or representative results, and this small sample size was sufficient to study women's experiences in-depth within the scope of a PhD project (Gray, 2009). Women took part in between 1 and 3 interviews in total at different stages of preconception or pregnancy, with some follow-up interviews taking place after participants had given birth.

Figure 1. Number of interviews per participant

Number of interviews	Participants	Total
1	6	6
2	3	6
3	4	12
Total	13	24

I was able to recruit some women during the first trimester of their pregnancy as I had originally hoped, but some volunteered to take part at a late stage of pregnancy, so they did not have the time in the course of pregnancy to take part in multiple interviews as I had envisioned. I judged that it would still be valuable to interview these volunteers, as the multiple interview component of the study was not a requirement, with some participants I interviewed early in pregnancy taking part in only one interview. Additionally, I had found that the first interview was generally longer and where I found the most substantive data, with the follow ups being an opportunity for participants to reflect on how things had changed, and for me to develop further questioning on some issues they raised in their first interview. I asked at the end of the first interview if participants would be willing to be re-contacted in a few weeks' time for a follow-up interview.

All agreed, however some never responded to subsequent requests for follow-up interviews. I made contact as arranged, and if there was no response I would follow up one time but not again, taking their silence as a decline. No participants withdrew their data from the study, but they were offered this option.

As mentioned above, the sample was majority white and middle class. I collected demographic information via an online survey form using the software SurveyMonkey (appendix 7). A notable limitation of the study is that 7/13 participants completed the demographic survey, and 6/13 did not. I asked participants if they would be willing to complete an online demographic survey at the end of the interview and shared it with them shortly after the interview. Having shared the survey, I chased each participant once if they had not already informed me that they had completed the survey. While I could have offered this survey at the beginning of the interview, I aimed to avoid priming participants by not asking these types of questions upfront. As Weiss argues, this can influence the tone of interviews and discourage participants from giving full, narrative accounts of their experience, instead leading to a focus on more limited, ostensibly factual information (Weiss, 1995, p. 51). I used an online survey form as many interviews took place online, which made this a convenient alternative to a paper form, both of which are useful if participants would not feel comfortable disclosing this information verbally. Nonetheless, based on this experience in future I would ask the questions myself directly at the end of the interview, as this would have been a more reliable way of gathering this data in complete form.

I did not however intend to link this data to participant responses and make knowledge claims or findings in relation to these factors. I aimed to get an overall sense of the characteristics of the sample, and from the data I collected I can broadly say that participants were drawn from across the UK regionally – participants surveyed were based in Scotland, South West England, North West England, London, and South East England. Of those who completed the survey, all

identified as white or white British, married (in interviews all participants reported being in a heterosexual relationship, though I did not directly ask about sexual orientation so this cannot be assumed). Of those who completed the survey, the highest level of education reported by one participant was a foundation degree, two held a bachelor's degree, and four held a postgraduate degree. Participants who completed the survey were in age brackets falling between the ages of 25 to 40. Please see appendix 7 for the full survey questions and results. This data suggests that my participant group is majority white and middle class.

A factor that I did not include in the demographic survey but that is relevant to note is that the vast majority of participants were first time mothers. I made no specification that participants should be first time mothers, but only one participant already had a child. I expect this may be for a variety of reasons, including that first time mothers might be more likely to be in online groups looking for information, or they may not have the demands of parenting on their time so may feel more able to make time to participate in a research study. Previous studies have suggested that users of pregnancy apps are more likely to be first time mothers, and given that my recruitment adverts invited users of pregnancy apps to respond this may be an influencing factor (Wallwiener *et al.*, 2016, p. 942). Additionally, all participants experienced singleton pregnancies, which again, was not an inclusion criterion for participation. It was not necessarily the first pregnancy for all participants as some had experienced pregnancy losses – I was conscious of my language during interviews to account for the possibility of this and was careful in the write up of data to be precise, e.g. not referring to this being a participant's first pregnancy when they had shared with me that they had been pregnant three times.

Interview process

I conducted 24 qualitative, semi-structured interviews with 13 women between September 2017 and July 2019. Interviews took place in person at a location of the participant's choosing, via

online video conferencing software, or via online audio calls or telephone if these were not possible.

Figure 2. Breakdown by interview type

Interview type	Number of interviews
In person	10
Video call	9
Audio call	5
Total	24

In most cases participants agreed to use video during online calls, but we sometimes faced technical issues and resorted to telephone calls where necessary. One participant elected not to turn on video as her husband and daughter were also in the room and she did not wish to show them on camera, and one interview was arranged as a telephone call when this was most convenient to a participant. I requested video interviews as opposed to telephone interviews in order to allow me to build a rapport with participants more easily and to observe non-verbal cues, but telephone interviews nonetheless allowed me to gather valuable data, and may also have had the benefit of making participants feel more comfortable and able to share sensitive information (Novick, 2008).

All in-person interviews took place in public spaces – I gave participants the option of meeting anywhere including their home or workplace, but all chose to meet at a coffee shop local to them. I offered to meet all participants for in-person interviews if they preferred and made clear that I was willing to travel, but suggested an online interview in the first instance where participants were based at a distance that would require an overnight stay. Participants were welcome to bring their babies to interviews and all participants who took part in in-person interviews after giving birth did so. To my knowledge, online interviews were generally conducted from the participant's home, with one participant taking part in a telephone interview from the car with her partner driving while travelling. Most participants appeared to be alone,

but some made me aware they had their partner in the room. I followed their lead and made no request that interviews should be private, respecting a participant's right to set the terms in their own home space.[13] Having other individuals within earshot – either family members at home or members of the public in communal spaces – could however have influenced participants into giving socially desirable responses, in addition to the possibility that they may have demonstrated this tendency to me in my capacity as an interviewer (Bergen and Labonté, 2020, p. 786).

Interviews lasted between 24 and 65 minutes. The average length of a first interview was 50 minutes, the average length of a second interview was 35 minutes, and the average length of a third interview was 42 minutes. All interviews were audio recorded with the consent of participants. The presence of an audio recording device may make participants feel self-conscious during interviews and influence what they choose to share (Weiss, 1995, p. 53). I audio recorded interviews using a mobile phone or laptop (which I also used as a reference point for topic guides) for convenience, but this also may have made this less conspicuous than a Dictaphone as these electronics are more commonplace. All participants were given an information sheet and gave written consent prior to beginning the interview (appendices 4 and 5). If the interview took place in person they signed two copies of a paper consent form, and if the interview was online I either posted the consent forms with a prepaid envelope that they returned to me, or emailed them an electronic copy of the consent form which they printed, scanned, and emailed to me if they preferred this option.

Interviews were semi-structured, with a topic guide prepared in advance. I updated the topic guide as themes began to emerge from my findings, which was the case given that interviews took place in a timeframe of over a year and I began analysing the data during this process

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[13] I cannot make assumptions about the level of influence participants had over their own home environments, but within the dynamic of myself as interviewer and them as participant I judged that they should have more control than me in this situation.

(Weiss, 1995, p. 52), though the majority of data analysis was conducted once all interviews were complete. I used the topic guide as a loose model and followed subjects as they arose, and began with relatively straightforward questions, developing into more complex questioning later in the interviews (Britten, 1995). For second and third interviews with participants I included personalised follow up questions. I was careful with language to avoid priming and leading questions to the best of my ability (Gray, 2009). During interviews I did not specifically ask participants to show me the apps they used, but they would often take out their phones to look at their apps to demonstrate features and show me what apps they used.

Ethical considerations

Ethical approval for this project was granted by the King's College London Low Risk Ethics Panel (REP) in August 2017 (REC reference number LRS-16/17-4739). I submitted amendments for any subsequent changes to my original project proposal, for example expanding the remit to include fertility apps as well as pregnancy apps. Prior to participating in an interview, participants were given an information sheet and two copies of a consent form to sign, one of which they kept and one that I kept (appendices 4 and 5). With participants' consent, interviews were audio recorded, and these recordings, and subsequent transcriptions have been held securely in accordance with the UK Data Protection Act 2018 and the UK General Data Protection Regulation (UK GDPR). Participants were free to withdraw from the study at any time, and request that their data be destroyed.

In addition to the inconvenience and opportunity cost of participating in qualitative research, Richards and Schwartz identify four categories of potential risks: "…anxiety and distress; exploitation; misrepresentation; and identification of the participant in published papers, by themselves or others" (Richards and Schwartz, 2002, p. 135). I focused my thinking around potential risks for participants around these four areas. First, I was conscious of the need to

consider how certain topics had the potential to cause participants anxiety or distress. Questions were phrased carefully with awareness of where they could lead, for example, I avoided such questions as "is this your first pregnancy?", which could pressure a participant to disclose a previous miscarriage. When a participant raised distressing topics – for example a participant recounted their baby being admitted to a neonatal intensive care unit, an experience which they described as traumatic – I did not probe and formulated follow-up questions sensitively. I was particularly cognisant of how requests for follow-up interviews with women I spoke with at the stage of trying to conceive had the potential to be distressing. Rather than contacting participants who were interviewed at this earlier stage to follow up and ask whether they had conceived, I instead suggested at the end of the interview that they were very welcome to approach me in future if they wished to take part in additional interviews. Participants were reassured both verbally and in the information sheet that they were free to end the interview at any time, and that they were not obliged to discuss anything that they felt uncomfortable sharing.

I reflected on the potential for participants to be exploited. There is an expected power imbalance between researchers and participants, with the interviewer directing the questions (Kelly, 2014). Otherwise, I am not conscious of my interactions with participants to have been exploitative beyond these bounds usually associated with qualitative research. Participants self-selected in response to an online advert, and aside from being acquainted with my pilot participant whom I recruited through convenience sampling, I do not have personal or professional relationships with participants that might have compelled them to participate. Participants were not offered financial incentives for their participation in the study. Offering payment as a recognition of participation may have improved the response rate and is sometimes considered a reasonable way to acknowledge participants' contribution to the research (Head, 2009). However after much reflection I chose not to offer payment, as this can potentially influence the authenticity of data, for example individuals may be prompted to make false claims

of fitting the inclusion criteria for participation in order to receive payment (Head, 2009). I did however pay for refreshments for participants if we met in a coffee shop – I did not mention this before they had agreed to meet for an interview, and offered this before the interview began to be clear that this courtesy was not tied to participation.

To consider the potential risk of misrepresentation, I transcribed verbatim and was thoughtful in my analysis to represent participants' experiences as accurately as possible. An additional measure I considered was sending participants the findings of the study for their feedback prior to submission as "respondent validation" (Richards and Schwartz, 2002, p. 138), but I ultimately decided against this in order to avoid overburdening them, particularly as due to my having taken a year-long period of maternity leave a substantial interval of time had passed between the interviews and writing up my findings, and this re-contacting of participants could be considered intrusive.

Finally, in terms of the possibility of identification, I removed all potentially identifiable information at the transcription stage through a process of anonymization, and looked through all quotations used in the thesis again to reaffirm this. I held in mind the model of the "motivated intruder test" taken from the UK Information Commissioner's guidance on anonymisation: "The 'motivated intruder' is taken to be a person who starts without any prior knowledge but who wishes to identify the individual from whose personal data the anonymised data has been derived" (Information Commissioner's Office, 2012, p. 22). I am confident from this process that a motivated intruder would not be able to identify any participants involved in the study.

Interview data analysis

I followed Braun and Clarke's six-phase approach to thematic analysis (Braun and Clarke, 2012). As part of the first stage of familiarisation with data, I transcribed all interviews myself, a

decision I made rather than outsourcing this to ensure I was thorough in the nuances of the transcripts, such as my recollection of non-verbal cues during in-person or video interviews (Bailey, 2008). I transcribed the interviews verbatim in order to limit researcher bias, and indicated pauses with dashes or ellipses, and on occasion made note of tone, for example what I perceived as sarcasm, or non-verbal cues as appropriate – the transcription process nonetheless reflects my own interpretation of interviews (Green, Franquiz and Dixon, 1997). I anonymised the transcripts to protect the confidentiality of participants, removing potentially identifiable information and referring to participants using pseudonyms (Wiles *et al.*, 2008). I took field notes before and immediately after interviews, recording my preliminary reflections on the data. The next stage was the initial coding. I used NVivo software to code data line by line, and also used a Microsoft Excel spreadsheet to develop a code book. I searched for, then reviewed themes in the data, approaching this inductively. I used NVivo data analysis software, a spreadsheet, and handwritten notes to aid in this process – while using software for analysis is as much a deliberative process as coding by hand (Basit, 2003), I found using this combination of software and written notes helped me reflect on the data. A limitation of this study is that I conducted the analysis as a sole researcher, and asking another researcher to code the data independently could have improved the reliability of findings, and would be an opportunity to identify findings that I did not consider (Pope, Ziebland and Mays, 2000). After reviewing themes, I then named them, and produced the report (Braun and Clarke, 2012). I focused my themes based on my research questions, and after deliberation disregarded themes that were not relevant to these questions, for example birth choices, and participation in online groups. I ultimately decided on organising the thesis across four themes that reflected different types of usage or functionalities of apps: fertility tracking; self-monitoring and information seeking in pregnancy; understanding fetal development; and monitoring fetal movement. Some sub-themes appear as subtitles in these chapters, for example "data-led fertility". I explore thematic ideas that span these chapters and

again in the discussion, where I focus on the major themes of risk and reassurance, and ways of knowing.

App analysis methodology

After completing my interviews I turned to analysing app content, choosing to look closely at one feature that I had found of particular interest as raised in interviews by participants, namely fetal movement monitoring. I had not found this explored in the existing literature, and it drew together some interesting themes that had developed from my interviews, therefore I chose to explore it in depth and devote a chapter to this topic. The analysis I produced was not conceived of as a standalone content analysis, but an examination of app features that links to women's experiences of using apps for fetal movement monitoring, which I go on to explore in Chapter 5. I conducted a qualitative analysis of a sample of 20 apps that had a fetal movement monitoring feature – I did not aim specifically for a sample of 20, but this was the resulting number of apps that met all my inclusion criteria after excluding particular apps on the basis described below.

Fetal movement monitoring app sample

I selected my sample of apps on 8th October 2020, and extracted data between 9th October and 15th October 2020. I searched the Google Play store for pregnancy or fetal movement monitoring (kick-counting) apps with a minimum of 50,000 downloads, using search terms "pregnan*", and a separate search for "kick" to identify kick-counting focused apps. Each search resulted in 250 results. The sample of apps to be analysed was identified through keyword searches. Keyword search result rankings for the Google Play app store are determined by algorithms; the details of these algorithms are not publicly available. However, the algorithms take into account many factors, including the text relevance of app names and descriptions, download numbers, usage statistics (such as the number of active users), and user ratings (Google, 2021). As these details are not publicly available, it is not possible to determine

definitively whether a higher search result ranking equates to higher popularity. Nonetheless, a higher keyword search result ranking is likely to relate to greater visibility among potential users searching for pregnancy apps. This makes it a sufficient measure for the purposes of this study as an indication of which apps are accessible to potential users.

To determine my sample from the search results I read the descriptions of each app and excluded apps that were not pregnancy related; were games; were not in the English language; had fewer than 50,000 downloads; focused on a single topic not relevant to fetal movement monitoring e.g. pregnancy diet app, pregnancy photo app, fertility app (see figure 3 for full breakdown); were paid apps or the fetal movement monitoring feature was a paid upgrade without a free trial; and pregnancy apps that otherwise fit the inclusion criteria but did not contain a fetal movement monitoring feature. I chose to focus on apps that offered a fetal movement monitoring feature, rather than all pregnancy apps that offer advice on fetal movement, because I was interested in investigating the direct promotion of the practice of routine fetal movement monitoring and how apps facilitate this.

Figure 3. App sample exclusion criteria

	Number of results, search term: "pregnan*"	Number of results, search term: "kick"
Included	17	3
Excluded – reason for exclusion:		
- Game	76	
- Pregnancy app with no fetal movement monitoring feature	50	
- Fewer than 50,000 downloads	31	8
- Pregnancy exercise app	18	

- Language not English	12	
- Pregnancy diet app	9	
- Fertility app	8	
- Pregnancy music app	8	
- Pregnancy photo app	8	
- Infant tracking app	2	
- Pregnancy hypnobirthing app	2	
- Professional training app	2	
- Contraction timing app	2	
- Pregnancy app with no free trial for fetal movement monitoring feature	1	
- App not compatible with device	1	
- Period tracking app	1	
- Maternity leave app	1	
- Pregnancy prayer app	1	
- Not pregnancy related	0	239
Total	**250**	**250**

Figure 4. App sample

App name	Number of installations	Developer name	Developer location
Count the Kicks	50,000+	Healthy Birth Day	USA
I'm Pregnant - Pregnancy Week By Week	1,000,000+	BabyJoyApp	Ukraine
Kick Counter	100,000+	Amila	Canada
Kicks Count	50,000+	Kicks Count	UK
MomDiary: Week by week Pregnancy Tracker	100,000+	Hightech Solution	Unknown
My Pregnancy	100,000+	Mobiem	Poland
My Pregnancy - Pregnancy Tracker App	100,000+	Neiman	Unknown

My Pregnancy Tracker Week by Week + Due Date	100,000+	My Pregnancy	Argentina
Ovia Pregnancy Tracker: Baby Due Date Countdown	1,000,000+	Ovia Health	USA
Pregnancy +	10,000,000+	Philips Consumer Lifestyle B.V.	UK
Pregnancy Baby & Baby Kick	100,000+	gelato_cooper	Taiwan
Pregnancy Calendar	1,000,000+	Vladimir Fedrushkov	Unknown
Pregnancy Day by Day	100,000+	HokkabazSoft	Turkey
Pregnancy Tracker	100,000+	Enes Aydın	Turkey
Pregnancy Tracker	100,000+	Pregnancy Tracker	Unknown
Pregnancy Tracker, Due Date Calculator & Countdown	5,000,000+	Mobile Dimension LLC	Russia
Pregnancy Week By Week	1,000,000+	Amila	Canada
Pregnancy Week By Week	100,000+	HokkabazSoft	Turkey
Sprout Pregnancy	1,000,000+	Med ART Studios	USA
theAsianparent: Baby Care & Pregnancy Development	1,000,000+	theAsianparent	Singapore

Data analysis

I extracted data from the apps, focusing on the information and instructions that the apps provided alongside fetal movement monitoring features, as well as noting the design and structure of the features, particularly the parameters the apps set for how to monitor fetal movement. I took multiple screenshots of this content on each app, and entered the textual data and descriptions of feature design into a Microsoft Excel spreadsheet. Within the apps, I conducted multiple simulated fetal movement monitoring sessions, which spanned over several days. I reduced the quantity of hypothetical fetal movements over time and brought the movements I tracked below the alarm limits each app prescribed (if any) to test how they would respond. I recorded descriptions of how the apps had functioned and responded in the

spreadsheet. I then followed a process of thematic analysis and broke down the textual data and descriptions under headings within the spreadsheets to function as codes, and then themes. For example, themes included "justifications for fetal movement monitoring", "defining 'normal' fetal movement", and "self-awareness". Following this process, I also categorised apps based on such factors as the method for fetal movement monitoring that they recommended, and whether they made reference to the individuality of patterns of fetal movement. This enabled me to make claims as to the proportion of the sample that made particular recommendations, or referred to certain concepts. My data analysis process was in part inductive, but also involved deductive elements as I was interested in exploring how the apps compared with the guidelines on fetal movement monitoring that some participants had referred to. I was guided by my overall research questions,[14] but primarily question two of "How does the (non-)use of fertility and pregnancy smartphone applications relate to the ways in which women understand and experience their bodies before and during pregnancy", considering how apps enact and influence how women understand and experience fetal movement.

Conclusion

In the above chapter I have established the methodology I used for all components of this study. I have reflected on ethical considerations and some limitations of my approach to data collection and data analysis. In the following chapter I begin presenting my findings, focused on the theme of fertility tracking.

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[14] 1.   How and why do women use, or choose not to use, fertility and pregnancy smartphone applications before and during pregnancy?

2.   How does the (non-)use of fertility and pregnancy smartphone applications relate to the ways in which women understand and experience their bodies before and during pregnancy?

Findings chapter 1 – "That's not what I want to use it for, it's for tracking my fertility": The role of fertility apps in optimising and enacting fertility

Introduction

I initially approached the interviews for this thesis interested in pregnancy apps, but it soon became clear that fertility apps were significant as a precursor to participants' use of pregnancy apps. While it was not an inclusion criterion, all of the pregnant interview participants in this study had been actively trying to conceive.[15] The majority of interview participants had used fertility apps to facilitate their efforts. Of the 13 women interviewed, 11 reported using a fertility app, 1 reported intending to but fell pregnant in the first month of trying before she downloaded an app, and 1 did not discuss whether or not she had used a fertility app. This study recruited for participants who used pregnancy apps, so this sample was likely to demonstrate high levels of fertility app usage as it comprises women who actively use technology in this domain, but as a general trend the use of smartphone apps for monitoring fertility is becoming increasingly popular (Earle *et al.*, 2021). In this chapter I therefore explore how and why women use fertility apps, and how the (non-)use of fertility apps relates to the ways in which women understand and experience their bodies.

My findings in this chapter are organised along four key themes that emerged through inductive thematic analysis: accessing self-knowledge; data-led fertility; ways of knowing; and discontinuation of use. Across these themes, I examine different dynamics of use and non-use, the impact that fertility apps can have in defining aspects of bodily experience as related to fertility, and what constitutes fertility. I first consider a common theme that arose from the data,

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[15] See Earle's work for a typology of pregnancy intention. All of the pregnancies in this study fall into the category Earle describes as a "planned pregnancy" (Earle, 2004).

which was the role that fertility apps played in teaching users about their own fertility and shaping their self-knowledge. I then turn to app user practices of hierarchising different forms of data in pursuit of a "data-led" approach to fertility. I argue that in extending the range of relevant data points they encourage users to record, apps position a broader range of aspects of the body and practices as relevant to fertility. I find that participants responded to and made use of these calls for information in different ways, and argue that they were important to how they engaged with the app's attempted expansion of what was relevant to fertility. I present a view of users as analytical and engaged, and describe their usage practices of cross-referencing and judging app reliability.

I then engage with some of the existing literature on the relationship between quantified knowing and embodied knowing. As I established in the literature review, the connection between these ways of knowing is nuanced, and in this chapter I further explain how these are brought together by users in practice. I will argue that the way in which participants valued different ways of knowing was context-specific, and different ways of knowing can and do coexist, though these sometimes exist as different ends of a scale. I draw upon Mol's model of the body multiple to explain these findings, considering multiple versions of what constitutes ovulation (Mol, 2002). I examine the techniques of gamification employed by some apps. Finally, I consider discontinuation of app use as an aspect of non-use. Discontinued use was initiated by some users simply by ending their fertility journey and becoming pregnant, but some participants described stopping using fertility apps before this point, or continuing their use of fertility apps into pregnancy and later stopping. I argue that the use, and discontinued use, of fertility apps must be understood as informed by factors such as experiences of pregnancy loss, and also emphasise that discontinued use demonstrates the agency of app users, further developing my observation of app users as critical and analytical. Overall, this chapter affirms and builds upon recent existing studies of fertility apps when used for trying to conceive. Some findings offer

novel insights into fertility app use, particularly on the role of gamification, and emotional

aspects of fertility app use associated with pregnancy loss.

Accessing self-knowledge

Participants used fertility apps to track a variety of factors that will be explored in this chapter,

but the most commonly reported use of apps was for tracking menstrual cycles. In this form of

tracking, users enter the start and end dates of their periods, and the app estimates the span of

time in which the user would be most likely to fall pregnant if they were to have sex[16] on these

dates, in a period of time that many apps refer to as the fertile window. These predictions are

based on typical cycle data of when ovulation might be expected to fall. Some apps adapt the

guidance of fertile windows they provide the longer a user enters data, for example based on the

user's own variations in typical cycle length, but not all apps account for these variations and the

level of personalisation is generally limited.[17] Some participants were aware of variations in their

menstrual cycles, and some had maintained a practice of tracking their periods using an app that

predated their efforts to conceive, with the longest reported length of app use being 12 years.

However, several participants described using apps related to their menstrual cycles and fertility

for the first time when they became interested in trying to conceive. Alongside this shift in their

app use, many participants began a process of learning about their fertility. Some participants

referred to a variety of sources, for example reading books, talking to friends, and researching

online. This then prompted some participants to seek out a fertility app to help them implement

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[16] With a sperm-producing partner in such a way that might result in a pregnancy.

[17] Many apps continue to refer to this "fertile window", but in February 2021 the app Clue (one of the most popular fertility/period tracking apps available in the UK) removed this phrasing from its app to avoid encouraging users to use it as a form of contraception. Clue stated that "the fertile window in the Clue app was an approximation that didn't account for the variability of each person's cycle. Because there is too much variation from one person to another, and from cycle to cycle, we determined that it could be misleading to those who wish to use the fertile window to avoid pregnancy. Using the Clue fertile window to avoid getting pregnant involves an unknown, and therefore unacceptable, risk of unintended pregnancy" (Clue). What constitutes a "normal" or "typical" menstrual cycle is variable (King, 2020), and this could influence the accuracy of a fertility app if informed primarily by typical cycle data. A full discussion of the accuracy of fertility apps is not the focus of this chapter.

the fertility monitoring processes they had learned of through their research:

> … the books were all about charting your temperature, and um, your mucus, and like sort of being able to understand whether you're ovulating by looking at those signals. And so, I figured well I need an app to do that (Hanna).

Menstrual and fertility tracking do not represent a new practice in general, and the fertility awareness method of conceiving or avoiding pregnancy, sometimes with the use of charts produced with pen and paper, far predates fertility apps. The basis of fertility apps that measures changes to basal body temperature during menstrual cycles can be traced back to the beginning of the 20th century (Su *et al.*, 2017), and using observations of cervical mucus as an indicator of ovulation became more widespread in the 1970s (Grimes *et al.*, 2004). The books Hanna referred to having read above included the book *Taking Charge of Your Fertility*, which was first published in 1995 (Weschler, 1995). In this chapter I will explore the dynamics of fertility app use, some of which are a development in practices and may prompt different reactions when compared with this longer history of fertility tracking, for example gamification. However, rather than trying to argue that these apps are entirely novel, I seek to explore the current use of these apps. This is relevant in part because for some participants, while books on fertility with some relatively similar content have been in print for decades, fertility apps were their entry point to learning about fertility, and their primary source of information:

> I just found it really interesting, it [the app] made me a lot more aware of my body, like stuff that I didn't know at all before, I found that really interesting (Felicity).

As well as using fertility apps as sources of information about fertility in a more general sense, participants used fertility apps to monitor, and thereby to understand, their own bodies. Like

Felicity's description above of the app making her more aware of her body, it was common for participants to use fertility apps to develop an understanding of and familiarity with their own body and menstrual cycles after a phase of taking hormonal contraceptives that inhibited periods:

> I came off the pill and was using [a fertility app] to kind of get to learn about my cycles and work out how things are getting back to normal (Alissa).

Alissa refers to "learning" and aiming to "work out" her own sense of normal, using the app as a means to produce and gain self-knowledge. The value of this type of knowledge generation was, for most participants, that they could attempt to establish some level of control over their fertility to achieve the aim of becoming pregnant, or at least to optimise their chances of becoming pregnant. In addition to this goal-oriented use of fertility apps, there was also an element reported by some participants that they wanted to know about their fertility out of interest, and to understand more about their bodies as an end in itself. Several participants expressed that this knowledge and understanding was something they felt it significant that they had not known before, almost as if this knowledge had been withheld from them and they were reclaiming it. Several participants described using fertility apps, and the knowledge they gained as interesting, and some participants also described it as empowering:

> I think it's been so empowering, like I learned so much about my body, my cycle, like, why do we not know these things? It's absolutely mental, like it's so integral to your, the day to day workings of your body, and you, you don't know anything about it! I've learned, I've learned so much since being in my 30s that I should have known for, I don't know I feel like 15 or more years (Phoebe).

This language of empowerment that Phoebe uses to describe her discovery of this knowledge speaks to the value that she places on being able to understand her own body, which she suggests she has needed this external information to do. She also feels that this is "integral" to her body and how she lives each day, something fundamental that she should have known about herself. When questioned on what exactly it was that she now knew that she found empowering, she referred specifically to knowing about the changes in body temperature that can accompany ovulation. Hanna also highlighted this particular aspect of the new knowledge she had developed:

> And some people are like 'isn't that a bit much, like taking your temperature every morning?', and I'm like 'no it's super interesting, because you learn so much about your body' like the fact that your body temperature goes up as you're ovulating, I never knew that, and like, I've got to the age of 37 and I never knew that, right (Hanna).

Hanna uses very similar terms to Phoebe of having moved through life until her 30s without this knowledge about her own body. Accessing this bodily knowledge as reported by the participants above was also identified in Hamper's study on fertility apps, in what she describes as participants "relearning biology" (Hamper, 2020). In this way, fertility apps, and the new knowledge that comes with their use, inform how participants understand their bodies.

The change in basal body temperature being reported as particularly interesting to participants highlights the capabilities of technology – in this case, a thermometer, with data entered into a fertility app for recording and interpretation – to make something of the body visible in ways not know before. This echoes much of the existing literature on self-monitoring, where data makes unseeable factors of the body visible and therefore understandable in new ways; as

Ruckenstein states:

> self-monitoring is a practice that seeks to make known something that is typically not a
>
> subject of reflection, with the aim of converting previously undetected bodily reactions
>
> and behavioural clues into traceable and perceptible information (Ruckenstein, 2014, pp.
>
> 68–69).

Many fertility apps like those used by participants specifically made these factors perceptible in a visual sense by allowing users to interpret and interact with their data through visualisations such as graphs. This was mentioned by several participants as something they found useful, enjoyable, or interesting. Alissa, for example, felt that the data and the data visualisations encouraged her to continue using a fertility app:

> …it was really interesting, it's kind of data-led and that's maybe why I used it more, 'cause
>
> you could see- actually see the data kind of being plotted in a graph in front of you, and
>
> then I found it really interesting and probably will go back to using it once I've had the
>
> baby, um because I just think it- you can see whether things are as they should be, or
>
> maybe not quite, which is quite useful (Alissa).

Participants approached their use of fertility apps primarily in terms of aiding their efforts to conceive as their core objective, but Alissa also intended to use the app again after giving birth. This aligns with a recurring view expressed by other participants, that as well as the goal-based aspect of this tracking as a means to aid conception, there was some value in this practice as a form of self-knowledge. This was sometimes framed as contextualising their own body in terms of wider norms in line with other bodies – as Alissa stated, knowing how her cycle "should be" in normative terms. Fertility apps therefore serve as part of a process of learning about fertility,

but one that users applied specifically to their own bodies and shaped how they understood themselves. One aspect of the ways in which fertility apps shape understandings of the body is in influencing what aspects of the body, and of practices involving the body, are part of fertility. I will now consider these elements, and how they are related to the ways in which participants used fertility apps.

Data-led fertility

The majority of participants in this study who reported tracking their basal body temperature as part of their fertility tracking practices used the same fertility app, Natural Cycles. Several users of this app expressed their motivations for using this app using terms such as "scientific" or "data-led". Beth reported that she felt that Natural Cycles was likely to be more reliable than menstrual cycle tracking based on dates:

> …they have a good success rate, and I also like that they have a thermometer, that kind of made it feel like it would be a lot more reliable than the apps where you're just putting um, where they're working out your fertile period based on your previous menstrual cycles, whereas this is about being more scientific (Beth).

Drawing upon basal body temperature as a data point was perceived by participants like Beth as reliable, and a way to achieve greater success in conceiving than solely tracking menstrual cycle dates. Like Beth, participants in other studies of fertility apps, particularly Natural Cycles, have also expressed that they value the "scientific" and "data-driven" appeal of the app (Hamper, 2020; Grenfell *et al.*, 2021). As noted in Beth's statement above, different forms of data were seen by participants to carry different levels of validity, and this additional layer of data was seen as a way to optimise success rates. In this way, different forms of data are hierarchized by users, in this instance basal body temperature as more reliable than menstrual

cycle data based on the start and end dates of bleeding alone. In order to increase the accuracy of fertile window predictions, fertility apps encourage users to enter yet more forms of data (see figure 5) [18].

Figure 5. Examples of factors that can be tracked using fertility apps
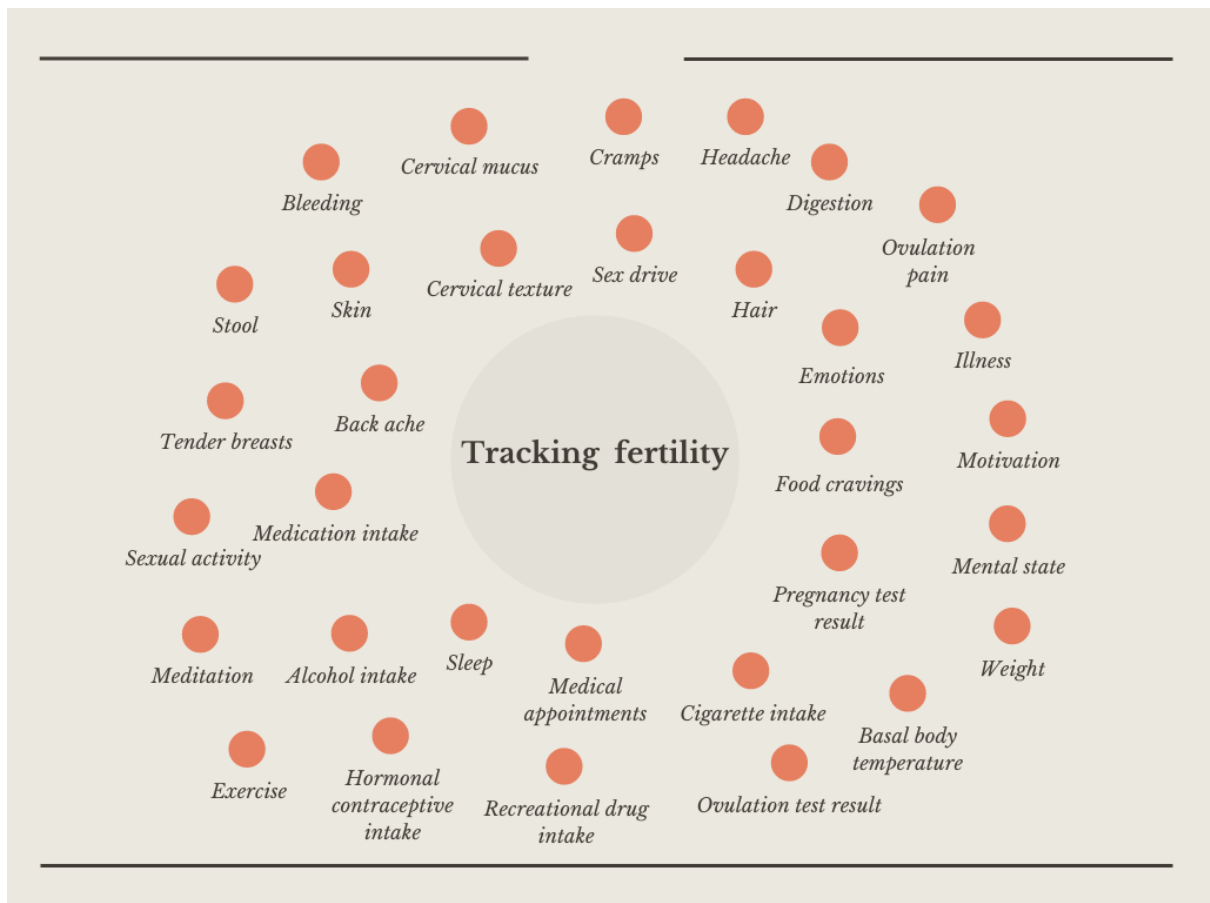
Fertility apps call for information by offering multiple entry points for data in the app interface, sometimes using push notifications and alerts to encourage the user to enter more data. These factors may be positioned as bodily "symptoms", such as cramping that some women report experiencing during ovulation, or breast tenderness, that can be a symptom of

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[18] These illustrative examples are drawn from a brief review of popular fertility apps (loosely based on app store search rankings) and is not intended as an exhaustive list or systematic review.

pregnancy. Some apps extend this to include a range of social practices as relevant to fertility.

For example, the fertility app Clue allows users to log data under the category "party", with

the option to record having consumed alcoholic drinks, cigarettes, experiencing a hangover,

or a having had a "big night", which refers to having consumed "substances other than

cigarettes and alcohol" (Clue).

The Clue app advises users that "some people may find hangover symptoms are worse around

the time of their fertile window" (Clue). This demonstrates how processes of fertility are enacted

as fundamental to the body and encroach into other areas of life. I intentionally use a very open

interpretation here of what "fertility" might mean and do not seek to examine this concept in

depth – this could for example refer more broadly to health and vitality, or to fertility as an

aspect of femininity. Some participants seemed to have a clear definition of what fertility meant

to them, and what it did not (which I will explore shortly in the case of Hanna's use of fertility

apps), while others were more open to considering different factors as relevant to fertility.

In the course of attempting to increase the reliability of predictions by expanding the range of

relevant data points, and by encouraging users to analyse their own fertility in relation to various

symptoms and lifestyle factors, the apps situate a wide range of bodily experiences and

behaviours as relevant to fertility. This can increase users' bodily awareness in focusing on

certain signs (as Felicity was previously quoted as having said, "it made me a lot more aware of

my body"), and more broadly leads to an understanding of certain aspects of the body and of life

as linked to fertility, and fertility as measurable and potentially controllable (see also Hamper,

2020). Users responded to and made use of these calls for more information in different ways.

Some participants did choose to link a broader range of data points to their fertility:

But on Ovia I could log things like, what I'd eaten, what supplements I'd been taking, how

many glasses of water a day I'd been drinking, um, things like signs- like I suffer with

headaches, migraines, which typically seem to be hormone related, so logging things like

migraines, the severity of them, um, things like cervical mucus, all these things that we

look for, it was all, that was all being logged on Ovia basically (Chloe).

Chloe logged several different factors that she understood could have been related to fertility. She described logging her diet and daily water intake, suggesting that she supported the advice that the app provided that lifestyle practices can increase the user's chances of conceiving. She directly related her migraines to hormones, and used the app to try to see patterns in when her migraines occurred and how this could inform predictions on when she might ovulate. She thereby merged her own experiential and embodied knowing with how the app knew her body. She refers to "all these things that we look for", indicating that she was actively looking out for particular signs, and considered them to be some type of shared knowledge or practice among people trying to conceive. Compared with another app she used to track her menstrual cycles, she appreciated that this fertility app enabled her to track a wider variety of her activities, given that this would potentially give a more thorough account of her daily practices and bodily experiences, and therefore help increase her chances of becoming pregnant by informing the app's predictions. Other participants, however, responded very differently to the same phenomenon. Some participants rejected fertility apps' calls for further information, finding them irritating, or not trusting in the apps' capabilities to use what they perceived as the most relevant information effectively. Hanna first used the Ovia fertility app, but discontinued her use of it in favour of what she described as a more basic app. When describing the Ovia fertility app, she related that:

Hanna: …it was just annoying because it was like asking me for loads of information that

wasn't relevant. Um and I think it also, it wasn't necessarily just taking into account the

temperature and the CM, yeah it felt like it wasn't as robust I guess …

Interviewer: What sort of things was the Ovia one asking you that you found annoying?

Hanna: Like, it was all sorts of things, like what kind of exercise I'd done, what I'd eaten, things like if I'd drunk any alcohol, if I'd had any kind of symptoms, you know like swollen breasts or um bloating, and I was like well *that's not what I want to use it for, it's for tracking my fertility* [emphasis added]. Um, and yeah like I said, it was also the fact that I felt it wasn't necessarily suggesting those to predict my fertile period and stuff, so I felt I'd rather use a basic one … I was never really sure how they work (Hanna).

Hanna's need for an app was for one she considered more "robust", and the calls the app made for additional data were an irritation. Her casual use of the acronym "CM" to refer to cervical mucus gives some indication of her familiarity and knowledge base in the area of fertility. The novelty aspect offered by some apps was not an attraction for her, and she had specific needs of what she wanted the app to provide. The Ovia fertility app constructed the indicators that might be important to focus on when looking for potential signs of ovulation, suggesting that the user could develop an understanding of patterns that might be linked to ovulation, like Chloe's belief that understanding where her migraines fell in her menstrual cycle could help indicate when she might ovulate, and therefore when she might have the best chance of conceiving. However, Hanna's knowledge base and own perception of the relevance of different factors to fertility, informed by the book she had read, led her to reject this proposition, and she considered much of what the app asked her to track to be extraneous information. She refused to consider bloating, for example, as relevant to tracking her fertility. There are limits to the extent to which apps can compel users to frame particular bodily experiences in terms of fertility, and users can choose to reject these constructions. Additionally, Hanna was unsure how the app processed the data she entered to make recommendations. This lack of transparency of how the app worked added to her doubts about the utility of tracking additional data points. The more "basic" app

that she ultimately preferred was a companion app to a book on fertility she had read, and therefore seemed more robust as she had a stronger understanding of the theory on fertility that informed that particular app.

Hanna's preference was to focus on what she judged to be the most relevant and important factors to track, namely cervical mucus and basal body temperature. Basal body temperature was the second most commonly tracked data point among participants, after menstrual cycle tracking. For some participants, tracking menstrual cycles on a single app was the extent of their fertility tracking practices, and they used the fertile windows suggested by apps based on this data to inform when they timed sex. Other participants used multiple apps, seeking as reliable a fertile window as possible. A relatively common practice among participants was to supplement the period tracking apps they had previously been using with an app that offered additional functionalities or guidance tailored towards trying to conceive, beyond the basics of menstrual cycle tracking. It was not unusual that the two or more apps used suggested different fertile windows:

> …I had a couple of different period tracking ones, and I found that they gave quite different results actually, for days when - so I used Glow as well, and they both gave different kind of fertile periods, which is a bit weird (Beth).

Rather than rejecting the use of fertility apps in light of these inconsistencies between them, users would generally continue to use them, but use a process of cross-referencing as a means to validate the information. If the fertile windows suggested by different apps matched up, they were seen by participants as having a greater likelihood of being accurate. Participants who had used period tracking apps prior to their use of a newer fertility app considered the apps they had used for a longer period of time to be valuable, and a more trusted source in cycle length due to

the longevity of the data that they held on them. These apps already had established a longer term view of the user's cycle, while the newly downloaded app still had to "learn" the user's personal cycle:

> I was basically tracking my cycles using the two apps, trying to see at what point they lined up, because usually when they lined up, you know, we had a chance, um, because obviously Woman Log I'd been using for years, and Ovia was still learning my cycles basically (Chloe).

Chloe considered the app she had used for longer as more reliable in terms of her own body, as she had used it for around 12 years, but it was more limited in terms of what different factors it allowed her to track, being based solely on menstrual cycle dates. In this sense the app can be characterised as an entity that needs to earn the user's trust, and is more to users than a mere tool. By drawing together two apps she felt she could optimise her chances by looking for when both apps "lined up" in their predictions to validate a reliable measure of her fertile window.

Some participants also used ovulation tests as another indicator to increase the reliability of app predictions, or to validate the accuracy of the app. For example, Phoebe tested a fertility app she downloaded before she was even using it to try and conceive to verify its temperature-based predictions of her ovulation:

> …especially when we started thinking about having a baby, I then tried to track it a little bit more accurately, so I would use ovulation tests, not- it wasn't even when we were trying it was before that, just so I could see how, how accurate the app was. And it was actually amazingly accurate (Phoebe).

The extent to which participants engaged in these types of validation practices varied widely – some simply used an app that had been recommended by a friend or in an online forum, and found them to be sufficient for their purposes. The type of practices that users engage in when evaluating the fertility apps they use could be part of their personality and approach to using technology. For example, Phoebe, who above described her process of testing the validity of the fertility app before she was even using it to try and conceive shared that she enjoyed reading textbooks about fertility and learning as much as she could. For other participants, their analysis of the apps they used was in part influenced by their experiences of trying to conceive. Some participants who did not conceive as quickly as others were more likely to examine the apps they used more critically. For example, Beth described having a challenging time trying to conceive, having experienced a pregnancy loss then taking 18 months to conceive again. During this time she used multiple period tracking apps, as well as a fertility app. She had purchased a further fertility app, Natural Cycles, in the time between having been referred to a fertility clinic and waiting for an appointment, thinking that this might be a more "data-led" way to optimise her chances of conceiving and offer more than the apps she had already been using without a thermometer, as described earlier in this chapter. This demonstrates that some users engage in a critical process of validating apps, judging what they consider to be robust, reliable or relevant in terms of data points to be recorded, and the analyses made by the apps. Therefore this builds upon existing literature that characterises users of self-monitoring apps as "active participants", rather than uncritical (Nafus and Sherman, 2014, p. 1793). An extension of the process of evaluating fertility apps is to consider how users understand and negotiate this data in terms of their own bodily knowing.

Ways of knowing

Some of the existing literature on fertility apps, and digital self-monitoring practices more

broadly, has put forth an argument that fertility tracking apps enact fertility as measurable and controllable, and may contrast quantified knowing with embodied knowing. For example, in her study of fertility apps, Lupton contends that:

> …quantification and the supposed benefits of neutrality offered by digital data are promoted and valued over people's own embodied knowledges of their bodies. The rhetoric used to promote the apps and in the text of the apps themselves suggests that the apps allow women to achieve a greater level of knowledge about their bodies than they otherwise might through observing and recording their bodies' signs, symptoms and sensations using 'data science' (Lupton, 2015, p. 447).

I observed similar rhetoric in some fertility apps that I reviewed to inform my background knowledge for this chapter. For example, the app Clue states that one of the benefits of use is that you can "become the expert on your body", suggesting that the user was not already the expert in their own body and that use of the app allows users to reach a higher level of bodily knowledge (Clue). Additionally, as described in the section above, many participants did report valuing a "scientific" approach to managing their fertility, and sought reliable and robust data through a variety of systematic practices, which reflects these narratives. I do, however, think the matter of quantified data being valued over embodied knowing is more nuanced, as explored in the literature review chapter of this thesis. An argument I develop across this thesis, particularly in the later chapters on monitoring fetal movement, is that different types of knowing interact, and that quantified self-monitoring enabled by app use and embodied knowing can coexist.[19] For fertility apps specifically, my findings generally align with existing recent studies of fertility apps like that of Grenfell et al. (2021), who similarly found that "participants widely viewed Natural

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[19] In findings chapter 4 I present the results of my analysis of fetal movement monitoring apps, and find that even in the rhetoric of apps themselves, this relationship between quantified data and embodied knowledge is complex.

Cycles as a scientific yet natural tool to support planning pregnancy – one that could teach them about their bodies and help make sense of, but not necessarily replace, felt, embodied knowledge" (Grenfell *et al.*, 2021, p. 126). In this way, self-monitoring apps are a supplement to embodied knowing, and can in some ways help augment embodied knowledge by increasing awareness and lending new understandings to bodily processes.

While I maintain that there is complexity in this area, there were, however, some cases I found where participants did describe making the types of analyses and prioritising quantified knowing over their embodied senses that Lupton identifies in the rhetoric of apps. Lauren, for example, described a disconnect between her embodied knowing and the data she measured and recorded on a fertility app:

> There'd be times when I had- I had a feeling and when I took my temperature the feeling was- the feeling I had was different to what the temperature was coming out as. So like for instance, so last month - once you've ovulated [the app] says you know, that you have to have three temperatures above the cover line to show that you've ovulated. Well I had two, and then it dropped down, but I was convinced that it had happened. I had all the symptoms and I was convinced that it had happened, and then, and then the temperatures dropped, which then indicated that it hadn't (Lauren).

Lauren reported that the app sets clear parameters for what counts as ovulation – "you have to have three temperatures above the cover line to show that you've ovulated". Conceptually, this echoes Mol's notion of the body multiple. Mol argues that objects come into being through practices. What an object "is" is situated in a particular context, and there can be multiple versions of the same object, hence her use of "the body multiple" to describe the several versions of the body that are enacted through different practices (Mol, 2002). In the

case of Lauren's fertility app, multiple versions of ovulation are enacted. Ovulation is Lauren's embodied experience of physical symptoms, but ovulation is also an appearance of three temperature readings above the app's cover line.[20] The fertility app therefore shapes what it means to ovulate, and by extension what it means to be fertile, as it can be defined by how it is measured. For example, a further version of ovulation could be enacted by the ovulation tests that Phoebe used to verify the analysis of the fertility app she used.

Mol observes that a process of "coordination" occurs where different versions of the same object are incoherent. As an example of a process of coordination, she identifies that where there are inconsistencies between the results of different diagnostic tests, "…a hierarchy is established and the discrepancy between the tests is explained away" (Mol, 2002, p. 84). This process of coordination is evident in Lauren's experience with the fertility app. Lauren went on to share that she had determined that the app's analysis of her temperature readings was correct, i.e. that she had not ovulated, and she trusted this over her bodily experience, despite having expressed that she was "convinced that it had happened". She chose to place the analysis of the app at the top of a hierarchy, rather than for example questioning the metrics of why three readings, rather than two, were legitimate evidence of ovulation, whether her temperature readings had been accurate, or whether temperature was a reliable indicator of ovulation:

It turned out that yeah, it was anovulary [anovulatory] – I can't say that word. Um you know, body attempted, and nothing happened sort of thing. Yeah, but it's weird, like 'cause when you've had all the symptoms, and then, and you've gone through- you know, because it was quite uncomfortable, like you get quite bad cramps, and then for them to be

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[20] Temperature readings are taken daily each morning, therefore this refers to three days of measurements, with Lauren's temperature having fallen on the third day and meaning that she did not reach this three day metric.

nothing, but it felt like for two days that it happened, and then on the third day it drops off

and you're like 'oh, ok well that didn't work, ok, fine' and it almost feels like it's a bit of a

waste (Lauren).

She described her experiences in terms unfamiliar to her that she struggled to pronounce, as this

language to describe her body was informed by her use of the app. Her app use also shaped her

experience of her bodily feelings, like cramping, as something to be achieved, and indeed as

something linked to her fertility. She described her symptoms as a "waste", as she regarded that

discomfort as something she would endure as part of her goal of ovulating in order to conceive,

rather than experiencing the sensations of her body as an end in itself or simply something that

occurs. This positions the functions of the body as predicated on outcomes, with the lack of

achievement at the end of these processes as wasted effort, energy, and endurance of pain. The

app she used is likely to have heightened this by enacting aspects of fertility as achievements, in

particular through techniques of gamification.[21] As mentioned earlier, my goal in this thesis is not

to suggest that fertility and pregnancy apps are entirely different to fertility practices and

resources of information that have existed for a long time; instead I intend to demonstrate how

women engage with and use these technologies. Nonetheless, there are some dynamics that are

newer, and gamification and the responsiveness of technology to users fall into this category.

Some apps, such as Ovia Fertility (a popular fertility app used by several of the participants in

this study) offer users virtual medals for consistently inputting data. For example, when first

downloading the Ovia Fertility app the user is presented with a "fertility key" and advised to

"start tracking your cycle to unlock the best fertility predictions possible!", able to unlock further

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[21] My use of the term "gamification" is informed by the definition of Hamari et al. of gamification as "…a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioral outcomes" (Hamari, Koivisto and Sarsa, 2014, p. 3026).

levels of the app like unlocking levels of a video game (Ovia). For Chloe, these types of awards for consistent tracking encouraged her to continue:

> …the app does that really childish thing of going 'yay! you've logged things for this many days!', and then you sort of go 'ooh I'll keep logging things', 'cause it gives you that positive like reinforcement every time you use it, so it, it encourages you to keep tracking stuff … when I'd get a headache, or when I'd get a bit of backache or abdominal pain or pelvic cramps, anything like that, I would sort of go 'ooh, I twigged that today, I'll make a note of it on my app'. So even like when you've logged 50 things, 50 days in a row it goes 'oh yay! have an award for it!', it encourages you to keep going basically (Chloe).

Chloe described this playfully as "childish", seeming to enjoy the novelty the app provided in this positive feedback to her tracking of physical signs that might indicate ovulation. In this way, the gamified aspect of fertility app use encouraged her to heighten her awareness of physical sensations and to record these as part of her ongoing attempts to conceive. Through this practice, the fertility app encourages users to perceive particular bodily experiences, for example a headache, as related to their own fertility, as explored earlier in this chapter. This therefore contributes to shaping self-knowledge with regard to fertility, and the use of gamified strategies to encourage continued tracking forms one part of embedding this process.

While participants like Chloe found the positive reinforcement from fertility apps encouraging and novel, gamification in the context of fertility tracking was identified by others as problematic. At the time of our interview, Lauren was actively trying to conceive and was using a fertility app. She was a highly engaged user, committed to tracking every day and participating in an online community specific to users of the app to exchange advice and discuss their shared experiences. Through her use of the app and tracking her basal body temperature, Lauren had

established that she had not yet ovulated during the span of time in which she had been self-monitoring. In light of this, she expressed her disapproval of the gamified features in the app that reward users for reaching particular targets:

> They've almost gamified in a way, by giving you levels. So newbie, junior, star, pro, whatever they called them, and I think that's wrong, because I don't think based on whereabouts you are in that process you can be given a level or a star rating. And I think they need to drop that.…It's not how much information you know at all, it's what part of the process you're in…all you can see is that star rating all the time you're like 'I just want to progress' and it makes you feel like you want to progress, but you can't push your body, you can't change what your body is doing, you can't- you know, so it almost seems pointless (Lauren).

Lauren felt frustrated that the app was gamified in relation to a factor that she did not have the ability to control, i.e. ovulation.[22] Despite her enthusiasm for tracking data consistently and building knowledge about her own fertility, the app gave her "newbie" user status that she would be unable to progress beyond until she had ovulated. As she described it, "it's not how much information you know at all" - her efforts were not valued by the app, rather the focus was on a physical bodily process of ovulation that she was not able to achieve. The app was branding this aspect of her body as failing to achieve the appropriate award, adding to her existing frustration and concerns about not ovulating in the significant context of wanting to be pregnant and not being able to accomplish this goal. Several participants in this study who had faced difficulties when trying to conceive described this experience as extremely challenging. Gamification in this

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[22] As many fertility apps suggest, ovulation could potentially be influenced by a number of factors including exercise, diet, and management of stress, and biomedical interventions can be used to try to induce ovulation (Hughes *et al.*, 2010). But fundamentally, these are things that can be attempted, and there is still a significant lack of control. Here, Lauren felt like this was something she could not control.

context means that as well as offering virtual rewards for fertility tracking practices, in the inverse users may be penalised for elements that are both distressing, and not within their power to change.

Existing studies of fertility apps have identified how users can be motivated to use apps in an attempt to gain control over their fertility. Grenfell and colleagues found that "…many women felt the app gave them control over their bodies and fertility…" (Grenfell *et al.*, 2021, p. 126). However, the example above emphasises the lack of control that users ultimately are able to exert over particular bodily processes. They are able to control specific practices, and can aim to influence their fertility through a variety of factors, but cannot control what their bodies do. This highlights the emotional reactions that can be evoked by fertility app use, and I will now turn to the ways these emotional aspects of app use can contribute to discontinuation of use.

Discontinuation of use

While most participants presented their use of fertility apps as a predominantly positive experience, some participants reported that their use of fertility apps had become problematic in some way, particularly for those who were trying to conceive over longer periods of time. For example, Cara had been using multiple fertility apps to support her efforts to conceive, but later discontinued her use of apps:

> …actually just before I got pregnant I stopped using them, because I was getting a bit obsessive about it, and one of my friends, who'd just found out she was pregnant, said 'stop, you know, just stop with the apps, and take a multivitamin, and it will be fine', and then that's what happened (Cara).

As Cara described it, her use of fertility apps had become obsessive to the extent that she had spoken to a friend about her use of apps, and felt the need to avoid using them. As discussed earlier in this chapter, there are gamified features and inducements from apps to enter data about multiple factors on a regular basis, and this may exacerbate the amount of usage and contribute to this feeling of obsession. However, while fertility apps may heighten stress or anxiety and can contribute to users becoming obsessive, Cara's decision to abandon the fertility apps she had used highlights that users retain the agency to reflect on their own behaviour and may choose to discontinue use.

In addition to discontinuing the use of fertility apps due to feeling overly obsessive, a further reason for ending app use raised during interviews related to previous pregnancy experience. Some fertility apps encourage users to continue tracking their basal body temperature beyond the stage of trying to conceive and maintain the practice in pregnancy. In the same way that changes to basal body temperature can be used as an indicator of ovulation, some research suggests that these temperature changes may also signal that a miscarriage may be about to occur, or has occurred (Watanabe *et al.*, 2016). Some participants were aware of this feature but chose not to continue temperature tracking into pregnancy as they felt it was of minimal use or interest. Other participants did choose to use this feature, but reported that the continued practice of temperature tracking was associated with anxiety. Prior to our interview during her second trimester of pregnancy, Phoebe had experienced a pregnancy that ended with a miscarriage. Having conceived again, she had initially continued to track her temperature each morning as she had while trying to conceive during this subsequent pregnancy, but had fallen out of the habit as her pregnancy continued. She first explained the reason being that nothing was changing in her temperature as the pregnancy progressed so she became "fed up", and experienced boredom in this form of self-monitoring. This was a reason given by other participants who chose to stop tracking their temperature when they fell pregnant, as they felt there was nothing interesting or

useful to observe in this practice if nothing changed. However, Phoebe later expanded on her reasons for her discontinued use of the fertility app during pregnancy, and reflected that her choice was also layered with her fears of experiencing another miscarriage:

> I think there was probably an element of- because we'd lost a baby… I was a little bit apprehensive obviously in the first few weeks of the pregnancy, um, and I think I was maybe almost afraid, and I did- I know I was afraid of taking my temperature in the morning in case things had dropped down, so that, that's why I go out the way of it, more than anything else. Because I was a bit, afraid, in a way (Phoebe).

In this way, the practice of temperature tracking when continued into pregnancy manifested her fears of experiencing a miscarriage. This demonstrates that interacting with and interpreting personal health data can be challenging for users, as in this example, the data point of basal body temperature had effectively become a powerful, daily measure of whether or not her pregnancy was continuing. As mentioned above, the technology makes these features visible, and a way of the user understanding themselves to be fertile or not, or in this case, pregnant or not. Several participants in this study reported feeling nervous or anxious during the first trimester of pregnancy, and this was especially the case for participants who had experienced a miscarriage in the past. For Phoebe, this self-monitoring practice that she had portrayed as entertaining and empowering while trying to conceive became a practice associated with fear to the extent that she discontinued use. She reported that she intended to get back into the habit, suggesting that despite her fears she felt there was some value in the practice, but at the time of the interview she had not done so. The use, and discontinued use, of fertility apps must therefore be understood as informed by factors such as past pregnancy experience, and an emotional experience, that aligns with Pantzar and Ruckenstein's argument that the emotional engagements

that individuals have with their data are significant factors when considering self-monitoring technologies (Pantzar and Ruckenstein, 2014).

Conclusion

In this chapter I have explored how and why women use fertility apps, and how the (non-)use of fertility apps relates to the ways in which women understand and experience their bodies. I found that fertility apps help users make sense of their bodies in terms of a scientific or data-led view of fertility, and have implications for users' understanding and valuation of their own bodily knowledge. Self-knowledge about fertility was seen by several participants as empowering, and self-monitoring with a fertility app enables access to a form of self-knowledge by making aspects of the body visible through the analysis of temperature readings. Participants used multiple different apps, used techniques such as cross-referencing to validate the apps, and made their own judgements on what constituted reliable information. They valued different data as able to provide more or less reliable insights into their own bodies. Factors that some participants considered to judge reliability included the quantity and type of data. Quantity can be informed temporally, i.e. the length of time an app has been used, which gives the app status as having "learned" the user's cycle, or by inputting more data points spanning a shorter period of time. Within this, there are hierarchies of the type of data and what value users give to different forms of data, with examples given by participants of considering temperature readings to be more reliable than dates of menstrual cycles, considering symptoms of bloating less relevant than cervical mucus, and for some, valuing an app's interpretation of ovulation based on temperature readings as more reliable than embodied sensations of ovulation, which were in turn informed by self-knowledge gained from using an app. Through techniques of gamification, apps normalise and reward or chastise particular behaviours and bodily processes. There are emotional responses to features like gamification, with some participants enjoying being rewarded for self-

monitoring, while others reported frustration that they were deemed unsuccessful and objected to the presentation of fertility as something that can be achieved. While the majority of participants made use of fertility apps to self-monitor while trying to conceive, they used apps critically and were analytical in making judgements on what features were relevant for them. The following chapter will consider what happened next when participants progressed from fertility apps to pregnancy apps.

Findings chapter 2 – "That is normal, everything's going ok": Women's practices of self-monitoring and information seeking during pregnancy

Introduction

The app Glow promises "a powerful new way to visualize and analyze your pregnancy symptoms and emotions" with premium upgrades offering "more metrics, more advanced analytics" (Glow 2021). In the previous chapter, I described how many participants valued a "scientific" and "data-led" approach to fertility that aligns with this narrative, and used fertility apps to optimise their chances of becoming pregnant. This chapter, however, tells a different story of pregnancy app use. I consider the ways in which women engage with pregnancy apps as part of their personal self-monitoring practices during pregnancy, with a focus on food intake and bodily symptoms. While a data-led approach to fertility was valued by many participants and they used fertility apps for self-monitoring, the same practices did not extend into pregnancy for the majority of participants. All participants used pregnancy apps, and all used at least one app that offered self-monitoring functionalities, yet only a minority of participants used them for self-monitoring.

Among the participants that did use apps for self-monitoring, they were selective in what factors they chose to track, and intermittent in their usage, with most self-monitoring focused around diet. It is then pertinent to ask why participants generally did not use apps for self-monitoring, and why instead they did use pregnancy apps. Rather than valuing pregnancy apps for their self-monitoring functionalities to "visualise and analyse" their pregnancies in the way apps like Glow suggest, most participants' motivations for app use centred on seeking reassurance that their experiences were normal, and understanding their bodies during pregnancy.[23] Data-led analytics

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[23] A key aspect of this was understanding fetal development, which I explore in depth in the following chapter.

were therefore not a priority for most participants, with self-monitoring features seen as unnecessary, and the limited extent of personalisation offered by most apps was not considered to be problematic.

Instead, the condensed feed of information that apps offered was an attraction for several users, particularly those who found vast quantities of pregnancy advice overwhelming, although others noted the limitations of these "nutshells" of information. The temporal nature of these updates was reflected on as a reassuring feature, that gave some users a sense of companionship in what they were experiencing during pregnancy. This also had the potential to shape participants' bodily experiences in pregnancy, which speaks to my research questions of how and why women use pregnancy apps, and what impact they have on how they understand and experience the body in pregnancy. I argue that pregnancy app use as reported by participants in this study can be characterised as what Oudshoorn terms "selective use" of technology, and I use Wyatt and colleagues' taxonomy of non-use to describe participants as "resisters" of particular aspects of pregnancy apps (Wyatt, Thomas and Terranova, 2002; Oudshoorn, 2008). I also engage with literature that asserts – based on content analysis – that pregnancy apps promote self-responsibility and self-management during pregnancy by encouraging self-monitoring with data. My findings indicate that in practice, participants demonstrated some resistance to apps, and were selective in how they chose to use them. As self-monitoring features were resisted by the majority of participants, this suggests that users are entirely capable of disregarding these inducements to self-monitor, and the power of these apps to exert influence in this way should not be overstated. Nonetheless, participants did generally appear to endorse self-responsibility and self-management in pregnancy, and pregnancy apps offered information to users that promoted this narrative, for example advice on food safety. Therefore while many participants did not use apps for self-monitoring, they can nevertheless be configured as part of their practices of self-management in pregnancy.

Pregnancy apps for self-monitoring

As established in the previous chapter, the majority of participants reported using fertility

tracking apps and were active in measuring and recording different aspects of themselves when

trying to conceive, for example their menstrual cycles and daily measures of basal body

temperature that might indicate ovulation (chapter 1). For several of these participants, their

entry point to using pregnancy apps was a prompt from a fertility app that aimed to continue

their use on to the pregnancy app produced by the same developer:

> For me it followed on quite naturally from using some of the fertility apps. … So the Ovia
>
> Fertility one I'd been using, and then, I graduated, 'graduated' from the fertility one, it
>
> invites you to put in if you're pregnant this month, and then it prompts you, helpfully
>
> [sarcastic tone], to download the pregnancy app, so that's the main one I've been using
>
> (Eleanor).

> So you kind of enter your information, to say 'I'm pregnant' and immediately it says,
>
> basically you can't be in the app any more, it just kicks you out – which is a bit annoying,
>
> 'cause you might actually want some of that data – but anyway, it's like 'you're pregnant,
>
> you must go!' So then I got the Ovia Pregnancy app (Rebecca).

Both Eleanor and Rebecca described the fertility app they had been using as dynamic in

prompting their behaviour, with their being actively 'kicked out' of the app and progressing their

use to the same developer's pregnancy app. They had a clear awareness of the influence the app

was exerting in encouraging this behaviour, with Eleanor noting ironically the "helpful" nudge

from the app to encourage the user's choice of using the corresponding pregnancy app. This is

an initial indication of how participants demonstrated an awareness of the influence the app

attempted to exert on them. With this in mind, they nonetheless both chose to follow this proposed continuation from fertility app to pregnancy app, but the extent to which participants complied with the various prompts of the pregnancy apps they used going forward varied.

Many pregnancy apps prompt users to generate and enter data about their bodies during pregnancy in a similar way to fertility apps, for example physical symptoms, weight, and blood pressure. The categories some apps offer for self-monitoring can be extensive, and may be related to health practices, for example food intake, exercise and medication intake, as well as aspects such as mood, and relationship quality. In the previous chapter, I argued that fertility apps can influence users' conceptions of what constitutes fertility by enacting multiple factors as related to ovulation (chapter 1), and a similar dynamic is visible here, with many factors and practices being enacted as related to pregnancy through the construction of the app.

Figure 6. Examples of self-tracking prompts
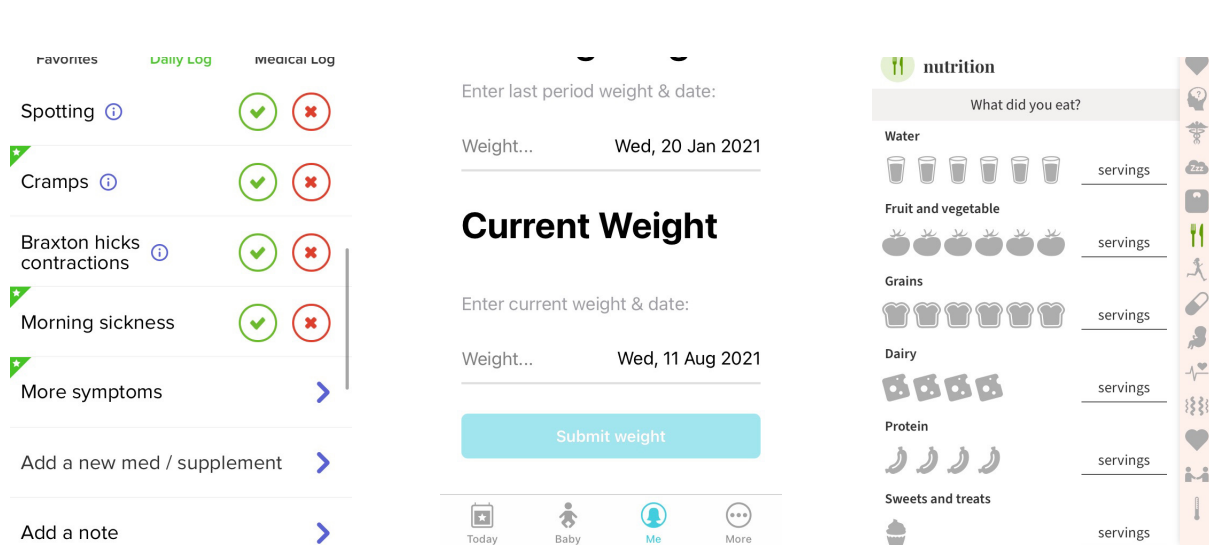
Sources left to right: Glow Nurture; Pregnancy +; Ovia. Screenshots taken August 2021

Additionally, Lupton and Thomas argue that in presenting users with these factors to monitor,

"…pregnancy self-tracking apps enact the soft politics of algorithmic authority, encouraging people to conform to expectations of self-responsibility and self-management by devoting attention to monitoring their bodies and acting on the data that they generate" (Lupton and Thomas, 2015, p. 2). I will now turn to my findings to consider how participants used apps, and consider these dynamics of self-responsibility and self-management informed by self-generated data.

Diet tracking

Diet tracking was a common form of self-monitoring explored in interviews. This was both as a frequent response to open-ended questions I asked participants about any data they had chosen to enter into the apps, as well as a specific example of self-monitoring I raised during some interviews. Diet was discussed by participants in a number of ways: in terms of eating particular quantities of food, in terms of eating particular types of food, and in terms of avoiding potentially unsafe foods. All of these elements intersect with pregnancy app use. Some participants chose to track their diets during pregnancy to help enable them to consume what they considered to be enough food:

> I actually found that tracking my calories helped to make sure that I was actually getting enough, and there have been days where I- I've had like 1,000 kilocalories, whereas before I used to struggle to you know stay below a certain amount. Now I'm like one half of that, but I'm just full, so I kind of yeah make sure I'm still kind of eating enough basically (Maya).

Maya found this tracking practice helpful, and was informed by her past use of diet-tracking apps that had helped her establish the calorie intake ranges that were normal for her. Her

fullness cues changed in pregnancy, and she was trying to reconcile her bodily experience of being full and having eaten enough with her understanding of how many calories she should be trying to consume. As introduced in the previous chapter, the interactions between embodied knowing and externally tracked factors and metrics are complex. In this instance, Maya did not fully trust her bodily feelings of fullness to mean she had consumed enough food, referring to metrics of calorie counting to ensure she consumed a sufficient amount of calories. This is an example of different ways of knowing being aligned – it is an active process, where sometimes there are perceived tensions, but ultimately users manage to align different ways of knowing.

Some other participants who tracked their food intake in pregnancy reflected similar ideas of apps supplementing their bodily self-knowledge. For example, for some participants tracking diet with a pregnancy app was an useful means of identifying new reactions to foods during pregnancy. Chloe described using her diet-tracking information on a pregnancy app to identify that she was no longer able to tolerate eating tomatoes:

> … because I'd been logging things, and I went back on my app and I was like 'well that was the day I was feeling sick', because all these days were such a blur anyway, I was able to go back on the app and figure out what day it was, what I'd had for lunch that day, and link it that way. So it's helped in that sense, 'cause there's other times that I've thought 'oh I've really gone off that food', when in fact I've just not fancied it (Chloe).

Using the app to track her diet enabled her to identify what she considered a link between eating particular foods and vomiting, and added a layer to her own self-knowledge about her reactions to foods, with some being identified through her analysis of data to be linked to symptoms of vomiting, allowing her to differentiate other foods that did not give her this

reaction, but that she simply did not feel like eating. She felt she would not have noticed this connection as quickly had she not been using the app to track her food intake:

It was a lot quicker in coming to mind that actually this is a food-related thing, it's not just a pregnancy-related thing, it's food in pregnancy. And it did come to me a lot quicker, purely because like I said, I'd logged it (Chloe).

As well as identifying aversions, some participants' diet tracking was motivated by their aim to align with the model of healthy eating enacted by guidelines, which can be reinforced by pregnancy apps. App prompts for self-monitoring can structure supposedly ideal behaviours, for example with icons to complete that refer to a goal to consume six servings of fruit and vegetables and four servings of dairy products as shown in figure 6. Some participants used a pregnancy app to ensure they were meeting these recommended portions of food:

The good thing on Ovia is now that I'm eating a wee bit better again, I'm tracking my diet. Because I couldn't believe they want you to eat like, six portions of protein a day! And lots of grains, yeah. It's from the Mayo Clinic, the sort of recommended intake for pregnant women. And I find that really hard! I'm trying to track that as best I can. Just to make sure that I'm doing everything I can (Phoebe).

For Phoebe, eating these recommended portions of food and tracking it can be seen as aiming to meet expectations of ideal behaviour in pregnancy. She refers to "doing everything [she] can", as if she can perform more or less well in pregnancy for the wellbeing of her unborn child. This aligns with existing research on the social expectations for people to eat well in pregnancy and conform to healthy practices in the interest of the fetus, which, as mentioned earlier, Lupton and Thomas have argued is inherent in pregnancy apps in driving

this type of "self-management" and "self-responsibility" (Lupton and Thomas, 2015). The way Phoebe describes "they want you to eat" indicates that this is received advice, and while in this instance she specifically cites the Mayo Clinic as having produced these diet recommendations, which she had then read on the Ovia app, several participants used similar expressions of "they say" when discussing pregnancy guidelines in the sense that some governing force dictated what they were and were not "allowed" to do and consume during pregnancy:

> I haven't done what food I've had tracking-wise. It was just having a basis of what I'm allowed and what I'm not allowed, and finding my way round it (Julie).

This narrative of avoiding potentially risky behaviours through practices such as following food safety guidelines was common among participants, and I will return to this idea, and the use of food safety look-up features on pregnancy apps later in this chapter. Phoebe's tracking of her diet, however, was only conducted by a minority, and most participants, like Julie, resisted diet tracking using pregnancy apps.

Resisting self-monitoring features

In early pregnancy, the nausea that several participants described experiencing meant that they limited their diets to foods that were easily palatable, a commonly reported phenomenon in early pregnancy (Lou *et al.*, 2017). This early stage of pregnancy generally involved participants eating what they felt able to, rather than achieving an idealised diet like Phoebe describes above (and she herself noted only being able to achieve this after her early nausea had passed). When it came to self-monitoring, some participants did not want to track their food intake during this time:

No, not food and stuff, no I think I'd find it too depressing (Felicity).

Felicity had reported subsisting largely on crisps, and as she explained it, while she was broadly aware of what she was eating – or indeed, what she was not eating – seeing this information recorded in front of her would be "depressing", suggesting she would not be achieving an ideal, healthy diet. This was a similar approach to some others participants who cited this reason of avoidance for not self-monitoring:

Yeah so I didn't really track my food, I didn't really want a record of what I was eating because I felt so grotty, I just felt so nauseous chicken nuggets were literally all I could stomach (Eleanor).

This echoes existing studies of food-tracking apps not exclusive to pregnancy that found that some users "morally evaluated" meals and "cheated" the app by not recording them, not wanting a record of this perceived "failure" (Didžiokaitė, Saukko and Greiffenhagen, 2018). In this instance these participants did not engage in any food tracking, which was in part for similar reasons of not wanting a record of their diet when they considered it to be unhealthy, or as Felicity states, "depressing". Like in chapter 1, where some participants suggested that apps earned their trust over time, there is a similar dynamic here of individuals engaging with technology in similar ways to if it were a human entity, in this case not wanting to report their diet to the app that both forms an external record of what they have been consuming and prompt them to reflect on their own behaviour, but also is something that might pass judgement on them.

In addition to wishing to avoid a record of an undesirable diet in early pregnancy, many

participants did not track diet or the many other factors that can be tracked on pregnancy apps, such as physical symptoms, because of a lack of perceived utility of these features. When tracking for fertility, participants had a clear goal in mind and hoped that generating and recording their data would help them to conceive, often citing a belief that this was a scientific, data-led way of optimising their chances of becoming pregnant (chapter 1). A comparable goal that could be achieved through self-monitoring with an app did not seem to extend into pregnancy for many users of pregnancy apps. When asked whether she utilised any self-monitoring features on the pregnancy app she used, Beth's answer was typical of most participants:

> No, no. I don't use that aspect of it at all, which um, yeah. I just- I don't know, I just sort of- I did- I used it when I was trying to conceive as well, the period tracker, and I did enter data then, but just with this, it's just not an aspect of it that I particularly want or need (Beth).

Beth did not offer a strong opinion on her non-use of the tracking features: as she first stated when explaining why she did not use them, she mused "I don't know". Several participants reported comparable perspectives when asked if they used a pregnancy app for self-monitoring, having not really considered using tracking features, or in some cases not being particularly aware of the features that existed:

> No uh I don't, I don't think so. Um, let me check [checks phone]. Um, no I haven't- I don't think I put any data in it. Oh, it has a health assessment in there, I didn't even realise that. No I haven't. I- like you can put doctors' appointments and stuff in it but I haven't put any of that in it. I just use it for, for the feed of information basically, yeah (Rebecca).

The feed of information was the primary utility of the app for Rebecca, which I will explore in the next section. Alissa also did not appear to have reflected much on why she did not use a pregnancy app for self-monitoring during pregnancy:

…I've not really kind of entered any information. I don't know why, but I just think, because we're living it and we're going through it I've not really recorded it as much as you probably can do on there, I've not really used that function much. Um, I know you can put like milestones in it and things but, I've not been recording- like you can put weight gain and stuff like that in it, and I don't record a lot of that so I've got all my hospital notes with everything that's important kind of in there, and I've kept it to that (Alissa).

For Alissa, the health records that she and her health care providers produced through her antenatal care were sufficient, and she did not feel the need to replicate any information or generate her own data to supplement this. She drew an interesting contrast between "living it" and recording it, suggesting that her lived experience of the pregnancy negated a need to add any tracked form of the pregnancy in this way. Eleanor developed a similar point, noting that she wanted to enjoy her pregnancy without becoming obsessive about tracking:

I mean you do have the option to track your symptoms, track your food intake, track your water intake, but I- I've found using apps like that in the past to be quite um, they become the focus, and become too much of almost an obsession, rather than it being a 'this is what's so lovely' (Eleanor).

For Eleanor, focusing on self-monitoring in this way would detract from the focus she wished to place on the "lovely" aspects of her pregnancy. She considered self-monitoring to have the potential to become an obsession, a finding which will be developed further in

chapter 5 regarding the reasons why many participants chose not to make use of fetal movement monitoring app features. Eleanor's non-use was informed by her past experience of using diet tracking apps. It is important to consider pregnancy app use as part of users' past patterns of technology use, which can inform how they choose to make use of pregnancy apps.

Even among the participants who did use pregnancy apps for self-monitoring, they were selective about what they chose to track. For example, Maya tracked her weight throughout pregnancy on a pregnancy app, intermittently tracked her diet, and occasionally logged a symptom such as cramping in early pregnancy, but did not track consistently, and did not enter the full range of data points that the app enabled her to track. She noted how time-consuming it would be to track the full range of data points available:

> If you wanted to track everything the app suggests you can track, you'd spend like an hour a day tracking stuff (Maya).

This is reminiscent of a finding in Peyton and colleagues' study of pregnancy apps, in which they found that due to the demands of pregnancy "…the suggestion that they should actively track and record their activities was met with incredulity, laughter and sometimes derision" (Peyton *et al.*, 2014, p. 581). The effort involved in tracking was not seen by participants as worthwhile, and while they used other features of pregnancy apps, they therefore resisted the self-monitoring features that apps offered. This was in part due to a lack of perceived utility:

> I've not really been using it to log my symptoms and things 'cause I find, you know, I don't have any, or, or I could- I could log tender breasts every single day and I don't think there's much point of it. I did log it when I had like my bad cramps, and I have- like I

actually found it very useful then to be able- when, when I see my midwife, I can tell her 'on that day I had that', so she can kind of see when- how far along I was when something happened, so yeah that's quite, quite useful for that (Maya).

There was some convenience she reported in being able to pinpoint when exactly a symptom had occurred in order to report this to her midwife. Some of the discourse surrounding the benefits of self-monitoring technologies is that users can share their data with health care providers in order to inform their care and improve health outcomes (Morley and Floridi, 2020). Maya's experience demonstrates an element of this, but in general in this study this was not common practice, and the majority of participants had not mentioned their use of pregnancy apps to health care professionals. It is beyond the scope of this chapter to engage in a full discussion of why this was, but participants tended to report that antenatal appointments are relatively short, and they did not generally consider their app use to be relevant or worth discussing in this limited time. Rebecca described the lack of time for any nonessential conversation in her antenatal appointments, with the appointments being a short run through of

Are you ok? How big's the bump? Pee in a pot. That's all (Rebecca).

Some of the existing literature on internet use in pregnancy and pregnancy apps has established that online information seeking may meet some of the gap of information needed before and between antenatal care appointments (Hearn, Miller and Fletcher, 2013; Kraschnewski *et al.*, 2014; Peyton *et al.*, 2014). My findings generally support this, with pregnancy apps providing participants with information between appointments. Some participants mentioned reading information on a pregnancy app that meant they would not then ask the same question of their midwife:

One good thing about the app I'm using is it's got videos as well from midwives, so like rather than building a list of questions to go and ask my midwife, it meant I'd know what I was doing there (Julie).

Julie found the videos recorded by midwives that her app contained gave her some confidence in following their advice which she judged to be reliable from their status as midwives, and it meant that she felt less need to seek general advice from her own midwife. Yet other participants found the reverse, with the information they read on a pregnancy app informing what they would then ask their midwife about:

It has made me think of things, so one thing mentioned the whooping cough vaccine and then so that made me kind of ask when I needed that, um, and then there was something about travel cause we've just been away and it said something about possibility needing a fit to fly, so I asked the midwife about that, so I've not specifically mentioned the app, but things that have kind of come up on it have made me, kind of think 'ah I need to ask that when I go and, and see them' (Alissa).

Even among participants who would refer to pregnancy apps for information that they would then not ask their midwife about, pregnancy apps were situated by all participants as something that complemented their formal antenatal care, and did not displace their desire for professional guidance for their pregnancy care.

A useful concept that can be used to describe the way participants used pregnancy apps can be drawn from the literature on telecare, which considers patient use of technology in conjunction with health care professionals. Oudshoorn uses the term "selective use" in her

study of patient use of a telemonitoring device to measure heart function to describe how patients made choices on how to incorporate technology into their daily lives (Oudshoorn, 2008). This is a different context of technology use to pregnancy apps, as in this thesis I consider user-led, independent use of technology. Nonetheless, Oudshoorn's analysis of different forms of users is highly relevant. She argues that:

> Since many sociological studies of user-technology relations focus on users or, more recently, non-users, this case study suggests that a focus on selective use of technologies is important to improve our understanding of the relationships between users and technologies. In this respect, it seems to be useful to extend the, otherwise very appropriate, distinctions between different categories of non-users introduced by Wyatt, Thomas and Terranova (2002) with the category of selective users to avoid an a priori dualistic distinction between use and non-use (Oudshoorn, 2008, p. 284).

As mentioned here, Wyatt, Thomas and Terranova proposed a taxonomy of non-use of technology, considering the example of the internet. They identify four types of non-users: resisters, who have never used the internet by choice; rejectors, who used the internet at some point but discontinued use; excluded, those who have not been able to access the internet; and expelled, those who stopped using the internet involuntarily as their access was limited in some way (Wyatt, Thomas and Terranova, 2002, p. 36). They note that there are differences between non-use of a technology as a whole, and non-use of specific aspects of it (Wyatt, Thomas and Terranova, 2002, p. 36) – Oudshoorn's term "selective use" captures this well. Drawing upon both this taxonomy, and Oudshoorn's reference to selective use, participants in this study whose (non-)use I described above generally fell into the categories of resistance of self-monitoring features, as they did not want to use them and therefore chose not to, and there were also aspects of rejection among participants who tracked for a short time but

discontinued use.[24] Weiner and Will further develop the concept of resistance, referring to Armstrong and Murphy's differentiation between conceptual resistance and behavioural resistance (Weiner and Will, 2016). They give examples around prescribed medicines to explain this division – individuals being reluctant to take medicine they have been prescribed because of concerns of side effects, or what taking medication might mean for them in terms of illness identity, falls into the category of conceptual resistance. Aspects of behavioural resistance might include modifying regimens to minimise harms, for example taking a lower dose than prescribed, as well as outright rejection of a medication. In both contexts, Weiner and Will suggest that "…resistance implies an oppositional stance…" (Weiner and Will, 2016, p. 292). While ostensibly the resistance of apps as reported in this chapter may be characterised more as disinterest than resistance, there is something of resistance to push notifications and attempts of apps to call for information and integrate into daily life that echoes this notion of resistance. In particular, several pregnancy apps aimed to feature in the daily lives of users and implored them to track data through the use of push notifications. Johnson highlights the "pushiness" of many pregnancy apps as being intrusive, representing a process of "push responsibilisation" in frequently imposing information and practices on users (Johnson, 2014, p. 336). The majority of participants in this study did not comply with the demands of these push notifications, which I suggest is one particular example where these practices represent behavioural resistance, albeit it in a more subtle form than has been identified elsewhere in discussions of resistance of technologies. Next, I will turn to the practices of app use reported by participants, including those who otherwise resisted self-monitoring features.

Information seeking and information overload

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[24] "Rejectors" could also be used to characterise the discontinuation of use of fertility apps described towards the end of chapter 1.

When asked if she had been using apps for recording her symptoms, Julie stated that this was less of a priority for her than understanding what she was experiencing:

> I haven't done tracking, it was just kind of actually 'can I get an explanation for it?' And that was the biggest thing I needed, like I just needed to understand what was happening and why it was happening, and what kind of level I should be worried about (Julie).

This desire for understanding was common to many participants, and was a primary motivation for using pregnancy apps, rather than the potential of using these apps for self-monitoring. While self-monitoring may enable self-understanding, it was in a slightly different sense that participants spoke about their desire for information. Participants used a variety of sources of information, including advice from health care professionals, friends and family, books, and websites. All participants used pregnancy apps, and it was not uncommon for them to download several different pregnancy apps rather than exclusively use one, which aligns with the findings of other studies of pregnancy apps (Barassi, 2017). There were a number of features of pregnancy apps that participants described as useful or valuable to them, some of which are aspects of pregnancy apps that differentiate them from other sources of information such as pregnancy books. Some participants reported that the availability of the app on their phone was in itself reassuring as they had instant access to information:

> I did find them really reassuring to kind of have that information at your fingertips, and that's the really nice thing about the apps and having them on your phone is your phone is always with you, um, so you can kind of- if there's something that kind of comes up you can just like check it and you kind of, yeah you always have it … (Felicity).

Participants like Felicity carried their phones with them habitually, and valued having information easily available to look into any concerns they might have. This regular proximity to a phone is reflected in the fact that the majority of participants reported using their apps very regularly. Most pregnancy apps provide users with regular updates of information that are relevant to their stage of pregnancy, for example advice on possible pregnancy symptoms that might appear around that time. These were popular among participants, with most participants reporting using the apps daily or multiple times a day, particularly in the earlier stages of pregnancy:

> I use it for the daily kind of- it gives you a daily update for advice for like, how to cope with back pain, or um eating well or, just at different stages of pregnancy. So I kind of use it for that, I read it every day (Cara).

This regular usage of apps demonstrates that many participants were selective users, as they used pregnancy apps on a very regular basis, but did not make use of all the features the apps offer and ignored many of the prompts of apps to track their data. One aspect of pregnancy apps cited by some participants as a helpful feature that they did make use of was that a relatively limited amount of information on pregnancy was drip-fed to them according to their stage in pregnancy:

> I think sometimes too much information can be a bit anxiety inducing … so I thought the apps would be a good kind of, sort of in-between of having a bit of information without kind of too much (Beth).

Several participants reported that the sheer quantity of information available about pregnancy, and in particular conflicting advice, could be stressful or cause anxiety. Consuming a more

limited range of information through a pregnancy app was seen as a way to curb some of this anxiety. This echoes Johnson's findings on the appeal of limited and accessible information delivered through pregnancy apps, what she describes as the "tidbitisation" of information (Johnson, 2014). While this was appealing for some participants, others sought out more information. Some participants did this by downloading multiple pregnancy apps and comparing them, though this sometimes had the consequence of causing information overload. I interviewed Felicity during the pregnancy of her second child, and she noted how she had used multiple apps in her first pregnancy but had chosen to limit her use this time:

… having too many of them was actually quite stressful. It was almost like a bit of an overload, but yeah, having fewer for me did work. But it's funny, 'cause my sister had her first just last month, and she was the same as I was in my first pregnancy, had sort of six or seven different pregnancy tracker apps, and was reading them all every week and they all say the same thing just kind of written in a different way, um, but yeah, I think- I suppose in hindsight I would maybe have had fewer apps with my first (Felicity).

She reflected that this had been stressful, and given that she had consumed similar information on each app with different wording, this had not added value for her. Other participants felt that the distilled information offered by pregnancy apps was a limitation. Rebecca used pregnancy apps but felt like the tidbitised information, what she described as a "nutshell" format for considerations like food safety could not distil down the broad range of evidence and opinions on risk and safety issues. She therefore used other sources and did more research:

I think the whole world of online pregnancy advice is very complicated, and when you Google something you get 12 answers anyway, and so unless the app is gonna talk you through why there are 12 answers in the world … you can never distil it down into these

little nutshells … it's so hard to reflect what is actually not a very united set of opinions on what it is you should and shouldn't do (Rebecca).

Researching for information online in this way is self-guided and more diffuse than the more limited information that is delivered to users of pregnancy apps in a more structured way. Some participants appreciated this structure and the limitations, but some, like Rebecca, suggested that the structure was being imposed on them and did not meet the full extent of their information needs. Furthermore, inherent once again in what Rebecca had discussed about pregnancy advice, and "what it is you should and shouldn't do", are the ideas of self-management and self-responsibility introduced earlier (Lupton and Thomas, 2015). Aside from the self-monitoring features, the feed of information on pregnancy apps often included advice that reinforced these narratives. For example, as previously mentioned Cara identified "eating well" as one of the topics that the feed of information on the app included. Some apps offered specific features for looking up the "safety" of foods in pregnancy, which some participants reported using to inform their choices on what to eat when out and about as this was easily accessible on their phone. While Eleanor reported making no use of the self-monitoring functions on the app, she did utilise the food safety feature:

…one thing I have used actually is for looking stuff up is what I can eat, and what I can't (Eleanor).

Figure 7. Food safety lookup feature
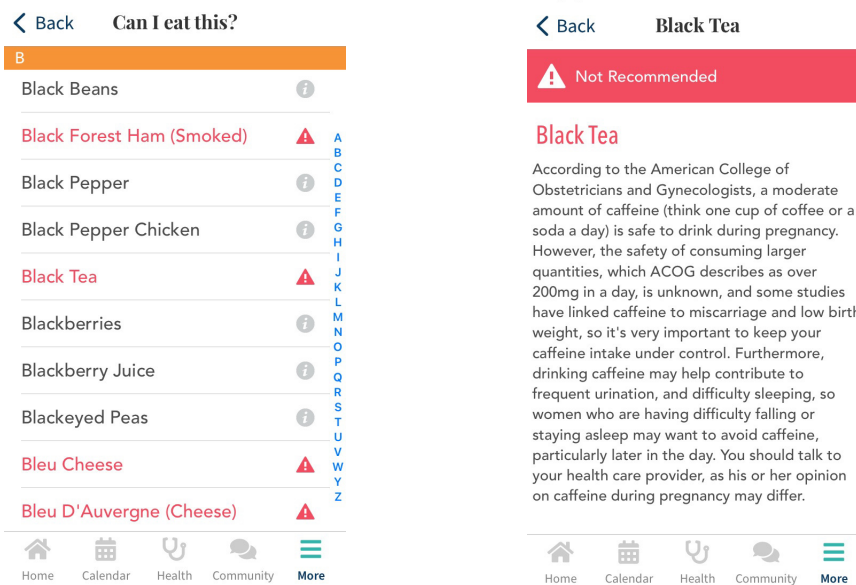
Source: Ovia. Screenshots taken August 2021

While this is not a self-monitoring feature involving user-generated data, this feature reinforces expectations of self-management and self-responsibility. The heading of the feature is "can I eat this?", setting parameters of what the user can and cannot do, which is reflected in Eleanor's statement of using the app to look up "what I can eat, and what I can't". Some participants suggested that this feature had directly reinforced their practices of avoiding potentially risky foods:

> There's another feature on Ovia that is a food safety finder, so you can look up foods and then it tells you whether they're safe or not to eat and I'm not sure whether it's a bit, a bit American at times, cause it's slightly different to some of the stuff I've read here, but that's helpful. Um, and yeah so it's kind of prompted me to think 'well is that food safe, can I eat that?' and 'should I- you know- do I need to check it out first?' in that respect (Alissa).

Having noticed this feature, Alissa felt prompted to further consider whether the food she was intending to eat was safe. A further point notable from the screenshot above, and Alissa's quote

is that there is American advice on an app available in the UK, with a reference made to the American College of Obstetricians and Gynaecologists. Several participants reported observing that international guidelines on pregnancy can differ, which sometimes added to their experience of dealing with conflicting advice and information overload.[25] Rebecca reflected on her experiences of seeking advice on food safety, giving the example of trying to establish the safety of salami. She was not able to find an answer that satisfied her on the pregnancy app, which she described above as offering "little nutshells" of advice, so sought more information online:

> …a lot of the American websites will just write 'no you can't eat salami', then the original
> NHS response I found was 'eat salami with caution', what does that, what does that mean?
> Like, eat it whilst thinking it might hurt my unborn child? But it's fine? Or is it not fine?
> (Rebecca).

While she did not track her diet, she clearly was engaged with self-responsibility to avoid "hurting [her] unborn child", and self-management of her diet in controlling what she chose to eat for the safety of the fetus. In terms of what this means for how participants used pregnancy apps, participants like Rebecca who found limitations to the information available on pregnancy apps would generally continue to use the apps for the purposes they found interesting or valuable, for example the weekly updates on fetal development, and would supplement them with other sources of information. But like Rebecca states, this often involved uncertainty in trying to establish what they should do or not do.[26] Many participants reported feeling a need for reassurance, particularly in early pregnancy, and pregnancy apps

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[25] In the case of this screenshot the guidelines on caffeine in the UK and US are the same at 200mg a day, but other variations were reported by participants (NHS, 2021a).

[26] There is not sufficient space in this chapter to consider all the ways that participants processed and engaged with risk and attempted to avoid potentially "unsafe" practices in pregnancy. For further research on how pregnant women negotiate risk in pregnancy see for example the work of Hammer and Burton-Jeangros (Hammer and Burton-Jeangros, 2013).

offered some semblance of this.

Temporal personalisation and reassurance

As discussed above, pregnancy apps generally provide users with a feed of "tidbitised" (Johnson, 2014) information, for example on pregnancy symptoms the user might be experiencing, that is time-specific. These can be considered one minimally personalised outcome of user data, as they are based on gestational age, informed by the initial data that users enter into the app to create their profile. Several participants reported that it was reassuring to know that the symptoms they were experiencing were common at a particular stage of pregnancy:

> …a lot of the information that it gives you, you know with things like typical symptoms in week 17 or whatever, that, that are quite reassuring, so you're just beginning to notice, you know indigestion or whatever, you know and it says 'ooh, this is quite common in week 17', so um, so that's been good (Eleanor).

Participants wanted to be reassured that what they were experiencing was normal, and furthermore that other people were going through it too. For example, on one app several participants reported using, there are weekly video diaries filmed by a pregnant woman detailing her pregnancy experience, that are delivered to users at each corresponding week of their pregnancy. Several participants who used this same pregnancy app mentioned this particular feature as something they enjoyed about the app:

> It's really nice actually, it's really personal. I mean she does just basically say what the sort of week's update is, but then it's nice because she gives you what her experience of the week is as well, and that's the bit I usually just scroll to 'cause I want to see what she's kind

of been going through, and see. And there- like this week in particular there have been some similarities and that has made me feel really reassured. I don't know why a stranger in a video has made me feel reassured but it, it really did (Phoebe).

This information was not specific to the user's pregnancy beyond being at the relevant point in pregnancy, but still had the effect of being reassuring. Phoebe found some similarities between her pregnancy and the woman who appeared in the videos, and that helped her feel that she was not alone in her experiences. Some participants felt there was a sense of shared experience they felt through these video updates:

They do a weekly video, with 'Gina' who is pregnant, and you know she tells you about her week and what happened, and how she's been feeling, and all that sort of thing, which is really really lovely, like I always look forward to watching Gina, on Thursday, um, so um, which is really silly!… I think it can be quite um, quite isolating, particularly in the first 12 weeks because obviously, a lot of mums-to-be choose not to tell people until they have their 12-week scan …so I think having, having a little, even if it's just an app, and then a lady on an app, you know, she's, she shared quite a lot with you so you feel like it's you know, you've at least got a friend in Gina! (Eleanor).

In this way the app offered a form of companionship and reassurance in what can otherwise be an isolating time. Once again, the way that users engage with the app suggests it takes on some human elements. Like Eleanor says, there may be some secrecy around pregnancy in the early stages, but a neutral, digital companion can be included and informed about the pregnancy without the user directly sharing this information with other people. Some participants mentioned being guarded about their pregnancy app use in order to avoid other people finding out about their pregnancy before they felt ready to share this information – for

example, one participant took out her phone during an interview to show me her pregnancy app, and showed how she had hidden the app in a folder so it would not be immediately visible to any friends or colleagues who looked at her phone over her shoulder. Therefore, finding some shared experience in the app was valued by several participants, particularly when they also offered reassurance that their experiences were normal. Other participants expressed a similar feeling about the time-specific updates on symptoms:

> …it's been kind of good in, in that, if it has happened, you think 'well that is normal, everything's going ok, other people have experienced it', so it's- because-, it's, it's a completely new process to me, it's a new experience it's, it's something completely different and you don't, and I think until you go through it you don't really understand it (Alissa).

When asked about how the advice had aligned with their experiences, several participants reported that there had been multiple occasions when it had been relevant to them:

> …up until now almost every week has been quite, quite accurate with what signs and symptoms it's had, it's told me. I don't know whether or not I'm just looking for them, it's probably all a bit psychosomatic, but hey, it's been pretty spot on really, up to now. Even with things like the nausea and it telling you when the nausea would ease up and at what point you would get more energy, even things like that have been pretty spot on really (Chloe).

As well as reassuring participants that their symptoms and experiences were normal, this suggests that the app could also influence the ways in which users experience pregnancy and understand their bodies. As in chapter 1, where some participants reported that fertility apps

made them more aware of their bodies, and influenced them to interpret particular bodily experiences as related to fertility, these temporal updates can increase users' attention to bodily signs, or like Chloe says, perhaps influence users into feeling they for example have more energy at a particular stage.

This was not always the case, and some participants also described times when they did not have experiences that aligned with the symptoms their app advised. But in general, participants were not troubled by this. They did not expect the advice to be highly personalised to them, for example noting that:

… obviously with pregnancy things do vary quite a bit (Beth).

An interesting illustration of how pregnancy varies was an example described by Grace, who had a stoma, so found that some of the app updates on symptoms she might experience did not apply to her:

… so things that I feel smug about, have been when my app told me that I'd start getting constipated, and I was like 'well I don't have working bowels so I'm not going to'. Uh so that was nice um and piles as well, just don't- don't have that functioning kind of thing any more, but apart from- yeah, apart from pregnancy things that affect the digestive system, everything else is just completely exactly the same. Like everything else has been completely applicable (Grace).

Pregnancy apps were just one of many information sources that participants utilised. In this instance, Grace sought more specific advice on pregnancy and birth with a stoma through online communities that fit this niche. She was not concerned, and in fact was slightly amused, by this

example of advice not fitting her, and did not expect that the app would be personalised to this extent. She found that most of the advice was still relevant to her, and the temporal personalisation of the app was sufficient for her needs.

Conclusion

Overall, participants were selective in the contexts in which they utilised apps for self-monitoring, and enthusiasm for tracking for some purposes does not necessitate this continued attitude in other areas. Some participants found aspects of self-monitoring using apps useful, but this practice was generally resisted during pregnancy by the majority of participants. More commonly participants used apps as a source of information to help them understand their pregnancies, and establish whether their symptoms were normal. Characteristics of pregnancy apps such as the close proximity participants had to their phones, temporal pregnancy updates, and features like relatable video updates were aspects that participants valued. In chapter 1, I reported that participants were goal-oriented in using fertility apps to try to conceive. Going into the pregnancy stage, there is a shift in what participants wanted from apps, and how and why they used them. Rather than seeking data-led insights into their pregnancies, participants sought advice and reassurance on the changes they were experiencing.

When considering these findings in relation to Lupton and Thomas' argument that pregnancy apps engender self-responsibility and self-management by encouraging datafied self-monitoring, I found that most participants resisted this "algorithmic authority" of a proposed need to self-monitor using an app. This somewhat tempers their claim, as while Lupton and Thomas' perspective appears accurate as an analysis of pregnancy apps, in practice for the majority of participants, this pattern of "monitoring their bodies and acting on the data that they generate" in this particular way was not compelling and was generally disregarded or resisted (Lupton and

Thomas, 2015, p. 2). But nonetheless, while most participants used apps selectively and did not use the self-monitoring app features, that is not to say that they resisted the notion of self-management in pregnancy overall. Most participants described practices and perspectives that demonstrated their conforming with these expectations, and the updates they consumed from pregnancy also encouraged self-responsibility and self-management. While resisting self-monitoring, participants found utility and value in using the apps in other ways. The reassurance and sense of shared experience that was engendered through app features like video updates was valued by several participants. Additionally, a key motivation for pregnancy app use was the ability to understand the progression of fetal development across pregnancy, which will be explored in depth in the next chapter.

Findings chapter 3 – "Showing you what's going on in the inside that you can't see": Understanding fetal development through counterpart pregnancies, and the involvement of partners

Introduction

In chapter 2, I found that rather than using pregnancy apps for recording data, most participants were motivated to use pregnancy apps in order to access information to help them understand their bodies during pregnancy. For all participants, a major facet of this motivation for use was monitoring the progression of fetal development. This was an app function used universally by participants, and remained so across pregnancy even when they had lost interest in other features. My use of the term "monitor" above to refer to how participants used apps to understand the progression of fetal development is something of a misnomer, given the lack of true monitoring that can be achieved with the capabilities of a pregnancy app – apps generally offer generic information on fetal development delivered temporally in line with the assumed progression of the user's pregnancy. In the course of this chapter, I introduce an emergent concept of the "counterpart pregnancy" enacted through pregnancy app use. I consider the counterpart pregnancy to be a virtual pregnancy that develops in parallel to, but that is separate from, the physical pregnancy of the user. After introducing this concept, I go on to consider the ways in which users engage with pregnancy apps for understanding fetal development, and how the concept of the counterpart pregnancy can help explain these dynamics.

First, I argue that pregnancy app use shapes how women make sense of their pregnant bodies, especially in the earlier weeks of pregnancy when many participants described their pregnancy as abstract. The counterpart pregnancy lent solidity to participants' understanding of their bodies as pregnant. An interesting aspect of this is that the development of the counterpart pregnancy gave participants reassurance, despite the lack of personalisation offered by most pregnancy apps

and the lack of real insight the apps could offer users into the development of their own

pregnancy. The level of reassurance this offered was less than would be offered by an ultrasound

scan, but the practice of checking the app helped participants feel reassured, and gave them

some indication that the fetus could be developing when they could only hope or imagine this to

be the case.

I then turn to consider the engagement of partners with pregnancy apps. I found a variety of

dynamics and patterns of pregnancy app use with and by partners. While some partners had little

interest in pregnancy app use, for some, downloading their own pregnancy app was a way to

access the pregnancy independently and have their own counterpart pregnancy to experience,

relate to, and take ownership of. This emphasises the position of a counterpart pregnancy as

something separate, that allows a form of access and connection to the physical pregnancy

through digital means. The separateness of the counterpart pregnancy from the physical

pregnancy of the user (or user's partner, or other interested party who may use the app) is also

demonstrated when there are discrepancies between the development of the two pregnancies.

Some participants described becoming aware of differences between the size of the counterpart

pregnancy as reported by the app and measurements taken during their antenatal care. Rather

than providing the reassurance that was described as a benefit of pregnancy app use by several

participants in early pregnancy, this then became something that caused some participants

anxiety when their pregnancy did not conform to the development of the counterpart pregnancy.

In the furthest extension of this deviation between the counterpart pregnancy and physical

pregnancy, the counterpart pregnancy continued to develop even when the physical pregnancy

did not. This was reported to add to the distress of experiencing a pregnancy loss, as the

counterpart pregnancy came to represent the physical pregnancy that "should" be progressing

but was not. Through these findings I address my overall questions of how and why women use

pregnancy apps, and in particular provide insight into the impact of pregnancy apps on how women understand and experience their bodies during pregnancy.

Counterpart pregnancies

To ensure your app is specific to your needs, please enter your due date… (Pregnancy +)

Upon downloading Pregnancy + and opening the app for the first time, a prompt appears that requires the user to enter their due date. The majority of pregnancy apps make the entry of the due date compulsory to access the app, as the apps release content in parallel with the progression of the user's pregnancy. Many apps request more data from the user at this initial stage, for example their name, age, the sex of the fetus(es) if known, and whether this is their first pregnancy.[27] Some apps encourage, or require, that users choose a nickname for the fetus. By entering this data the content of the app will be personalised to the user at a basic level, for example, the app will refer to the fetus by the user's chosen nickname, or as he/she.

The most substantive updates appear on a week by week basis, but several apps also provide new content daily. The fetal development updates take both written and visual form. A typical weekly written update on a pregnancy app might include the gestational age of the pregnancy; an approximate length and weight of the fetus; details of any particular features or senses the fetus may be supposedly developing that week e.g. fingernails or a sense of smell; and symptoms that the woman may be likely to experience that week. Sometimes these predictions of symptoms are linked to aspects of fetal development – for example, "Amelia's pancreas is producing her own

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[27] Many pregnancy apps can acknowledge more than one fetus in the case of a multiple pregnancy. For brevity, and due to the fact that all of the interview participants in this study experienced singleton pregnancies, I generally refer to "fetus" in the singular.

hormones, which may help take the pressure off of you" (Ovia).[28] The range of images and animations available on apps vary, but there are some overall trends. A common feature is an illustration of what a fetus may look like in that particular week. Some are interactive 3D avatars, that allow the user to use the touch screen of the smartphone to move the fetus around, view it from different angles, and see how the virtual fetus responds to their touch. Some apps feature ultrasound images, that can include both 2D and 3D scans. These demonstrate what a user may be able to see during an ultrasound using images taken of other fetuses at the same stage of gestation. A further category of image is comparative illustrations. The app will display an image of a similarly sized object to a fetus that week based on its length, with the comparative object most commonly taking the form of a fruit or vegetable. Some apps allow users to select from a variety of themes of object to compare to fetal size, including animals and bakery items. Several pregnancy apps also feature a hand and foot size tracker. The app shows the user an image that illustrates the approximate size of the fetus' hand or foot in that particular week, scaled to the size of the phone screen.[29]

These insights into fetal development, however, are based on averages, and the progression of a supposedly typical pregnancy. Although some pregnancy apps request more information than others, in general the range of data that users can enter to personalise their profile at the initial download stage is relatively limited.[30] Users are not able to enter further data on fetal development, for example personalised measurements of fetal size taken during ultrasound scans. Additionally, there may be factors that a user deems relevant to their pregnancy, such as pre-existing health conditions or previous childbirth experiences, that are not requested, and therefore the app content will not be personalised on the basis of these types of considerations.

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[28] "Amelia" is the baby nickname I entered into the Ovia app as part of a simulated user profile.
[29] This begins with a very small image at around 12 weeks, as this feature would not be visible prior to this point.
[30] There are usually other opportunities to enter data into pregnancy apps at a later stage, for example tracking weight, but here I refer to the initial registration stage.

The generic nature of the fetal development information is sometimes signposted by the app, with several apps overtly offering ranges or approximations of fetal size, as opposed to a specific measurement, but there are often direct references to fetal development that are not couched in these ambiguous terms, e.g. "hair is starting to sprout on your baby's head" (Sprout).

In providing weekly updates that progress in parallel to the user's pregnancy, based upon the application of collective information to the personal level of the user, these apps enact what I term a counterpart pregnancy. I use counterpart pregnancy to refer to a virtual pregnancy that corresponds to, but is distinct from, the user's pregnancy.[31] The use of the term "counterpart" highlights the interlinked nature of the user's physical pregnancy and the virtual pregnancy, because while the counterpart is something separate, it is inherently linked back to the user's pregnancy. While here I refer to the "user's" pregnancy, as I will demonstrate in this chapter, a counterpart pregnancy can also be established independently of the pregnant woman, for example by partners using pregnancy apps. Other studies of pregnancy apps have demonstrated that other interested parties, such as a prospective grandparent, may also download a pregnancy app independently (Hamper and Nash, 2021) but this was not reported by participants in this study.

There are alternative concepts from existing theory that have informed my thinking in developing this analysis, but that are less appropriate as explanatory tools. For example, Ruckenstein applied the concept of a data double that emerged in the discipline of surveillance studies – notably in the work of Haggerty and Ericson – to self-monitoring (Haggerty and Ericson, 2000; Ruckenstein, 2014). Through the generation of self-monitoring data, the body is broken into data flows and aggregated into personal data doubles, which are "decorporealized

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[31] A notable use of the term "counterpart" can be found in the field of metaphysics, with Lewis' counterpart theory developed in the 1960s to define the ways in which individuals correspond to potential counterparts existing in multiple possible worlds (Lewis, 1968). My use of the term counterpart is not related to this theory.

and decontextualized bodies" that users then engage with in a variety of ways (Ruckenstein, 2014, p. 72). The data double constituting a separate assemblage informs how I think of the counterpart pregnancy as an entity enacted by app use. There are also some parallels with how users engage with data doubles and how users engage with pregnancy apps as I go on to describe in this chapter, for example making bodily experiences visible and therefore influencing how users make sense of their bodies. However, the concept of what could be referred to as a fetal data double is not fully applicable here, as there is a distinct lack of personal data used as a foundation for a data double: instead information from a supposed "typical" pregnancy is mapped onto the pregnancy of the user, delivered temporally on the basis of the simple data point of a due date, and personalised only in references to sex and name. I therefore consider a counterpart pregnancy necessary as an emerging concept.

Visualising pregnancy

A common finding reported by the majority of participants was that the fetal development updates on pregnancy apps made their pregnancy feel more tangible. Several participants described their pregnancy as feeling "abstract", particularly in the early stages:

> … it was interesting, and it makes it easier to imagine that there's an actual baby in there. Especially before you start really showing, or before you really start feeling anything, it's really abstract, 'cause you don't look different. You feel different, but you don't really look different. I mean, you could just have a bug and feel different, you know, so it's quite, yeah. It's quite reassuring to kind of see, oh there is like a head and you know there's a heart in there, yeah, I quite liked that yeah (Felicity).

As Felicity describes, in the absence of many physical indicators of being pregnant, i.e. visibly appearing pregnant, or feeling fetal movement, pregnancy can be intangible. The temporal updates on fetal development from a pregnancy app informed the ways in which she understood the growing fetus within her body, "in there". The description on the app that informed her that a head and heart were developing influenced her embodied experience of pregnancy, by enacting the physical sensations she felt as symptoms of pregnancy, rather than of illness. This echoes Georges' ethnography of ultrasonography in which she found that particularly in the early stages of pregnancy, women considered ultrasound images to be evidence of their pregnancies, and this in turn made them feel more pregnant, increasing their own physical awareness of being pregnant (Georges, 1996).

Beth made a similar point on experiencing her pregnancy as abstract, and like Felicity who described the fetal development updates as interesting, expressed that it was fun to see these updates:

> I guess it just was really fun to see, and I guess it helps you to visualise. Because, although obviously you're getting bigger and you see your bump, you don't know how much of that is fluid, or- I don't know, I guess it helped to, it probably helped it to feel a bit more real. It just feels, for me anyway, it does feel a bit abstract in a lot of ways (Beth).

Beth explained that even when she was able to observe physical signs of being pregnant in her body, i.e. her growing abdomen, it was difficult to contextualise what that physical space contained. Within the space was fluid, as well as the growing fetus. She found the development updates of the app's counterpart pregnancy enabled her to better visualise what those physical changes represented in terms of fetal growth within her own body.

The terms participants used here to describe this process are "imagine" and "visualise", emphasising the visual aspect of these technologies and how they serve to help enact this visualised sense of the pregnancy for users. Alissa noted that the animations of fetal development and illustrative examples of ultrasound scans at the relevant points in time on the pregnancy app she used allowed her to "see" what was happening inside:

> … it's quite good because it shows you what like the scan would look like of the baby each week, so that was quite different, 'cause you could see- it gave you one each week so you could see how the development was happening kind of in real life there. Um, and it also gave you kind of an animation of what baby looked like, so going from looking roughly like a baby to kind of more, so that was good, I liked that feature. Um, more for the visual side of things than the information … (Alissa).

While participants were all clearly aware that these animations or ultrasound images were examples and not specific to them, several participants described the experience of viewing these images as giving insight into their own pregnancies. Participants often reported relating to the counterpart pregnancy on the app in a way that helped them make sense of their own experience. See for example Felicity's phrasing above: "It's quite reassuring to kind of see, oh there is like a head and you know there's a heart in there". In this way, the depersonalised fleshes out the user's personal experience of pregnancy, and the counterpart pregnancy offers a template that the user's pregnancy is mapped against. There is undoubtedly a distinction between viewing a generic image and a personal ultrasound, a difference which some participants confirmed when I asked. Expectant parents often approach an ultrasound scan seeking reassurance while facing anxiety (Thomas, Roberts and Griffiths, 2017), which is a multifaceted experience that is likely not fully encompassed in the use of pregnancy apps due the limits of what viewing a generic image can offer compared to an ultrasound scan. But nonetheless, participants reported feeling

their pregnancy was made more "real" by viewing only temporally specific images, rather than ultrasound images that represent the actual pregnancy in question. While this is not a finding I have found widely reported, Han described a similar phenomenon in her study of pregnancy in the US in women's experiences of viewing illustrations of fetal development in pregnancy books (Han, 2013, p. 38). This aligns with my finding that particularly in the early stages of pregnancy, pregnancy apps can help validate a user's status as pregnant, and influence their sense of the fetus.

Ultrasound scans were also significant for participants in establishing an understand of themselves as pregnant. All of the participants had chosen to attend ultrasound scans, which were relatively infrequent across the course of pregnancy.[32] The apps served as a means of visualising pregnancy at a personal level that supplemented ultrasound scans, and also offered a different perspective on the images seen through scans. This was the case not only for the images and animations that illustrated a possible fetus in a more realistic manner, but the comparative objects shown to illustrate size, for example a vegetable. Both forms of imaging and reported size could have an impact on participants' understanding of fetal development. Chloe explained how these updates helped her to contextualise the images she saw during ultrasound scans:

> …it became difficult to sort of um- not difficult, it was weird sort of visualising that, when
> we were looking at the scan. 'Cause on the scan they look, they look so big. Like unless
> you're very early and you can just see a little speckle, as you go along they get bigger and
> bigger on the scan, and you're like 'oh god that's massive in there!' and then you think of

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[32] Standard NHS antenatal care offers women an ultrasound scan at around 12 weeks and again at 20 weeks (NICE, 2021). Additional scans may be offered in the case of additional monitoring being considered necessary, or in a smaller number of NHS trusts that offer a further routine scan e.g. a growth scan at around 36 weeks. Women can also pay to access additional scans privately, often marketed as reassurance scans or gender scans.

like, it just being the size of maybe like a cinnamon bun and you're like 'oh, that's not that big', it's weird more than anything (Chloe).

Even an ultrasound scan that offered imaging of her own pregnancy was not easy to interpret and scale relative to the size of the ultrasound screen. She described this experience as "weird", highlighting the experience that was common among participants of finding pregnancy and fetal development abstract and hard to make sense of.

Textual fetal development updates

In addition to these visual aids, the textual updates also served a similar purpose to participants in supporting their conceptualisation of fetal development. Julie explained these fetal development update features:

> …they do like the picture every week, of like a really nice 3D like image of the baby and then they've got little extra information that you can click on and like say that 'your fetus is developing eyelids' and things like that, and it's just kind of like three little facts of the week, and it's just quite nice that you have a bit more of an understanding of what, what's growing (Julie).

Together these images and updates on development helped her to understand "what's growing", giving her a greater sense of the fetus. Cara made a similar point:

> It's just nice to see kind of what something says about the size of the baby or what the baby might be doing, or what I'd be doing, you know (Cara).

Cara's description of "what the baby might be doing" suggests her view of the fetus, or in her words, baby, having an unseen experience of "doing" something, in this case, growing and developing. The "might" represents an unknown possibility that the app counterpart pregnancy aids her in imagining what this experience might be. This type of narrative, of imagining a parallel existence of a potential baby, was significant for all participants, for whom the fetus was their current and future child. In this chapter I have used the term fetus, and this was sometimes a term used by participants without my prompting, but equally many participants referred to the unborn as their "baby". When participants spoke of their babies, as part of this dynamic, there was an imagined aspect of their unborn child as a future person. For example, Eleanor spoke about how learning the sex of her baby had helped her visualise the future of her baby, and what expectations she and her partner had on their role as parents in facilitating a particular quality of life for her:

> I think now we- because we found out we're having a girl, so I think, um, that really helped us to sort of begin to focus onto the kind of things that we hope to be able to provide for her, or you know the kind of person we hope she'll be. So um, we just want to meet her now, and, and find out, you know, what colour hair she's got, what colour eyes…" (Eleanor).

Fetal development updates ground these types of imaginings in physical aspects of early development, ascribing human characteristics such as hearing. These enact the fetus as a future person, which confirms the findings of several existing studies that pregnancy apps emphasise fetal personhood, and in doing so may increase the impetus for women to engage in practices of self-surveillance to protect and nurture the fetus (chapter 2, and for example Lupton and Thomas, 2015; Ley, 2016). The use of apps for accessing information on fetal development as described above is significant as a finding on the ways in which women experience pregnancy.

But further to this, there may be some more practical implications in influencing users' health practices. For example, Rebecca described how the development updates encouraged her to feel a sense of responsibility to engage in healthy behaviours during pregnancy:

…having the vegetable was like, 'ok, like that makes sense', because probably I wouldn't feel a Brussels sprout, um or like a raspberry, so- but it makes it feel like there is something there, whereas actually in the very early stages, you- like there's no feeling at all that you're pregnant. So it's quite hard to envisage the growth, and like the development. You can kind of just ignore it. Um but knowing it's growing with the vegetable, makes you be like 'ok well I should take my vitamins, I should not drink alcohol' like all those things (Rebecca).

While this data is not evidence that without the app's fetal development updates of comparatively sized fruits Rebecca would have otherwise ignored her pregnancy and not made any changes to the behaviours she considered to be potentially harmful, for example drinking alcohol, she reported that it influenced her thoughts in this way, and intensified her self-identified status as being pregnant. Later in this interview she explained that some of the specific updates would influence her behaviours at particular points in time, for example taking supplements that would support fetal development[33]:

So like occasionally it will say things like, like especially in the early days it would say things like 'oh this is the week when the brain gets developed' and then I would like remember to take my folic acid that week or whatever, which I have not been good at (Rebecca).

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[33] Taking a folic acid supplement is recommended to pregnant women to help prevent neural tube defects in the developing fetus, hence Rebecca relating this to brain development (Al-Gailani, 2014).

For some participants, the fetal development updates helped to validate their experience of pregnancy-related symptoms. This was expressed by Grace, who made similar points to Rebecca in terms of the development updates reminding her of being pregnant, giving the example of back pain being validated by the reported size of the fetus on the app:

…I do like knowing the weight of the baby, like that makes it feel more real. Um, I guess it's like- yeah it like reminds you that you're pregnant as well in a way, and like just- not justifies it, but you're like 'ok, so like this week the baby's like 600 grams, oh well actually you know that's, you know that's like a big bag of sugar, like no wonder my back's aching if I'm like you know lugging around this big massive baby' [laughs], sort of so you know, so I guess it kind of validates the experience um yeah in terms of kind of like, showing you what's going on in the inside that you can't see (Grace).

Conceptualising the unfamiliar size of the fetus in comparison with a familiar bag of sugar validated the pain that someone might expect to feel when carrying extra weight for an extended period of time. Grace reported the written estimated weight as the factor that initiated this reaction, but she then envisaged this through the comparative weight as a bag of sugar, something she could see and lift to experience the sensation of holding its weight as a frame of reference. This emphasises the desire for a comparison that is met through the use of similarly sized objects on pregnancy apps, as length and weight measurements can be visualised more easily in this form. Reading this estimated weight on a pregnancy app, and furthermore the suggestion of a similarly sized object, can allow the user to gain a more tangible sense of the stage of development of their fetus in relation to the counterpart pregnancy, making the unknown more easily knowable, or at least, imaginable, and "reminds you that you're pregnant".

In Grace's words, the app fetal development updates are "…showing you what's going on in the inside that you can't see". This echoes the findings earlier in this chapter of participants suggesting that pregnancy apps would provide insights into their own pregnancies, despite being based on averages of a supposedly typical pregnancy. This emphasises the connection between the counterpart pregnancy and the user's physical pregnancy. These insights were reported to be reassuring by many participants. It was common for participants to reduce the frequency with which they engaged with pregnancy apps across the course of pregnancy. In interviews that were conducted earlier in pregnancy, the usage of apps was more habitual and regular, often daily or several times a week. In later interviews, the same participants generally reported using the apps less. The weekly fetal development updates were by far the most used feature of pregnancy apps among participants, and participants generally sustained this usage throughout pregnancy, even after their use of other features may have tapered off. Some participants linked their usage habits later in pregnancy to a greater feeling of confidence in the viability of the pregnancy as time progressed[34]:

> I think maybe, probably as I've become less anxious in the pregnancy, maybe as the weeks have gone by, as things have become more and more viable … I've felt less of a need for uh reassurance, basically I guess is what it comes down to. Perhaps that's why I look at the, the apps less… (Beth).

While the fetal development updates on apps do not offer any real insight into fetal wellbeing, for participants like Beth, there may be some reassurance that emanates from the practice of checking the fetal development updates. While Beth was uncertain in her characterisation of her app use as an act of reassurance, she felt she could relate her usage to her changing emotions at

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[34] At a population level, the likelihood of a miscarriage decreases over the course of pregnancy. From the threshold of viability at around 24 weeks, the survival rates for premature births increase over time (Royal College of Obstetricians and Gynaecologists, 2014).

different stages of pregnancy. Experiencing anxiety, particularly early in pregnancy, was commonly reported among participants. One aspect of using pregnancy apps was as a means of allaying some of this anxiety through the enjoyable, entertaining qualities of the apps. Participants often described app features using phrases such as "really fun", "just nice to see", or "makes you smile". For example, Chloe expressed that the fetal development updates comparing the fetus to animals helped her to deal with anxiety, which had been a struggle for much of her pregnancy and led to her midwife referring her for counselling. Reflecting back on her pregnancy in an interview after the birth of her daughter, she recalled:

…every Friday morning we'd wake up and I'd be like 'what size is the baby now?! What is it the size of?!' and for the next week she would basically become known as that thing. Which was funny, more than anything, it was- it, more than anything it added sort of a lightness to things. Obviously I was quite anxious anyway, um, so it sort of gave a bit of light relief to it all really. Like 'oh she is growing, because now she's the size of an otter' [laughs]. I mean, yeah, it was good. And it, having that sort of visual aid as it were, definitely helped um, relax me, as well as providing humour more than anything (Chloe).

This illustrates some of the emotional experiences that are a part of consuming fetal development updates on apps during pregnancy. As in chapters 1 and 2, the emotional engagements users have with fertility and pregnancy apps is an important factor to consider to understand their significance. Furthermore, in this example Chloe's language gives some indication of the role the app could play in terms of offering her reassurance about her pregnancy. She reported observing "she is growing" when seeing the size increases on her app in the counterpart pregnancy, and finding this reassuring, noting that somehow the app could relax her about that continued growth even though it had no way of knowing the fetus was actually growing. This lack of real insight into fetal development could become

problematic for participants whose pregnancies did not conform to the typical updates reported by apps, which I will explore later in this chapter. Chloe refers to "we", highlighting that her app use was not in isolation, but something that she engaged with alongside her partner.

Partner involvement with app use

Many participants reported checking the fetal development updates on pregnancy apps on a regular basis. For some this occurred daily, or even several times a day. For others, their usage was mainly structured around the day of the week when their pregnancy increased a week in gestational age:

> I definitely do it on the Wednesday, 'cause that's when I change weeks, so I tend to sort of flick through all of them and try to find relevant stuff, and then I'll come back to it if I've got something in my mind. Um I'll probably look twice a week (Julie).

Like Julie's habit of looking on Wednesdays, checking the app's (or multiple apps') fetal development update became a weekly routine across pregnancy for the majority of participants. The use of the app becomes a companion to the pregnancy, as Julie described it as part of the countdown to birth:

> …it does the week by week so it's part of your countdown with you… (Julie).

Through these habits, often centred on the weekly fetal development update, the use of apps became integrated as a digitally practiced part of the experience of pregnancy for participants. Partner involvement with this aspect of app use varied, with participants describing different

levels of interest and ways of engaging with pregnancy apps among their partners. Many participants shared that they formed a weekly ritual of checking the updates on the pregnancy apps together with their partner:

> Yes, I love all the little sort of development stages, um, so my husband and I every – our sort of changeover day for the weeks is a Friday, so usually on a Saturday or a Sunday morning we have a little read through everything, um, to see what's, what's been happening in the past week and is due to happen in the following week, we find that really interesting (Phoebe).

The format explained by Phoebe of this being a shared weekly ritual centred around the update on the app was common, and in this way represented a regular practice between participants and their partners and a way to engage with the pregnancy together. Hamper and Nash describe a similar phenomenon, and note that pregnancy apps can represent a form of "bonding work" prenatally (Hamper and Nash, 2021). There were also other dynamics of partners' use of pregnancy apps reported by participants in my study (as well as in the study cited above). The bulk of pregnancy app use reported by participants was by the pregnant women themselves. It was most common for the woman to download the app or apps on her own device, and to invite partner involvement by sharing the development updates with her partner:

> Yeah, so the Ovia um, I know I said earlier, every morning I check it, 'cause um it's kind of a thing now that we do in the morning, that I give my husband the update of like what's happened today (Maya).

As Maya describes it, checking the pregnancy app update was something she and her partner did together, but she was the instigator of this sharing, and effectively owned this information that

she then passed on to her partner as it was held on her device, which was in some ways an extension of her ownership of the pregnancy. Other participants expressed that their partners enjoyed receiving screenshots of the updates or looking at them together. For example, Eleanor reported sharing the app updates of the growing hand and foot size with her partner:

… it gives you a really cute, visual indicator of how big the baby's getting, so every week I've tended to sort of send him that, um, but it's, I think it's really- [he] has really wanted to be involved, but I keep saying to him 'Well what you do want to be involved in? 'Cause there's kind of nothing going on outside here' [Eleanor laughs and uses a hand gesture to indicate towards her uterus] (Eleanor).

Eleanor linked her sharing of the fetal development updates from the app with her partner's desire to be involved with the pregnancy, but noted that there are limits to how much he could in fact participate. Using apps as a means for partners to engage with or be involved with pregnancy was also reported by other participants:

It's been good in terms of that, purely from a communication with my husband point of view as well. Because obviously he's not experiencing it, um so each week as we progress, he'll sort of say like 'Oh so how big's the baby now?', and we'll check in on the app how big it is, and he says 'What can it do now? What's it experiencing now?', and I'll read him what the app tells me you know, and give an idea (Chloe).

Chloe's partner asked her about the progression of the pregnancy, and she referred to the app as a source of knowledge to then answer him. It is notable that in this example she gave, the app was her reference point for sharing information about the development of her pregnancy, rather than reporting back based on her own embodied knowing. The counterpart pregnancy therefore

served as a way for her to understand and describe her own pregnancy, by giving insights into different aspects of fetal development than those she would be able to explain from her own bodily experience.

The model of partner involvement described above is led by the pregnant woman, but a stage further removed from this is partners accessing fetal development information on a pregnancy app independently from their partner showing or sending them the information, but not on their own device. For example Hanna stated that her partner would see the pregnancy app notifications appear on her iPad in the mornings and he would read the updates himself:

> … he likes to read in the mornings and check you know emails and social media and whatever, so in that I guess he's ended up checking the Baby Buddy app as well. And then I guess sometimes he'll tell me, he'll be like 'oh I learned about this' or 'did you know that baby's like this now?' (Hanna).

In this example, the partner took on the role of sharing knowledge, providing Hanna with updates on her pregnancy that she may not have read herself. Other participants also described that their partners had used pregnancy apps in a self-directed way, with some citing a desire for involvement as a reason why their partners had chosen to download pregnancy apps themselves. In very similar terms that Chloe used above, Grace described how her partner was not actually experiencing the pregnancy himself:

> I think he's quite jealous that I get to like feel it kicking and like all of this, and he only has like my word- not like my word for it, but like he's not actually experiencing it, he's just like experiencing it by proxy … I think he didn't want to like find out stuff from me, like I think he wants to find out on his own as well, like, the same way that like at the same time

that I'm finding out rather than hearing like everything through me, kind of thing (Grace).

Here, the app was an entry point for the partner to establish their own counterpart pregnancy to aid them in visualising the pregnancy in a similar way to the pregnant woman, as explored earlier in this chapter.[35] An important aspect of this situation is that Grace reported that her partner wanted to be involved in this way. She described him as proactive in wanting to access information about the pregnancy in order to inform his own experience – while Grace was able to have an embodied experience of pregnancy and have access to their unborn child, he was unable to do the same without her sharing her knowledge, which even then was not an embodied experience for him, it was what she described as experiencing "by proxy". Grace's partner downloaded a pregnancy app in order to have some more autonomy over his consumption of information, not wanting access to information on fetal development to be the exclusive domain of Grace. He thereby enacted his own counterpart pregnancy using an app, to access a version of the pregnancy independently that bypassed Grace. This solidifies the idea of the counterpart pregnancy as something distinct from the physical pregnancy, as it allows users other than the pregnant woman access to the pregnancy independently, and they can form their own engagements with the counterpart. There are some parallels here with the capabilities of ultrasound technology, which Sandelowski argues empowers expectant fathers[36] and adds to their otherwise disembodied experience of their partner's pregnancy by giving them access to a "machine-generated relation of embodiment" to the fetus (Sandelowski, 1994, p. 241). As I argued earlier, personalised ultrasound images and generic fetal development images are not directly comparable, but similar dynamics are present in Grace's partner accessing an independent form of the fetus to establish his own relationship to the fetus.

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[35] All of the participants in this study were in relationships with the father at the time of interview. Not all pregnancy app users will relate to this heteronormative family structure, and this finding is far from universally applicable.
[36] Sandelowski's study focused on heterosexual couples and refers specifically to expectant fathers (Sandelowski, 1994).

Other participants also reported that their partners had downloaded pregnancy apps, either apps targeted specifically at expectant fathers, or pregnancy apps generally marketed towards women. Participants whose partners had used apps marketed towards expectant fathers reported that they reinforced gender stereotypes in ways that they found problematic:

…he wanted basically my version, like which is slightly more scientific, for fathers, and that doesn't seem to exist. You get these weird comedy dad apps that are super weird (Rebecca).

…actually another thing on it was like 'oh don't worry if your wife shouts at you because like you know that's hormones for you' or something, and it was a bit like, oh that's you know taking the agency away a little bit. But yeah, it could be good having something like that but just slightly less patronising, yeah (Grace).

This aligns with Thomas et al.'s study of expectant fatherhood apps, in which they found that pregnancy apps aimed at expectant fathers are often condescending and trivialise the role of fathers (Thomas, Lupton and Pedersen, 2018). While some participants expressed that their partners were not interested in using pregnancy apps, for those that did wish to be involved in this way the existing apps on the market did not feel suitable for their needs and were patronising, rather than offering the level of "more scientific" information that Rebecca suggests the apps targeted towards women tend to include. The participants who shared that their partners had downloaded such apps were critical of them and conscious specifically of the gendered dynamics of their content, affirming the finding also reported in chapters 1 and 2 that fertility and pregnancy app users often engage with them critically and use them selectively.

While the partners described above were either engaged by participants in their use of pregnancy apps, or proactive in using apps independently, some participants did not involve their partners with the apps they used:

> …he's always come to the scans and everything. So I think I felt the baby kick for the first time this morning, I think, so I text him and he replied saying 'brilliant'. So he's interested in stuff like that but, 'the baby's the size of a pomegranate', he probably isn't, yeah. I've never asked him basically (Felicity).

In this case, Felicity described other aspects of her pregnancy in which her partner was involved, which she portrayed as more significant. Attending ultrasound scans with her and engaging with her experiences of pregnancy, such as fetal movement, were things she positioned as important, but she suggested that the app's updates on fetal size were something more trivial that he would likely not be interested in and she had not asked him to participate in. Other participants also reported that their partners were not engaged with their use of pregnancy apps, and some partners were more proactive than others in rejecting pregnancy app use. One participant shared that her partner had expressed some concern about her use of apps:

> … he was getting quite worried about how much I was on the apps, he was sort of saying 'are you checking the app again?', and I'm like 'yeah', particularly in the early stages. Um, but no he doesn't sort of seem that interested in the apps… (Cara).

Cara had reported using pregnancy apps multiple times a day in the earlier stages of her pregnancy, and her partner's suggestion that she may be using the apps too frequently demonstrates that even while some individuals may technically use pregnancy apps without

partner involvement, their use of apps is not in isolation. Overall, the use of pregnancy apps was predominantly practiced and initiated by women, and while partner involvement varied, the weekly fetal development updates represented the most common entry point for partners in the use of pregnancy apps.

Deviations in fetal development

There are some instances in which fetal development updates, as well as the associated maternal symptom updates, can cause or increase anxiety for users. As mentioned, the weekly measurements of fetal weight and length reported by apps are based on averages that might be expected in a particular week of pregnancy, and do not correspond to any data entered by the user other than the due date. Users may become more conscious of the generic nature of these development updates when measurements taken during antenatal care report different sizes.[37] During interviews, participants often made reference to the fetal development updates showing 'what size the baby is'. This was not taken uncritically as the actual size of the fetus, and for several participants, their language expressed their awareness that the average updates may not correlate directly with their own pregnancy, with mentions of the updates reporting the size the fetus 'might be':

I do still look every week because I do really like that, like seeing how long the baby is, how much it weighs, and what it's doing, things like, you know, odd-, theoretically like what the average baby is doing at this point (Beth).

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[37] It is important to note that any measurements taken during antenatal care are also approximate. Different measurements of fetal development exist, for example symphis-fundal height measurements taken to establish based on external measuring of the distance between the top of the pubic bone and the top of the uterus, or measurements taken based on ultrasound scanning, where the reported weights given are also an estimation (Milner and Arezina, 2018).

More problematic for participants were references to these updates showing what the size of the fetus "should be". This was the case for Cara, for example, who had been referred for growth scans due to her having developed gestational diabetes.[38] In an interview late in her pregnancy, she mentioned that the fetus measured smaller in her most recent growth scan than was being reported on the app she used that week. She found this discrepancy worrying:

> … on the Ovia app I think he was a melon [laughs] let's see, but of course he's not 'cause he's small, so, I suppose that's actually- to be fair that is the downside, 'cause you see what they should be, but it's an average, so then you think 'ooh, mine's not', it's worrying. He's a honeydew melon this week. Um, so on this app they're saying he should be six pounds something, um, over, even he should be over six pounds, well mine's not, so they're estimating that he's around five pounds two, but they get that wrong as well, I think, I mean often they overestimate or underestimate so, but it, so that sort of thing is a downside to the apps because you, you compare and you think 'oh', and it can worry you, but overall I'd rather still go on them (Cara).

This lack of correlation between the counterpart pregnancy and her own intensified an anxious time, as the gestational diabetes meant that Cara would likely be induced early, and she had concerns about panicking (in her terms) and requesting an induction too soon. Despite the app adding to some of this anxiety, she reflected that "…it can worry you, but overall I'd rather still go on them". For her, the benefits of using pregnancy apps outweighed these worries. She noted that even the estimations given by health care professionals were still potentially inaccurate, highlighting the general uncertainty of attempting to assess fetal size, and through this, fetal wellbeing. In providing ranges of typical development pregnancy apps establish the bounds of

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[38] Gestational diabetes can increase the chances of a fetus growing larger than average, and has been linked to an increased risk of particular birth complications. Clinical guidelines in the UK therefore advise that women are offered additional ultrasound scans to monitor fetal growth and amniotic fluid volume (NICE, 2015).

normalcy of fetal development, a normal pregnancy, and a normal baby. These do not account for variations in fetal development, for example related to ethnicity. A participant in Hamper and Nash's study of pregnancy apps reported that the fetal size estimates "…were inaccurate for her because women of a Southeast Asian 'cultural background' tend to have smaller babies than the 'Anglo population'", which highlights the lack of sensitivity of measures in providing unnuanced averages (Hamper and Nash, 2021, p. 589).

Like Cara above, other participants in the present study also reported discrepancies between fetal size as measured in an ultrasound scan and the counterpart pregnancy on the app. Maya was referred for a growth scan as during a routine antenatal appointment her abdomen had measured 3cm smaller than the lower end of the expected range. The scan demonstrated that fetal growth was as expected, but Maya became more aware of the lack of precision of the development updates on the app she used. She noted that this inconsistency between measurements may have added to her concern:

> …I guess the disconnect between then the app and what's happening in reality, yeah, it didn't probably help. And obviously I wasn't concerned before I went to the midwife and then I was, yeah, a little bit concerned, but then I went for the scan and then they told me that we're at 95th percentile so the baby is fine … you don't put your measurements into the app, so yeah there's weekly updates with the random animals, it just- it's quite useless to be honest. I mean it's kind of fun, but you're not actually inputting your own data (Maya).

She continued to find the size comparisons with animals to be "fun", and she reported that they had been more helpful earlier in her pregnancy when she had no real sense of the size of the fetus, but it was not a useful piece of data for her. Maya used the app in late pregnancy primarily

for tracking her weight gain, and her preference for entering data she had measured is consistent with her desire for an app to provide accurate, personalised information based on measured data.

An extension of this inconsistency between fetal development updates reported on an app and actual measurements taken occurs in the case of pregnancy loss. Several participants reported experiencing a miscarriage prior to the pregnancy during which they participated in interviews. Phoebe described the distress caused to her by fetal development continuing to progress on the pregnancy app she used after her pregnancy had ended in miscarriage:

> It's actually really difficult to…uh, stop them. So when we'd had a miscarriage, um, it was incredibly difficult to go in to the app and then, you, because even if you delete it you still get email notifications. So you have to go in and basically explain to the app, which I found, quite an- it was quite a difficult thing to do. Um, at the time obviously you're hormonally all over the place, it's been quite an emotionally charged time, but that was just almost like a little extra kick in the ribs that I think that women probably don't need to feel at a difficult time …Especially when it's saying all the like 'today your baby's 17 weeks 3 days', which is amazing, but when you go in and you're like 'oh well it should be, it should be 9 weeks and 4 days and it's not', and then obviously that then brings a whole host of emotions to the forefront that you've already tried to deal with (Phoebe).

This demonstrates the way in which pregnancy apps becomes integrated into the experience of pregnancy. Earlier in this chapter the app fetal development updates were described as "part of your countdown with you", and the weekly rituals of usage became a digitally practiced aspect of being pregnant. In the case of miscarriage, the process of reporting a miscarriage to the app and ending the development of the digital fetus becomes a part of this practice, a presence which the user must "explain to", similar to how in the previous two chapters the apps demonstrated some

human characteristics in terms of how participants interacted with them. As Phoebe states of the counterpart pregnancy continuing to develop in the absence of the physical fetus, "it should be 9 weeks and 4 days and it's not". This emphasises the counterpart pregnancy enacted as a distinct entity. The occurrence of miscarriage highlights this divide, as well as the ways in which the pregnancy that has now ended may continue in this abstract sense, as was the case with Phoebe dealing with the emotions of imagining that the pregnancy should have been continuing. The virtual, counterpart fetus alongside this imagined fetus existed in different ways even when the physical fetus did not. In chapter 1 I discussed Mol's concept of the body multiple, and how individuals negotiate discrepancies between different versions of an object, for example different versions of ovulation (chapter 1). Here, there is little negotiation to be had, as rather than truly being a version of the pregnancy, the virtual pregnancy is a separate counterpart. While its origin is related to the physical pregnancy in its due date, and users find meaning in their interactions with the counterpart pregnancy that relate to their own (or their partner's) pregnancy, the correlation is limited, and the app does not give real insight into the progression of the user's pregnancy.

The finding that pregnancy apps have a limited capacity for accounting for pregnancy loss, and the continuing development of the counterpart pregnancy has been noted in other studies of pregnancy apps. For example, both Ley (2016) and Barassi (2017) analysed user reviews of pregnancy apps, and found users reporting that they had difficulty in stopping fetal development updates after a pregnancy loss. Andalibi conducted a systematic feature analysis to explore how pregnancy apps deal with pregnancy loss, and found that 72% of apps do not account for loss, which she terms "symbolic annihilation through design" (Andalibi, 2021). An estimated 1 in 4 pregnancies result in miscarriage (Tommy's, 2021), and experiences of miscarriage reported by participants in this study were relatively common, with 4 of 13 participants sharing that they had

experienced a miscarriage prior to their pregnancy at the time of interview. This is therefore a significant omission in design, and one that adds to the emotional distress of pregnancy loss.

Conclusion

In this chapter I have addressed my overall questions of how and why women use pregnancy apps, and how they impact how women understand and experience their bodies during pregnancy. Through the emergent concept I proposed of the counterpart pregnancy, I explored the dynamics of how engaging with this virtual version of the fetus informed how participants understood their bodies during pregnancy and made sense of the development of the fetus within their bodies. While all participants took part in ultrasound scans during their pregnancies, some noted that these scan images were difficult to conceptualise, and that comparatively sized objects as reported on pregnancy apps could help them to appreciate the scale of the developing fetus. Several participants portrayed the pregnancy app, and what I describe as the counterpart pregnancy, as something that made their own pregnancy feel more real when they experienced symptoms and sensations that they otherwise might associate with illness, and supported them in developing their identity as being a pregnant person. For some participants, consuming fetal development updates on a pregnancy app, or multiple pregnancy apps, reassured them about the development of their pregnancy, even though they were aware of the lack of personalised insights it could offer them. While participants made reference to reassurance and some of the information on apps being "scientific", several participants also depicted their app use as something they did for entertainment, and as one participant described it, "a bit of light relief". While no participants used the term "bonding" to describe their use of pregnancy apps, many aspects of their usage reflect this dynamic, confirming the findings of existing studies of pregnancy apps (Hamper and Nash, 2021).

This was also the case for some partners who engaged with pregnancy apps. While some participants reported that their partners were not interested in using pregnancy apps, and engaged with their pregnancies in other ways such as attending antenatal appointments, others were keen to use pregnancy apps as a way of being involved with the pregnancy. Some chose to establish a counterpart pregnancy by using or downloading their own pregnancy apps, which sometimes shifted the more common configuration of the participant using the app as a source of knowledge from which to describe the development of their pregnancy to their partner, to the partner sharing information back to the pregnant participant. With the pregnancy app being drawn upon as a source of information on fetal development, this reflects a dynamic I explore elsewhere in this thesis of knowledge from an app being juxtaposed with, or complemented by, bodily experience. Here, the app allows access to information on supposed fetal development that the expectant mother cannot access through their own bodily knowing.

A potential conflict in different forms of knowledge providing inconsistent insights into fetal development is when measurements taken during antenatal care do not correspond with the suggested ranges of fetal size on pregnancy apps. Here, I use my concept of the counterpart pregnancy to explore how the two pregnancies can diverge. Discrepancies between these suppose trajectories of development caused some participants anxiety, and was distressing in cases of pregnancy loss, particularly when reporting the loss to the app was difficult or incomplete, for example with email updates continuing to be sent to the user's inbox even after they deleted the pregnancy app. The limitations of pregnancy apps to deal with miscarriage effectively has been noted in some existing content analyses of pregnancy apps, and in the following chapter, I share the findings of my own analysis of pregnancy apps on a different topic, focusing specifically on the feature of fetal movement monitoring.

Findings chapter 4 – "Trust your intuition. Trust the data": An analysis of fetal movement monitoring apps

Introduction

While the majority of this thesis is based upon the experiences of users, in this chapter I have chosen to analyse app content directly to complement this data. I advance my research questions by examining how specific fetal movement monitoring apps, and pregnancy apps with fetal movement monitoring features (referred to collectively as fetal movement monitoring apps for brevity) inform women's understandings and experiences of fetal movement. Furthermore, I address a supplementary research question specific to this chapter of how fertility and pregnancy smartphone applications shape women's knowledge and/or understanding of pregnancy. My interview sample is small, and therefore this chapter focusing on app content allows for some consideration of what the implications these apps may have more broadly. This chapter explores personal fetal movement monitoring, which is a key theme drawn from the interview data of this study. Many pregnancy apps have functionalities that enable users to track fetal movement, and while several participants used these features, others chose not to. In explaining their decisions to reject fetal movement monitoring apps (as will be explored in the following chapter), some participants referred to guidelines they had read that advised against formal fetal movement counting. As such guidance emphasises the importance of what has been referred to as "maternal subjective perception of reduced fetal movements" (Heazell and Frøen, 2008, p. 147) and generally opposes the routine use of charts for personal monitoring of fetal movement, these apps capture an interesting issue surrounding what it means to monitor fetal movement, against a background of ambiguity within the evidence base.

I begin this chapter with some context on personal fetal movement monitoring. I provide a brief account of the methodology used for app analysis, then turn to my findings. Across this chapter

I describe the features that fetal movement monitoring apps offer, and the justifications and explanations the apps provide for their intended use. These findings are organised along three major themes which I use to refer back to my research questions: fetal surveillance; raising awareness; and interpreting data and taking action. I find that apps offer a variety of guidance and different functionalities that could shape how users monitor fetal movement. The value of using apps for formal fetal movement monitoring is often poorly articulated by the apps themselves, with some apps providing little to no written guidance to accompany the tracking features, and there are sometimes contradictions between advice and design. Apps draw upon narratives of risk and good motherhood to compel users to track fetal movement, and portray the unborn fetus as having its own health status that must be monitored. I argue that fetal movement monitoring apps may influence the embodied experience of fetal movement by structuring quantity and frequency as measures of fetal wellbeing that need to be observed along particular parameters, as well as portraying fetal movement data as emotionally significant.

While many apps highlight the need for personalised awareness of unique patterns of movement, half of the apps in the sample imposed particular standards of normal fetal movement. The intended use of apps blurs boundaries between externally recorded data and embodied knowing, with many apps positioning themselves as learning tools. I argue that almost universally, despite offering tracking functionalities, apps relegate self-generated knowledge beneath biomedical monitoring. While they purport to offer some reassurance to users in affirming fetal wellbeing, in some cases, data is argued to be a way to lend credence to intuitive knowing and a tool for users to advocate for themselves, highlighting the social norms surrounding help-seeking, and how the value of this data is relational.

The evidence base on monitoring fetal movement

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Reduced fetal movements have been associated with stillbirth, and other adverse pregnancy outcomes (Warland and Glover, 2017). Maternal perception of fetal movement is a potential means of recognising this; some studies have found that the majority of women who experience a stillbirth report having noticed a reduction in fetal movement (Bellussi *et al.*, 2020). The value of maternal awareness of fetal movement is however subject to some debate, with some research suggesting that campaigns to educate pregnant women about fetal movement, and policies that emphasise taking action where pregnant women report reduced fetal movement, have no impact on pregnancy outcomes and instead may increase the rate of intervention in birth (Norman *et al.*, 2018). Nonetheless, to varying degrees, and by different actors, pregnant women are encouraged to develop an awareness of the movements of the fetus to recognise patterns in the hope that they would notice a change that could indicate a problem with fetal wellbeing (McArdle *et al.*, 2015). Past guidance on fetal movement monitoring (also referred to as kick counting) has included a range of different measures of what constitutes a normal amount of fetal movement (Heazell and Frøen, 2008). This has included the Cardiff count to 10 method, which instructs that if fewer than 10 movements in 2 hours are felt, then the pregnant woman should contact a health care professional (Heazell and Frøen, 2008). However, studies have found that a range of 4 to 100 movements in an hour can be considered normal, and there is a lack of evidence that any particular alarm limit is accurate (Warland and Glover, 2017). Some different approaches to monitoring fetal movement have been proposed, such as "mindfetalness", which advises women to take a qualitative approach to monitoring fetal movement, and take 15 minutes a day to be "…present in the moment taking note of both frequency and quality of the unborn baby's movements" (Rådestad, 2012, p. 59). However, no form of personal fetal movement monitoring has been conclusively found to be effective in improving pregnancy outcomes – a 2015 Cochrane review of methods of fetal movement monitoring found that "robust research by means of studies comparing particularly routine fetal movement counting with selective fetal

movement counting is needed urgently, as it is a common practice to introduce fetal movement

counting only when there is already suspected fetal compromise" (Mangesi *et al.*, 2015, p. 2).

The guidance for women issued by the Royal College of Obstetricians and Gynaecologists

concerning fetal movement monitoring therefore emphasises that there can be great variance in

what is considered a normal range of fetal movements, and advises pregnant women to become

aware of the unique pattern of fetal movement (Royal College of Obstetricians and

Gynaecologists, 2019). The count to 10 method may be advised as a means for a pregnant

woman to consciously focus on movements if she is unsure whether she has noticed a decrease

in movements, but is not advised for routine use (Royal College of Obstetricians and

Gynaecologists, 2012). These guidelines do not refer specifically to pregnancy apps, but the NHS

Apps Library, which includes apps assessed by the NHS as safe and secure to use, includes Kicks

Count. The rhetoric of this particular app aligns relatively closely with the guidelines, highlighting

the need for individuals to observe their individual patterns of fetal movement, rather than focus

on a specific alarm limit. Nonetheless, it is somewhat contradictory that this app is approved by

the NHS given the mixed evidence base. I do not seek to explore why this is in this chapter as it

is beyond the scope of my investigation to speculate. Some existing studies have explored the

information available to women on pregnancy apps that advises them on fetal movement (Daly

et al., 2019). However, no existing studies provide an in depth analysis of fetal movement

monitoring functionalities on apps, or take a social science perspective.

Methodology recap

My intention in this analysis was not to produce a content analysis that stands independently

from the rest of this thesis, but instead to study pregnancy apps and reflect upon the features of

apps that align with women's experiences. I conducted a qualitative analysis of 20 apps that offer

fetal movement monitoring features available on the Google Play app store. I focused on apps that offer fetal movement monitoring features, rather than all pregnancy apps that offer advice on fetal movement because of my interest in the direct promotion of the practice of routine fetal movement monitoring and how apps facilitate this. I extracted data focused on the information and instructions provided alongside fetal movement monitoring features, as well as the design and structure of the features. I conducted simulated fetal movement monitoring sessions over several days and either reduced the reported quantity of movements over time, or registered a quantity of movements that fell below the alarm limits the app had stated to test how the apps responded to a decrease in movement that could be linked to fetal distress. The full methodology and sampling strategy I used for the app analysis can be found in my methodology chapter.

Fetal surveillance

The apps in this sample vary in the quantity and quality of information they provide to users to explain the practice of fetal movement monitoring, and to provide guidance on how their tracking functionalities should be used. A quarter of the apps offer no written guidance to accompany the fetal movement monitoring feature. For those that provide written guidance, a common theme is for the guidance to highlight the importance of fetal movement as an indicator of fetal wellbeing, then directly or indirectly present the app as a tool that can be used to help the user detect potential issues. Most of the apps in the sample state that monitoring fetal movement can be used as a way to assess fetal wellbeing:

> By keeping track of each time your baby kicks, rolls or pokes, you can monitor
> your baby's health (Pregnancy Tracker).

Here, keeping track of movement is claimed to be a way to monitor the health of the fetus. This both asserts that movement can be used as an indicator of fetal health, and enacts the fetus as a future baby that can kick, roll and poke, with health status in its own right. This finding resonates with existing literature on maternal-fetal dynamics, for example Casper's argument that a focus on fetal health produced through the rise of fetal surgery constructs a fetus as an "unborn patient" with claims that can impact the agency of the pregnant woman (Casper, 1998). The suggestion that a pregnant woman should keep track of "each time" the fetus moves, or make time every day also makes claims to the daily practices of the user.

Most apps refer to the need for surveillance to monitor the health of the fetus, and to identify potential "problems". A minority of apps make direct reference to the potential of monitoring fetal movement to prevent stillbirth:

> Setting aside time every day when you know your baby is active to count kicks, swishes, rolls, and jabs may help identify potential problems and can help prevent stillbirth (My Pregnancy Tracker Week by Week + Due Date).

These references to preventing stillbirth or identifying fetal distress are framed emotively by some apps, and emphasise potentially avoidable risk:

> Counting kicks is very crucial, as any sudden or significant change in your baby's movements may be an indicator of an underlying problem with you or your baby's condition. So many lives, both mothers and babies, have been saved due to the mother's keen observation in counting kicks (Pregnancy Week by Week).

The importance of fetal movement monitoring is deemed to be "crucial", and there is value reported here in the "keen observation" of pregnant women who are named with this status of mother to the unborn. The responsibility of the mother to conduct surveillance in this way is enacted as potentially lifesaving. One app pushes this narrative even further, and offers a section titled "Baby Save Stories", detailing stories of multiple different mothers who had identified fetal distress and successfully "saved" their babies, whose photographs accompany the stories. As one mother writes:

If I didn't know about Count the Kicks, I don't know if I would have been as aware of my baby's movements as I was, and who knows what could have happened (Count the Kicks).

This emphasises the risky unknown, and the need for proactive monitoring of fetal movement to prevent potential catastrophe. These accounts justify a need to be aware of fetal movement, drawing upon narratives of protection and care as aspects of motherhood, and the underscoring of risk which can set up the use of the functionality offered by the app as a logical outcome. A focus on potential risks justifying a need for monitoring outside the realms of hospitals in everyday life, what Armstrong termed surveillance medicine, has been well-established in the literature (Armstrong, 1995). This is the case for pregnancy, where this purported need for risk management is layered with social expectations of "good motherhood" and "maternal responsibility" that begin before birth, with pregnant women expected to conform to healthy lifestyle behaviours and act in ways that are in the interest of the fetus in its status as a future child (Burton-Jeangros, 2011). This finding complements existing literature that has identified the role of pregnancy apps in portraying pregnancy as risky and requiring self-surveillance, as established earlier in this thesis (Johnson, 2014; Lupton and Thomas, 2015). Apps present monitoring fetal movement as a responsibility of a good mother, willing and able to save her baby from harm even before it has been born.

Having established the importance of monitoring fetal movement in this way, most apps leave it to be self-evident that using the tracking tool they offer would be useful or justified. Some apps also state that using an app to monitor fetal movement is convenient, or simply a good way to track movement:

> Keeping a track of fetal movement is a great way to ensure that your baby is healthy and can also be the onset of your bonding experience. Our Kick Counter is the best way to do so! (theAsianparent: Baby Care & Pregnancy Development).

Monitoring fetal movement is presented as an opportunity for bonding, affording emotional meaning to this tracking practice. Several other apps also state that monitoring fetal movement can be a bonding activity, with movements being described by one app as "precious moments", that can be recorded with the app (My Pregnancy Tracker Week by Week + Due Date). This resonates with Pantzar and Ruckenstein's work on the emotional engagements users have with self-monitoring data, with measuring devices and data "…deepening people's affective relations to their bodies, or even distinct organs such as hearts" (Pantzar and Ruckenstein, 2014, p. 12). In this case fetal movement data as recorded in an app is used to capture the movements of the baby, with its motion being portrayed as a form of communication and connection between baby and mother, also reflecting notions of good motherhood.

In the app quoted above, however, there is no explanation provided of what exactly makes using this app for keeping track "the best" way of doing so, and as established, there is little evidence to suggest that using an app is any better than non-recorded maternal perception of changes to fetal movement (Mangesi *et al.*, 2015). Interestingly, some apps acknowledge the potential

limitations of formal fetal movement monitoring, but continue to facilitate it. For example, the Sprout app communicates some of the evidence base on routine fetal movement monitoring:

Research regarding whether or not counting kicks actually reduces the risk of still birth has been mixed. Nonetheless, keeping track of fetal kicks can be comforting and in some cases tells your doctor something about the well being of your baby. Because of the limitations however, not all doctors say it is a worthwhile exercise. It is best to talk to your doctor to see if he or she recommends this and what parameters to use. Nonetheless, you should always try to be aware of your baby's movements (Sprout).

This is likely to leave the user slightly perplexed as to whether or not they should use the app's fetal movement monitoring tool, given that the app seems uncertain in recommending its own feature. The app suggests the user does not make this judgment themselves, but refers to a doctor for their advice on whether they should use the feature on the app. A further app also challenges whether the tool it offers is valuable, but based on a question of whether maternal perception of fetal movement is reliable:

Methods of self-assessment of fetal movements are quite simple, do not require medical knowledge and equipment. If the test results fit into the norm, a woman is confident that her baby is all right. However, the methods lack of objectivity: the perception of reality in pregnant women is very different! [sic] (Pregnancy Calendar).

This highlights the constructed tiers of subjectivity and objectivity involved with this particular facet of self-monitoring. Rather than using an external tool to take a measurement that can be seen to be more "objective" than the user's own sense of a bodily experience, using a fetal movement monitoring app is a way of quantifying and recording a subjectively perceived feeling

that is interpreted as fetal movement. In the example above, the confidence of a user that the fetus is healthy based on their personal monitoring of fetal movement should not be considered objective, and may not be "reality" (whatever that might mean). This positions the user's own data as potentially reassuring for the user, but not in fact an objective measurement of fetal wellbeing. This is an interesting extension to some of the literature on self-monitoring practices that observes the rhetoric positioning quantified data as more "objective" than self-perceived insights into health (Lupton, 2015).

It is noteworthy that this potential lack of validity is acknowledged within the apps themselves, particularly as the quotations above crystallise the uncertain space where fetal movement monitoring apps exist, as they encourage a particular form of surveillance that is not universally endorsed by the evidence base or clinical practice guidelines. It is possible that these apps acknowledge the limitations, but still facilitate it, because they are attempting to sell a product that offers useful features. A fetal movement monitoring function is often advertised in the list of features in app descriptions prior to download, and in some cases is a paid premium upgrade. If fetal movement monitoring is presented as valuable, these features may be more attractive to potential users. This is not necessarily an active attempt to profit from the provision of potentially inaccurate advice, but it is important to acknowledge the interest developers may have in fetal movement monitoring functionalities being considered a desirable feature of pregnancy apps. It follows to explore what features fetal movement monitoring apps offer, and to consider the ways in which they frame a normal range of fetal movement patterns.

Raising awareness

Several apps offer prompts to the user in terms of setting push notifications as reminders to encourage fetal movement monitoring sessions at pre-set times of the user's choice across a day.

This can influence the user to engage in fetal movement monitoring as a regular practice, enacting fetal surveillance as a part of the user's daily routine. This affirms what Johnson terms "push responsibilisation", with pregnancy apps imposing the responsibility for the user to care for themselves and the fetus through push notifications that arise at regular intervals (Johnson, 2014). In terms of the design of the tracking features, most apps are structured with an icon, often shaped as a small foot, that the user must tap when they feel a movement to record it. The movement will be inserted into a historic data log, and the user can refer back to this log, which on some apps is aided by graphs as visualisations of the data.

Some apps aim to help users to identify potential fetal distress by placing a focus on a specified alarm limit for normal fetal movement, which may correspond with the design of the app. For example, the session will automatically stop once 10 kicks have been recorded within a time period that is designated by the app to be normal. However, the definitions of what constitutes normal fetal movement patterns varies across the apps. Half of the apps in the sample advise that a particular quantified measure of the number of movements in a period of time is normal, which means that recording fewer movements than this may be cause for concern, i.e. an alarm limit. Most commonly this recommendation is 10 movements in 2 hours, with some apps also suggesting 10 movements in 1 hour, or 10 movements in 12 hours. Most of these apps highlight the need to identify deviations from the user's perception of the unique pattern of fetal movement, but still provide these specific alarm limit parameters for what is normal. By establishing what is considered normal, this may inform users' interpretations of the form of movement that indicates health based on frequency, and influence how they experience fetal movement as a measure of fetal wellbeing.

In some cases, the guidance on normal ranges of movement varies within the same app. Sometimes this is because the written guidance contains information that contradicts itself, for

instance the app Sprout advises that 10 movements in 1 hour is normal, but later in the text states that 10 movements in 2 hours is normal. In others the design of the fetal movement monitoring tool configures a pattern of tracking that does not correspond to the written guidance that is provided alongside it. For example, Pregnancy + app advises:

> There is a common misconception that you should be feeling 10 kicks over a set period, this no longer recommended as all babies are different. However, regularly counting the time it takes to reach 10 kicks will make you more aware of your baby's movements (Pregnancy +).

However, despite advising users that they should not aim to notice 10 movements in a specific time period, the Pregnancy + fetal movement monitoring interface is built with a pre-set 2 hour countdown, and modules for 10 movements that are filled as the user counts to 10. The app advises that "regularly counting the time it takes to reach 10 kicks will make you more aware of your baby's movements" (Pregnancy +). This focus on awareness-raising, rather than particular alarm limits, was a justification for use given by many apps. The remainder of apps in the sample offer no particular alarm limit, advising users that there is no such thing as a universal normal, and instead it is important to learn a unique pattern of movement. This aligns with clinical practice guidelines that advise woman to learn the normal patterns of fetal movement, rather than focus on alarm limits as a daily practice, other than following a perceived reduction in movement. However, these apps suggest that the use of routine kick counting should be used to track this unique pattern, and provide a quantified basis to monitoring fetal movement that supposedly justifies the use of an app.

While some apps are designed to compel the user to track based on an alarm limit, more commonly, apps suggest that kick counting can be used as a familiarisation process for the user

to learn a unique pattern of fetal movement. Most of these apps are still designed around a count to 10 model, but offer a slight variation on the apps structured around a count to 10 alarm limit that provide a timer alongside modules that can account for up to 10 movements. Instead, these apps advise users to time how long it takes for them to record 10 fetal movements to learn this personalised pattern of how long it should take to reach 10 movements. The user can make use of the history log feature to compare the results of past monitoring sessions, which differentiates these apps from the first category of app where the impetus is on reaching 10 movements in a specific time period. Alternatively, some apps operate on a countdown timer, and the session is structured to encourage the user to count how many movements they feel during that particular time period, which is usually 1 or 2 hours. Others apps are more open ended in their design, providing the user with a timer and a counter, but these do not stop after a particular period of time or number of movements recorded, and the advice that goes alongside these apps varies.

All 20 of the apps in the sample offer a historic data log feature, which enables the user to analyse their data over time. This is even the case for the apps that emphasise alarm limits, rather than unique patterns of movement. However the apps vary in the level of detail offered by the history log features. For example some provide summaries of the numbers of movements on a given day, while others include records of the time in the day that a movement was recorded. This means that some offer more functionality than others for enabling the user to build a sense of when a fetus is most active, e.g. that it is relatively quiet in the mornings, moves after lunch, and is more active in the evenings. This type of pattern is not visible with a simple number of total daily movements recorded.

There are different models of how apps encourage the daily practice of fetal movement monitoring to be structured (e.g. time how long it takes to reach 10 movements or count how many movements you feel in an hour), but these apps construct their use as a tool to help build

the user's own awareness of fetal movement, drawing an interesting picture of how bodily awareness and data are blended to develop this measure of fetal wellbeing. For many apps that encourage building an awareness of unique patterns of fetal movement, and particularly for those that align most closely with clinical practice guidelines and avoid prescribing alarm limits, there is a focus on learning and recording using the history log within the app, but also using this practice to extend awareness beyond app use. Some apps highlight the role of the data log in developing an external record of historic fetal movement patterns:

> If, when comparing the current session with your journal notes, you notice that the baby is moving more or less than usual or that the movements are changing, contact your doctor (My Pregnancy - Pregnancy Tracker App).

> The graphs will show you your baby's movements over the last 2, 7 and 14 days so you can see easily if there has been a change (Kicks Count).

Building awareness of changes to fetal movement is externalised using the notes and graphs in the app, locating the awareness that a user may have to the app outside of the body. However, as noted above, this will be limited by the functionalities the apps offer, with some providing more condensed summaries of historic data. This means that the externalised data entered into the app loses depth in this process, and does not serve as such a full representation of fetal movement. This suggests that users may find more value in using the app as a tool for building their own embodied knowing of fetal movement patterns. Some apps place this type of emphasis on the user building awareness independently of the data held in the app. For example:

> Using this app every day will help you learn the normal rhythms of your baby's movements. It's as easy as counting to 10! (Count the Kicks).

…regularly counting the time it takes to reach 10 kicks will make you more aware of your

baby's movements (Pregnancy +).

You will gradually learn your baby's sleeping and waking cycles, the most active times, and

what seems to trigger activity (Pregnancy Tracker).

These apps refer to learning, and becoming "more aware" with the app positioned as an external

tool to help the user build up an embodied sense of the pattern of fetal movement that is normal

for them. In this way, the app can externalise the development of this sense of normality, and

then with the feedback loop of the data log, or simply the practice of tracking in itself, create

greater focus on and influence the user's experience of fetal movement by increasing their

physical awareness of this aspect of pregnancy. The functionalities of apps shape the experience

of fetal movement in particular ways, as the methods of monitoring fetal movement that they

enable are generally quantified, based on the frequency and sometimes timing of movements.

Only one app offers a qualitative feature, which enables the user to select one of nine different

options for the type of movement they perceive, for example a swish, a jab, a punch or a roll.

This, along with the lack of capabilities of many apps to record the timings of movements,

shows that these apps present a limited assessment of fetal movement based on partially

quantified parameters that the designed functionalities of apps construct. This shapes the ways in

which fetal movement might be understood or experienced, as it selects a particular remit of

factors that are relevant to fetal wellbeing.

Another aspect of influence of apps on the experience of fetal movement is that some apps give

advice on moving or positioning the body in particular ways to further increase physical

awareness of fetal movement:

A steady and restful position, preferably with the feet upwards when sitting, will help you

be more attuned to your body and make sharper observations with the movements

(Pregnancy Week By Week).

This can enact changes to the embodied physicality of the pregnant body, encouraging particular

movements and focus on sensations to be interpreted in this way. Being attuned to the body is

highlighted here, and this suggestion echoes existing literature on self-tracking for other health

categories, that the value of self-monitoring is in the learning rather than solely in the data itself

(Sharon and Zandbergen, 2017).

The fundamental goal of building awareness as advocated by these apps is for the user to notice

a change in fetal movement that might indicate fetal distress or a potential problem. As shown

above, many apps allow for a duality in their intended use in terms of how users draw upon the

historic data log they provide, as well as using a regular practice of fetal movement monitoring to

build up their learned and embodied awareness of fetal movement. Some apps also make direct

reference to "instinct" and "intuition":

Trust your instincts, there's absolutely nothing wrong with seeking help if you're in

doubt (Pregnancy Week By Week).

The role that instinct or intuition plays is not clearly demarcated from the use of apps, and the

learned awareness informed by app use can in some cases be interpreted as intended to inform

intuitive self-knowledge. In a study considering the role of maternal intuition or "gut instinct" in

pre-empting stillbirth, Warland et al. define maternal intuition as "…natural inborn intelligence

that guides and supports the pregnant mother to deeply know, without external influence, about

her unborn baby's wellbeing" (Warland *et al.*, 2018, p. 175). The intended use of apps implies that the learning activity of fetal movement monitoring may be able to inform this intelligence. As one app claims:

> Our aim is to ensure mums are not only aware of the importance of their baby's movements but also that they have the confidence to trust their instincts if they feel something is wrong (Kicks Count).

This suggests that the learning activity enabled by the use of the app can serve to give the user more trust in their own sense of fetal movement changing. In another app, both intuition and data are directly referred to as measures of fetal wellbeing:

> What should I do if I cannot feel my baby move? Call your healthcare provider right away! Trust your intuition. Trust the data. Don't wait (Count the Kicks).

The use of an app for quantifying movements is therefore presented as a supplement to, rather than a displacement of, the value of intuitive knowing. This suggests that a hierarchical division between "reality" and a person's imperfect subjective knowing of fetal wellbeing as reported in one of the apps referenced earlier in this chapter is not supported by all apps, and the relationship between the two may be considered more nuanced. While a particular metric is sometimes applied for defining what is normal for fetal movement across particular time periods, the app may be presented as a means to augment the user's inner ability to build an awareness of fetal movements, and to provide an external means for quantifying and noticing changes. The relationship between subjectivity and objectivity is dynamic, with the user engaging with the app to build awareness of what might otherwise remain subconscious, rather than the data of the app being presented as a means to dominate the user's own experience and judgment. The lack of

app functionality in terms of responsiveness to user data further reinforces this position of user awareness and agency being integrated within the design of apps.

Interpreting data and taking action

In addition to instinct and awareness that extend beyond the app being acknowledged aspects of app use, interpretation is also left to the user due to the limits of app functionality. There is a very narrow amount of responsiveness across the apps analysed in the sample. A minority of apps are responsive by offering real time reactions to the user during a fetal movement monitoring session, for example offering encouragement:

> Great job on reporting the first kick! Keep going mum! (theAsianparent: Baby Care & Pregnancy Development)

or advising the user to continue tracking when attempting to stop a session before completion:

> Are you sure you want to stop this session? It is important to complete the one hour session for accurate reports (theAsianparent: Baby Care & Pregnancy Development)

However, importantly, while several apps actively encourage users to track changes in fetal movement patterns over time by referring to their data, only one of the apps analysed provides tailored or responsive insights to help users interpret their data. This is fairly limited in its content, taking the form of a pop-up warning message that appears when attempting to end a tracking session before reaching 10 movements in 2 hours:

Are you sure? You haven't reached 10 kicks in 2 hours or less which is the

benchmark for normal fetal movement. Would you like to end your session?

(Ovia).

The pop-up provides the options to either "Yes, end session", at which point the total number

of movements recorded would enter the historic log in red, rather than the green colour applied

to sessions that meet this benchmark, or to "Cancel" and return to the movement monitoring

session. However, no further feedback is offered to explain why the colour red or green had

been assigned to the log, what this means, or what action should be taken in response. This

particular app, Ovia, does not offer any other guidance alongside the fetal movement monitoring

feature other than advising users to "Time how long it takes to get to 10 kicks/movements when

your baby is most active". This low level of responsiveness and lack of information

demonstrates the limited capacity for fetal movement monitoring apps to facilitate self-care. In

some apps, user data is visualised in the form of graphs, which may help enable the user to see

the number of movements change over time, but the app would not notify the user of this or

provide an analysis that encouraged them to contact their health care provider. The graphs and

history logs are personalised based on the user's data, but there are no prompts or analysis based

on an alarm limit, so they are not responsive to the data in this way. The impetus for analysis and

action is with the user. They are tasked with observing changes, and performing their own

assessment of whether their data was normal, either in terms of their own personal history, or

the alarm limits that some apps use to define normal fetal movement patterns.

This suggests that fetal movement monitoring apps are limited in their functionalities, and may

also cause confusion, particularly in the examples given earlier in this chapter where the

information and design provided is contradictory and the justifications for using the apps are

unclear. The finding that different apps provide conflicting guidance on fetal movement

monitoring is consistent with existing evidence that pregnancy and parenting websites provide contradictory and inaccurate information about fetal movement monitoring (Farrant and Heazell, 2016). In this way the apps empower users to a restricted extent, particularly because they generally suggest that the course of action to take is to seek professional help. However, some apps directly argue that having this data will empower women in their interactions with health care professionals:

> Tracking your baby's movement every day takes the guesswork out of knowing if your normally active baby has slowed down. You have real data to show your healthcare provider if you have a concern (Count the Kicks).

This presents non-recorded self-knowledge as potentially secondary to quantified, externally recorded data, in part because the information about fetal movement that remains internal may be difficult to process in determining a decrease in fetal movement, requiring "guesswork" in the absence of anything external to measure. But additionally, the claims the app makes about external data being somehow more "real" are framed as a defence to justify a need for intervention to a health care professional. This suggests that the value of this data is not merely to reassure and inform the user, but also that there is a relational value of the data in providing credibility to the user's concern. The professed need for this shows that social interactions in help-seeking are significant in this area. Text from apps shown earlier in this chapter included such statements as "there's absolutely nothing wrong with seeking help if you're in doubt" and "call your healthcare provider right away! Trust your intuition. Trust the data. Don't wait". Smyth and colleagues studied both clinicians' and patients' perceptions of presentation with reduced fetal movements, and found that women often had concerns that they would not be taken seriously when seeking help following their observation of reduced fetal movements (Smyth *et al.*, 2016). The data produced by fetal movement monitoring apps therefore may have

value as a form of social currency to enable women to feel empowered to seek help. Feeling empowered to advocate for oneself following a perceived reduction in fetal movements is significant, as inadequate clinician response to a report of reduced fetal movement has been hypothesised to be a contributory factor to stillbirth (Saastad, Vangen and Frederik Frøen, 2007). Fiore-Gartland and Neff's work on health data and "data valences" explores the use of data in such contexts. They describe the use of data to evidence an individual's experience with the term "truthiness", with quantification being "…a validating interpretation of the data as somehow "truer" than the reported narratives of experience" (Fiore-Gartland and Neff, 2015, p. 1477). The potential for this use is layered with complexity given that there are tensions between what patients and doctors may "…want from data and how they expect that data to perform in interaction with others" (Fiore-Gartland and Neff, 2015, p. 1467). One doctor interviewed in their study of health data reported that some patients would bring in personal health data having already interpreted its meaning, therefore being less open to jointly interpreting data with the doctor, when the doctor suggested the data should form only one factor in the diagnosis process (Fiore-Gartland and Neff, 2015, p. 1473). The suggestion of this pregnancy app that users could present their data to a health care professional to justify their concerns does somewhat align with this analysis, which Fiore-Gartland and Neff describe as data for "self-evidence", though the interview data of my study (as will be explored in the following chapter) suggests that women may be more likely to use this data as an initial justification for seeking help, rather than an end point of diagnosis from the data. The lack of app capabilities to assess fetal wellbeing beyond recording movements also suggests the app data is more likely to serve as only a first step in a diagnosis process involving further interpretation and measurement.

Across the sample, where there is written advice, apps advise women to seek medical assistance for further investigation if they notice a change in fetal movement, or if they identify a level of movement that falls beneath a specified alarm limit. Most apps openly state that the app cannot

and should not be relied upon to monitor fetal wellbeing, and advise users to call a health care professional if any change in fetal movement is noticed. In part, this type of advice can serve as legal protection for app developers, and some apps provide a specific disclaimer that affirms that the app should not be considered a replacement for professional guidance. But this also implies that the data that women produce using these apps is not sufficiently reliable to be a basis for determining fetal wellbeing. This relates to the existing literature on the ways in which technology interacts with women's self-knowledge in pregnancy. Young argues that ultrasound and other technologies such as fetal heart rate monitoring devalue women's unique embodied knowing of the life of the fetus in favour of a supposedly more "objective", technologically informed assessment (Young, 1984, pp. 57–58). The notion of objectivity has been complicated in the work of scholars of self-monitoring and health, notably in the work of Pantzar and Ruckenstein. Departing from the notion of "mechanical objectivity", dominant in scientific discourse since the 19th century, they propose the concept of "situated objectivity" (Pantzar and Ruckenstein, 2017). In terms of self-monitoring, rather than focusing on precision and standardisation for interpreting the body through mechanically objective measurements, situated objectivity encompasses variation in how individuals define what is important in terms of their own data and measurements (Pantzar and Ruckenstein, 2017, p. 7). This concept aligns with the compatibility of different ways of knowing I discuss above, with embodied knowledge (a site of individual variation) coexisting with knowledge as measured through the use of an app. They suggest that "…rather than encouraging a mindless following of numbers and measurements, the new tracking tools might strengthen reflective thinking and problem solving" (Pantzar and Ruckenstein, 2017, p. 8). As some of the apps analysed suggest, embodied self-knowing and reflective thinking may be supported through app use.

As one example of a form of technology, fetal movement monitoring apps as examined in this chapter both support and nuance the claim of Young cited above. Rather than this type of

technology devaluing women's knowledge, different ways of knowing are presented as compatible by many apps, with tracking practices and app functionalities portrayed as tools that can inform and augment embodied self-knowledge. However, this suggests that rather than existing as a complete form of self-knowledge, a user might require an externalised way of tracking their perceptions of fetal movement, as their internal process may be imperfect or based on "guesswork". Additionally, this data is then set in a framework of seeking biomedical monitoring if the user's own sense indicates a potential problem. Both self-quantified and intuitive forms of self-knowledge are relegated below the need for professional judgement and measurement, and the introduction of different technologies into the arena that are not controlled by the individual.

This also links to broader debates on fetal movement monitoring, as well as utilisation of health care services. Many of the apps in this sample suggest that using them for fetal movement monitoring on a regular basis can increase the user's awareness of fetal movement and enable them to identify fetal distress, even though there remains to be conclusive evidence on whether formal fetal movement monitoring does in fact improve pregnancy outcomes (McCarthy, Meaney and O'Donoghue, 2016). It is possible that by using these apps, a user may feel reassured and not seek help when they are in a situation that does merit further investigation. The reverse may also apply, and a user may feel compelled to access health care due to the results of their app data when they may not otherwise have done so. For example, if a user were to count the number of fetal movements they felt for 1 hour each day, as several of these apps advise, then saw a visual representation of fewer movements each day on a graph, this may cause anxiety and cause them to seek help even if they otherwise felt that fetal movements were normal. This hypothesis is supported by large studies on fetal movement monitoring, as routine fetal movement monitoring like that advocated by the apps examined in this chapter resulted in more hospital admissions (Norman *et al.*, 2018). On a population level, this was not seen to

improve outcomes, but increased interventions such as induction of labour (Norman *et al.*, 2018). However, as acknowledged in ongoing debates, clinicians have reported interventions based on women's perceived reduction in fetal movement that they believe have been imperative in reducing infant mortality (Porreco, 2020). This makes it difficult to assess whether this constitutes "unnecessary" help seeking, and guidelines advise women to seek help when they have concerns. The role of fetal movement monitoring apps in this process is not possible to determine conclusively from the data in this chapter, as user response to apps is significant, but it is evident that the advice given and functionalities offer promote particular forms of self-monitoring.

Conclusion

This chapter has demonstrated that there are a range of forms of fetal movement monitoring promoted by apps, and that these have many potential implications for the ways in which women experience and understand fetal movement as an indicator of fetal wellbeing. There are inconsistencies between and within apps, and tenuous justification of the need for fetal movement to be quantified. However, a common theme was for apps to suggest that both quantified and embodied knowing can be complementary, with the apps used as a learning tool to augment embodied knowing. Most apps emphasise that they offer no substitute for professional medical monitoring, and if in any doubt the user should contact a health care professional. This is in part likely a legal disclaimer to protect developers, but also serves to position biomedical monitoring as superior to assessing fetal wellbeing through personal measures of fetal movement. In the following chapter, I will consider similar themes based on interview data of participants' experiences of using, or choosing not to use, fetal movement monitoring app features.

Findings chapter 5 – "I don't want to be that really neurotic pregnant woman": Women's experiences of monitoring fetal movement

Introduction

Having examined the content of fetal movement monitoring apps, I now turn to the experiences of participants of using these apps. Importantly, this chapter also examines non-use, and in the reasons participants articulated for both use and non-use, interesting dynamics emerged regarding different ways of knowing the body. In this chapter I offer some brief background on fetal movement monitoring apps, then present my findings which are organised along three themes: focusing conscious awareness; intuitive knowing; and apps as gatekeepers. I found that there were two models of app use: the first being as a temporary tool employed after a perceived reduction in fetal movement in a period of raised awareness; and the second being as a means to record patterns of fetal movement over a longer period of time. I draw upon Weiner and colleagues' (2020) concept of "partial data" to explain participants' usage patterns and the ways in which they found value in the data they generated. However, the majority of participants did not report using or intending to use a fetal movement monitoring app. For these participants, their non-use was due to a lack of perceived utility, concerns about anxiety and obsessive behaviour, or a rejection of the use of apps in favour of what can be described as embodied or intuitive knowing. As in the previous chapter, I found blurred boundaries between externally recorded data and embodied knowing, but some participants established this form of dichotomy, consciously rejecting quantified and externally recorded data on fetal movement monitoring.

Participants' descriptions of embodied knowing varied and were often vague. They used such terms as "in my head" and "memory" that situated embodied knowing as a form of conscious awareness, and expressions such as "I just knew" and "trusting my instincts" that suggest that

there are aspects of embodied knowing that are also innate and intangible. Many participants understood their perception of fetal wellbeing as intuitive, but also as limited and needing the verification of health care professionals. I utilise Warland and colleagues' (2018) definition of intuition to inform my discussion. Finally, I found that both for app users and non-users, anxieties about how they would be perceived when seeking help regarding perceived decreased fetal movements were noteworthy, and for users, I conceptualise the role of the app as a gatekeeper. Participants expressed that health care professionals had better judgment on fetal wellbeing than they did – their use of apps was largely structured around whether or not to seek help. This supports my finding from the previous chapter about the relational value of data, where some apps suggested that users might show their data to a health care professional to evidence their claim that they had perceived a reduction in fetal movement (chapter 4). Different ways of perceiving and experiencing embodied knowing are both shaped by and inform pregnancy app use. However, the use of these tools as reported by the participants in this study was infrequent, relatively uncommon, and did not displace biomedical monitoring in most cases. Therefore, while there is some significance to how apps have the potential to influence the body, this should not be overstated, and should be situated in the nexus of advice on fetal movement and interactions with health care professionals.

Fetal movement monitoring apps

As the previous chapter established, fetal movement monitoring apps are apps with features that enable users to record fetal movements they perceive. Fetal movement is commonly considered to be a measure of fetal wellbeing, and women in the UK are advised during their antenatal care to be aware of fetal movement in the later stages of pregnancy, and to take note of any changes, notably a reduction, to the pattern of fetal movement that they consider to be normal, as this may indicate issues with the health of the fetus (Smyth *et al.*, 2016). Fetal movement monitoring

apps offer the capacity to track fetal movements. Apps may set parameters for normal fetal movement and encourage users to track based on particular alarm limits, and/or provide historic data log features to allow the user to build a picture of fetal movement patterns over time so that they might be better placed to notice a change. This could be through reference to the historic data log, or through embodied knowing of fetal movement that has been augmented with the learning activity of app use (chapter 4).

There is some debate on whether routine fetal movement monitoring based on particular time periods or alarm limits for the quantity of movement as promoted by many apps is effective in improving pregnancy outcomes. More recently this debate has extended to include challenges to the premise that awareness of fetal movement, whether or not it is formalised, is of any value in improving pregnancy outcomes, with a large 2018 study of 409,175 pregnancies finding that a campaign to raise awareness of fetal movement, with full assessment and expedited delivery in cases of reported reduction to fetal movement, did not have a statistically significant effect on rates of stillbirth, but increased rates of intervention in childbirth (Norman *et al.*, 2018). Nonetheless, awareness of fetal movement is routinely advised by the NHS and the Royal College of Obstetricians and Gynaecologists, with guidance emphasising the need for women to be aware of the pattern of fetal movement that is normal for them (Royal College of Obstetricians and Gynaecologists, 2019; NHS, 2021b). The use of formal fetal movement counting based on particular alarm limits is not routinely advised other than as an option after a perceived decrease in fetal movement as part of a pathway of considering further monitoring. This recommendation aligns with the use of fetal movement monitoring apps reported by some participants regarding the app as a supporting tool for augmenting their conscious awareness of fetal movement.

Conscious awareness

The primary use of fetal movement monitoring apps reported by participants was as a tool to support a short period of heightened awareness of fetal movement in order to gain a sense of reassurance about fetal wellbeing. For two of the three participants who reported using a fetal movement monitoring app, this stage of heightened awareness was likely to have been prompted by an intuitive sense that something had changed. Felicity described using this feature during her first pregnancy:

> I used it when I was worried that I couldn't feel the baby moving. And it was just to kind of- I think if I remember rightly it kind of gave you tips of how to lie or things to do that would encourage the baby to move a little bit, like I think lying on your side, I can't remember how long for, I think maybe it was half an hour, not doing anything else and just concentrating on counting movements, that's what I used it for, but I never actually ended up going in for reduced movements or anything with the first one (Felicity).

In the focused period of time when she used the app, she would concentrate on counting movements. She specifically referred to counting movements in a quantified sense, with the support of the app to record it. This was in response to feeling worried that she could not feel the baby moving, therefore the quantified tool of the app was a supplement to her embodied sense of fetal movement that preceded her use of the app.[39] She followed the advice of the app

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[39] This relates to the conceptual issue of the separation of gestating and fetal bodies. As regards fetal movement, fetal movement monitoring apps reify the fetus as a separate entity with its own health status to be monitored (chapter 4). Participants in this study reported uncertainty about distinguishing between fetal movements and other bodily sensations, which has been referred to in the existing literature on fetal movement. Ross found that pregnant women sometimes experienced fetal movement as "…indistinguishable from their own embodiment, describing sensations that shifted from being attributable to a foetal presence, to their own corporeality" (Ross, 2019, p. 106). These suggestions of fluidity between gestating and fetal bodies as articulated by Ross complicate the idea of separate bodies. A full discussion of this is beyond the scope of this chapter, but I often describe the fetus as distinct as this is the way in which participants referred to their pregnancies, and I also refer to women's bodily or

to lie on her side and focus on her physical experience of movement for a period of time and count. Her use of the app was to provide some reassurance, and also to help make a decision as to whether further action would need to be taken, i.e. contacting a midwife or hospital maternity assessment unit. As she reported, this practice reassured her enough that she never felt the need to seek additional help from a health care professional regarding these concerns about periods of reduced fetal movement.

Similarly, Eleanor used a fetal movement monitoring app, and she noted that she did not make use of all the functionalities of the app. She reported that when she was working or engaged in other tasks she may not be particularly focused on fetal movement, which meant that there were moments when she realigned her attention and became conscious that she may not have felt a movement recently. Like Felicity, Eleanor described her use of the app not as a constant tracking activity, rather she would use it when she had intuited a possible reduction in fetal movement:

> I haven't really used it too much but I think it's more, it's more of a reassurance thing that like if I think 'oh I haven't felt her for a little while' I'll um, I'll just sort of consciously track, and 9 times out of 10 within half an hour I'm like yep, no she's alive it's fine… (Eleanor).

She defined this process as "consciously track[ing]" – which suggests that her usual process of awareness of fetal movement was less conscious and that this was a more focused moment of awareness which she then quantified externally using the app. The general awareness of movement Eleanor referred to may be characterised as more qualitative than quantitative. Later in the interview she spoke about noticing "…when the baby's more active, when it's quieter…".

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embodied knowing of fetal movement. This is because while the fetal body might be considered separate, it is within and can be experienced as part of the gestating body.

Rather than counting movements across the day, she would build a general sense of more or less active times, and think about how recently she had felt a movement, using the app on some occasions when she had not felt a movement for "a little while". For both Eleanor and Felicity, their use of the app was irregular, and used as a supplement to their own awareness and intuitive knowing of the patterns of fetal movement. Instead of using the app to track every episode of fetal movement, they would use it reactively once they had already noticed a possible decrease in fetal movement. The conscious process of tracking and focusing their awareness on the movements they could feel was significant in this process, and they experienced fetal movement and reported this to the app proactively, rather than for example a sensor recording and reporting this data. In this way, different ways of knowing – experiential, embodied knowing and externally recorded quantified data – coexist and are interwoven.

Having an embodied awareness of fetal movement was impacted by how cognisant of fetal movement a person was able to be at a particular time. This perhaps made an app more useful, as it could be used to help focus on fetal movement after a busy time, but also meant that the app could not be used consistently due to the demands of everyday life. Part of Eleanor's reasoning for using tracking devices irregularly was a practical point. While she acknowledged that the capability of the app to track patterns of fetal movement over time may be useful, she explained that the nature of her working environment precluded her from making use of this function, as she was not able to use the app at any time she felt a movement:

> …realistically if you're working in a corporate environment and you're in meetings
> and stuff, you know 'sorry, hi client, I'm just gonna get my phone out cause my
> baby's kicking', um it's just not going to- not going to work! (Eleanor).

Apps that require constant or frequent entering of data are created with assumptions regarding the availability of users. In practice, this may simply have the consequence that the user makes use of the app at times that they deem convenient or when they feel the need to, as was the case with Eleanor. This echoes the concept of "partial data" proposed by Weiner and colleagues to refer to how people choose to record data intermittently or selectively (Weiner *et al.*, 2020). They argue that this does not mean the data is "broken" by nature of being incomplete, but that the selective recording of data is a conscious decision by users that allows them to achieve their aims (Weiner *et al.*, 2020). Eleanor and Felicity found value in the data they recorded intermittently as it provided them with reassurance, and the lack of a complete record of fetal movement was not something they considered to be an issue. The data they did not record was not simply missing – there was intentionality in when and how they chose to record data. Their recording of data was responsive to their perceived need for data, or at least the practice of collecting data, what that entailed, and how this could reassure them. This resonates with Gorm and Shklovski's work on episodic use (Gorm and Shklovski, 2019). They argue that there is importance in carefully defining what successful use of self-tracking devices looks like, for example as part of an employee wellness scheme. In their study of self-monitoring they found that episodic use of such technologies was relatively common, but also meaningful and important. Questions they suggest posing to evaluate what successful use of activity-tracking devices is include "did the user learn what they wanted to learn? Did they enjoy using the device? Has the tracking helped them care for themselves, whatever care means to them at that point in time?" (Gorm and Shklovski, 2019, p. 2519). None of these require continuous self-monitoring. In the case of pregnancy apps, episodic use allowed the users in this study to learn what they wanted to learn from using apps. Chloe and Felicity, for example, gained reassurance through their episodic use of apps that involved intentionally deciding when to record data, and when not to.

While not a complete record, a variation on using a fetal movement monitoring app reactively as described above is using an app at a similar time each day to build up an awareness of changes. Some apps encourage users to make use of fetal movement monitoring features in this way (chapter 4). One participant, Rebecca, had not yet used a fetal movement monitoring app at the time of our interview, but she intended to use an app at a similar time each day, rather than solely in direct response to a perceived reduction in movement. She intended to download a fetal movement monitoring app and use it as part of her daily routine of pregnancy-related self-care practices, alongside taking supplements, performing pelvic floor exercises, applying oil to her skin in an attempt to prevent stretch marks, and practicing perineal massage as a preparation for the birth. She kept a physical checklist of these practices on a whiteboard beside her bed and intended to work through them each evening, though she noted that her enthusiasm for keeping up this daily schedule of activities waned over time:

> I need to download the app when you're meant to put in when the baby kicks. Because um, from now, if the baby stops kicking then you have to like pay attention, and I know a lot of people have that app, so, I will- I do need to look up that app, because that's similar, it's like every day you have to do it and like, add it into my whiteboard probably (Rebecca).

For Rebecca, having this daily awareness of fetal movement, likely enhanced by a fetal movement monitoring app, was a daily practice that she categorised alongside other forms of self-care. She notes that "every day you have to do it", suggesting that she considers the app can be used as a tool to build up an awareness of usual movement patterns, but also that it is something that you "have" to do. This relates to existing literature on the social expectations placed on women to engage in health-promoting practices during pregnancy and to be responsible for caring for the fetus (Coxon, 2014). Rebecca reported her intention to download

an app for this purpose, but only one participant, Chloe, reported actually having used a fetal movement monitoring app to help in the process of building up this continual awareness of patterns of movement over a longer period of time.

Chloe had particular concerns about reduced fetal movement, to the extent that after presenting at hospital with reduced fetal movements three times she was placed on a reduced fetal movement care pathway. For a period of time, alongside hospital monitoring, she used a fetal movement monitoring app on a regular basis to record every time she felt a session of movement. She felt some frustration with the design of the app she was using as it did not enable her to build up a record of past movements in the way she would like. She would register movements across the day in the app. The following day, however, only the total number of movements recorded in the previous day would appear, without the detail of the time at which the movement occurred. As she shared:

> So it might be that sort of on a really hectic day I might sort of be like, I'll just register that movement and register that movement, but I've not really clocked what time it happened, and then a couple of days later I'll be like 'Wait, when was that? What time of day was that roughly? What was I doing?' and I'm having to sort of jog my own memory, whereas the whole point of using the app is that it's doing the memory for you isn't it? It's doing all the remembering, so you don't have to (Chloe).

For Chloe, the purpose of the app was to outsource this "memory" of fetal movement. In this form of usage, the app is an external means of building upon the user's own memory and sense of fetal movement patterns. However, Chloe expressed some annoyance that the app did not fulfil this role she intended for it. Unlike the other participants above, the capacity for the app to

only provide her with "partial data" was problematic for her, as she was not able to rely on the app as a complete record of fetal movement. Chloe was the only participant who explicitly framed the development of awareness as an act of memory or remembering, but others often referred to "patterns", and building up their own sense of how patterns would change. An app could be used to aid pattern recognition, in developing an awareness of the patterns of fetal movement that are usual for the individual, like in the case of Chloe. There is some potential similarity here with what Mol and Law describe as "introsensing", a phenomenon they observed in a study of blood sugar level monitoring (Mol and Law, 2004, p. 48). Some participants in the study would use their monitoring devices to train their "inner sensitivity" over time, mentally referring back to previous readings and associating the physical sensations they experienced with an understanding of their blood sugar levels being high or low (Mol and Law, 2004, p. 48). This is similar to the observation here of the app being used for pattern recognition – however there is some difference in that this process is somewhat less tactile. In the example of Mol and Law, participants came to interpret their embodied physical sensations in relation to the measurements they had previously taken, for example feeling weak and knowing this was likely to mean their blood sugar levels were low. In this case, the measurements recorded in an app could be used to train and understand patterns of fetal movement, but the process would involve observing a pattern of when movement occurs, rather than interpreting physical sensations to correspond to a particular measurement. While there are similar processes at play of training inner sensitivity, the practice of measurement and training sensitivity is more quantitative than qualitative in the case of fetal movement pattern recognition. Some participants actively rejected the use of apps to outsource this role in "remembering" or providing a record of patterns, as they prioritised their own sense of embodied intuition over a measure of fetal movement as quantified by an app.

Prioritising intuitive knowing

This section will explore the reasons cited by participants for non-use of fetal movement monitoring apps, with particular consideration of the role of intuition.[40] Four participants discussed their choices to not use pregnancy apps to track fetal movement. Three of these participants were pregnant for the first time and had never used an app to track fetal movement, and one had previously used such an app in her first pregnancy but was not using one in her pregnancy at the time of our interview. Felicity had used a fetal movement monitoring app during her first pregnancy to help focus her awareness as discussed above, but for her pregnancy with her second child she did not, and after giving birth reflected back on this:

> I was aware of her movements, and she was moving well, um, I think those kind of apps are really useful if you um, perhaps aren't quite confident that the baby's moving as much, but she never stopped moving, um, really, um, so yeah no I didn't really (Felicity).

For this subsequent pregnancy, Felicity felt able to trust her own awareness of fetal movement without feeling the need for the additional reassurance that a fetal movement tracking app had offered in her first pregnancy. She noted that this non-use aligned with her general habit of using fewer apps and using apps less frequently than during her first pregnancy due to greater confidence in the pregnancy in general given that she had experienced pregnancy before, and less

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[40] In the previous chapter, I used the term "intuition" as this word appeared in some of the apps analysed. Interview participants tended to use the term "instinct" or "instinctively" to express the same meaning, and I make no particular differentiation between these terms. As referenced in the previous chapter, my thinking is informed by Warland and colleagues' definition of (maternal) intuition in the context of pregnancy as "…natural inborn intelligence that guides and supports the pregnant mother to deeply know, without external influence, about her unborn baby's wellbeing" (Warland *et al.*, 2018, p. 175). Warland and colleagues also use the term "gut instinct" interchangeably with intuition/intuitive knowledge, citing Gore and Sadler-Smith (2011) to support their claim that "intuition is difficult to define because it encompasses the ability to understand something instinctively, without the need for conscious reasoning" (Warland *et al.*, 2018, p. 171).

time and headspace to use pregnancy apps due to being busy taking care of her first child. As well as feeling confident in their perception of fetal movements, other participants also reported that they did not feel the need to use a fetal movement monitoring app, or would find them inconvenient to use:

> I know there is a kick-counter and stuff in it, but I just think, well I can do that in my head, rather than sort of go on every time I've felt a kick, so yeah. I don't use it so much to track (Cara).

In a similar vein to Chloe's statement that the app can be used as "memory", Cara refers to keeping track "in my head", contrasted with using an app. This suggests that familiarity with patterns of fetal movement is a conscious activity that requires some specific focus and awareness, as was the case with users who made use of the app for reassurance after noticing a possible reduction in movement. Cara preferred to retain this information internally "in my head", in part because the inconvenience of needing to enter data in the app each time a movement is perceived. This echoes Eleanor's experience above of finding the app impractical to use at work, and lacking the capacity to stay focused on movements while engaged in other activities. For Cara, this was also an issue, but unlike users who found the app reassuring and a means to focus their awareness on fetal movement after a period of being less aware, she was concerned using an app would cause her more anxiety than reassurance:

> I suppose I just notice the baby now more, and know whether he's moved a lot or not, and so I don't know- I know they say obviously keep an eye on movement and if that changes, but I don't know if I want to specifically count the kicks, because I think I'd be getting obsessive about it, and then if I'm at

work and 'cause I'm busy and I can't feel everything, then I'd be worried, so I

don't think I'm probably going to use that (Cara).

This concern about being unable to use the app consistently during busy periods led her to reject the use of an app entirely, as in this view, the "partial data" generated by intermittent use could be more problematic than non-use. Cara was aware that she may not notice fetal movements when she was working or otherwise occupied and not focusing on these physical sensations. Her not being entirely conscious of these movements was not something she was generally concerned about, given that she felt she knew whether the fetus had "moved a lot or not", but if attempting to record movements consistently on an app, these times when she was not focused on perceiving movements would be enacted as gaps in data and appear as periods without fetal movement, and therefore be a potential source of anxiety for her. Entering this data into the app could therefore transform it from a blank space of potentially unperceived movement, to being identified as possibly no movement, and when reviewing her app data she may become worried about fetal wellbeing when she otherwise might not have been overly concerned due to her embodied sense of fetal movement being normal. Other participants expressed a similar concern about becoming obsessive, particularly if they were unable to use the pregnancy app while at work, or if they were sometimes unable to accurately intuit a movement.[41] Like Cara stated, this may be due to being busy and unable to fully focus on movements, or due to difficulty in being confident that a physical sensation was in fact a fetal movement. Beth described this issue:

I didn't need them [fetal movement monitoring apps], and also I just felt I'd just

end up being a bit neurotic and constantly entering information into an app and,

it would be quite hard actually as well I think, sometimes you're like 'is that, is

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[41] Self-monitoring apps being associated with obsessive behaviour and anxiety has been frequently reported in the existing literature on self-tracking practices (Ajana, 2020).

that a kick or is that wind?' [laughs]. So yeah, I think yeah, I just felt - and I'm

glad I just trusted my instincts on it (Beth).

The potential for the app to cause greater anxiety than reassurance is once again a reason for

non-use. While apps can offer reassurance to users, they may also have the opposite effect,

particularly if the intended use of the app does not align with the lifestyle of the user, or in this

case, where the data entered is reliant on maternal perception of fetal movement that can be

uncertain or unreliable. Additionally, the notion Beth raises of "trusting my instincts" was a

recurrent theme in this area of discussion. She expanded on it further, explaining:

I just generally felt like I just knew without counting when things- when things

were quieter (Beth).

This expression of "I just knew" highlights that she trusted her sense of fetal movement patterns

without the need for using an externally quantified measure in the form of an app. For non-users

like Beth, the potential for a quantified measure of fetal movement held no stronger value than

their own sense of fetal movement. Similarly, Hanna described a contrast between an embodied

sense or "familiarity" with fetal movement, as opposed to tracking with an app:

I guess some people track movements of their baby, using an app or something,

but it sounded to me like it wasn't really a very reliable way of doing that, and all

the kind of NHS guidance just said to kind of become familiar with how your

baby moves, rather than trying to track it with like a measurement or something

(Hanna).

In a related way to how Beth "just knew", Hanna went on to discuss the role of instinct:

I think they say you really should trust your instincts on that, like if you think 'hold on, I'm not sure if I've felt her movements', or they don't feel quite the same, that's when you should get checked. Like you instinctively know when something's not right, or when you feel like 'oh this is different', then that could be a sign of something wrong (Hanna).

Both Hanna and Beth emphasised this point of instinctively knowing, and felt that instinct was in direct contrast with tracking using an app or more broadly quantifying movement. For them, embodied, intuitive knowing about their own perception of fetal movement was more valuable than an externally quantified record of fetal movement. Beth described a scenario when she was worried about a possible decrease in fetal movement:

… I'd just count it, or I'd just- I don't know if I'd count, I think I probably just felt like 'does this feel normal?'. I felt that was a better way of doing it than numbers… it was more patterns than numbers for me (Beth).

As Beth noted, in a similar scenario to those who used fetal movement monitoring apps during a period of heightened awareness, she had intuited a change in movement, but she would focus on a feeling of normality, rather than counting during this period. The crux of how this awareness is built in order to develop intuitive knowledge is complex. Feeling movement consistently and/or based on particular patterns was a common experience among participants during the mid and later stages of pregnancy. Some participants were able to recount their normal perceived patterns of fetal movement with a high level of detail. For example, at 25 weeks of pregnancy Cara was easily able to describe the usual pattern of movement she would feel across a day:

…he's not very active in the day. Well like morning time he's quite quiet, and

then as the day goes on he gets busier, and then eve-, like after dinner in the

evening he's a proper wriggler. And as I get into bed he wriggles a lot, so that's

what he was doing last night, so that's good (Cara).

Without having used an app, she had an inbuilt knowledge of the changes in fetal movement

across the day, and was able to recall how the previous night this pattern had been followed,

which she described as "good", with this normality in the pattern of movement and spurt of

activity in the evening reassuring her of fetal wellbeing. Several participants mentioned their

awareness of fetal movement, and an active effort to stay alert to fetal movement in general. At

26 weeks, Julie mentioned trying to concentrate on movement:

So I'm feeling a lot of movement at the moment, and it's like, quite consistent, so

I'm just like trying to concentrate (Julie).

There is a complicated dynamic, in that some people used instinct to develop an awareness, or

moments of realisation that they felt concerned that movements had reduced. Yet they also

referred to needing to concentrate and focus with a conscious awareness of patterns, which is

difficult to sustain when engaged in other activities. There are therefore multiple dimensions of

embodied knowing: Chloe and Cara described fetal movement monitoring as "memory" or

something to be tracked "in my head", and instinct was also presented by participants as

something that is known, like Beth states, "without counting". This aligns with Warland and

colleagues' definition that intuition "…encompasses the ability to understand something

instinctively, without the need for conscious reasoning" (Warland *et al.*, 2018, p. 171). I suggest

that awareness of fetal movement is both conscious and instinctive in different ways and at

different times. Participants' descriptions of monitoring fetal movement referred to a conscious

awareness at particular times, sometimes informed by an intuitive sense of change. This allows room for externally recorded, quantified knowledge where there is a conscious process of tracking. However in these reports of intuitive knowing like those above, there is reference to a less conscious form of knowledge about fetal wellbeing, which is exclusively embodied, as recording fetal movement in an app requires conscious action. I argue in this and the previous chapter that embodied knowing can coexist with app use as the boundaries of different forms of knowledge are blurred, for example the data generated by the user and recorded within the app is reliant on user sensations. The data of the app is not inherently separate from the user's embodied experiences, as it is informed by those experiences.

A level of separation could, however, occur if the user's "memory" (to use Chloe's term) of historic patterns of fetal movement could differ from those reported back to the user by the app, and there could be some conflict between the user's embodied sense of normal fetal movement and the app's record. It would be left to the user to interpret whether a change to the pattern of fetal movement has occurred based on the data in the app, and their own embodied knowing of fetal movement, particularly as apps offer minimal functionality in terms of feedback on user data (chapter 4). Additionally, some participants viewed these ways of knowing as separate, and felt that quantifying fetal movement using an app was unnecessary and undesirable. Interestingly, their perceptions of the value of embodied versus quantified, externally recorded knowledge were not the same in all situations. While some participants rejected fetal movement monitoring apps, these same participants used fertility apps to track their menstrual cycles when trying to conceive, and used self-monitoring apps or other digital health technologies in other situations. For example, Beth rejected the use of fetal movement monitoring functions on pregnancy apps, but later became "religious" in her use of an infant sleep-tracking app after the birth of her child, and spoke at length about how this data helped her make sense of the passing of time during the day and night, which she found harder to intuitively understand when in the depths of sleep

deprivation.[42] This type of opposition of different ways of knowing can therefore be considered context-specific. As I have argued across this thesis, different ways of knowing interact, and participants make judgments about their value in different contexts.

An explanation for these different evaluations of externally recorded or quantified knowing is that in this context of fetal movement monitoring, some participants went on to directly relate their decisions to prioritise their instinctive sense of movement patterns over the use of an app to guidelines. As mentioned previously, Hanna was aware of the option of using an app to track fetal movement, but she did not consider this to align with NHS advice that she chose to trust. Beth made a similar argument for choosing not to use an app:

> …there was the Count the Kicks movement wasn't there, but I, I'd heard that it
>
> was recommended not to do that anymore. That you should really just be
>
> thinking about what was kind of normal for you…. (Beth).

Beth highlights that awareness of fetal movement, and the recommendation to be conscious of fetal movement as an indicator of wellbeing was wider-reaching than pregnancy apps. For example, midwives asked participants about feeling movement during antenatal appointments:

> … the midwives give you a 'have you felt the baby yet?', 'yes', and if you have, you know
>
> 'how often have you been feeling it?' you know all that sort of stuff (Eleanor).

It is important to acknowledge this wider culture of encouraging awareness of fetal movement, while recognising that the content of pregnancy apps entrench this, and due to the temporal

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[42] This is not technically self-monitoring given that it is monitoring a child, rather than the self, but this broadly fits into the category of a digital health technology, and given that Beth described being awake whenever her baby was awake at night, the overnight sleep data that she analysed also represented her own lack of sleep.

nature of the updates pregnancy apps provide on possible symptoms or sensations users could be experiencing (chapter 2), this could initiate a heightened awareness at a particular point in time or stage of pregnancy. A third of participants reported having noticed fetal movement mentioned in their daily or weekly pregnancy app updates about physical changes to their bodies and fetal development.[43] All of these participants mentioned that they then took additional notice of whether they might begin to feel fetal movement. As Rebecca noted:

> … it said, oh, 'you should start to feel the baby kicking now' so then I was like 'ok', like on high alert for that (Rebecca).

Felicity also noted increasing her awareness based on this reminder:

> I remember in the app saying, you know, oh, 'you might start being able to feel movements at this time but you don't have to worry about counting kicks for a little while longer', and then it did say you should be aware of your baby's movements around this time, and so it- yeah, I didn't necessarily change what I did, but it did put things in the front of my mind (Felicity).

In Felicity's account, the app had specifically advised her to monitor fetal movement by counting kicks later in her pregnancy, highlighting that apps suggest this is an appropriate way to monitor fetal movement. Additionally, the app increasing this conscious awareness of having fetal movement in the "front of my mind" was described in very similar terms by Julie. She recounted the first time she felt a fetal movement – she lay in bed and felt a sensation that she suspected might be a fetal movement, but she was not

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[43] This was not a direct question, this refers to participants who reported app references to fetal movement unprompted.

entirely sure what it was. The following morning the daily update she read on the
pregnancy app advised her that she might begin to feel movements around that time, and
this affirmed for her that she had felt a fetal movement:

…I was just kind of like 'surely not' and then the next day I was reading it and it was on
there, so it was well-timed, it was really much at the forefront of our minds (Julie).

In this way, the app teaches users to feel differently, by encouraging a particular awareness of
sensations of the body, as well as interpretations of feelings as fetal movement. Several
participants described being more aware of fetal movement, or actively attempting to sense fetal
movement following a suggestion from the app that this was something they were likely to be
able to do at that point in pregnancy. This type of suggestion within the temporal updates on a
pregnancy app could also have the reverse effect – Ross found that some participants in her
qualitative study of initial accounts of fetal movement doubted that they had felt what they
believed could be fetal movement as they experienced it earlier than biomedical accounts of
gestation would suggest is normal (Ross, 2019). The app providing this temporal advice
therefore interacts with ways of knowing and feeling the body.[44] Fetal movement may be difficult
to perceive, particularly in the earlier stages of pregnancy: many participants reported being
unsure whether they had felt a fetal movement or another bodily sensation. While this
uncertainty remained among participants who used and did not use fetal movement monitoring
apps, by giving temporal advice on the user's stage of pregnancy, the app can shape the
embodied knowledge users have at particular times.

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[44] I refer to "the body", rather than making reference to the fetus as separate as this point considers how sensations
of the body might variably be attributed to the self, or to the fetus.

Fetal movement monitoring apps as gatekeepers

As this chapter has established, the two primary ways in which fetal movement monitoring apps were used by participants were on a temporary basis to support a period of heightened awareness of fetal movement following a perceived reduction in movement, or as a tool to support the building up of a pattern of movement over time. In all cases, the participants' use of apps continued to be entangled with professional health care. A concern that several women reported regarding their potential interactions with health care professionals was apprehension about the way they would be perceived if seeking help for reduced fetal movement. Several participants described their concerns of being – or being seen as – "neurotic", "paranoid", "silly" and "wasting time". The use of a fetal movement monitoring app as what I characterise as a gatekeeper is motivated in part by this apprehension. For example, Felicity made a direct link between these concerns and using an app to help determine whether or not she should call her midwife due to possible reduced fetal movement:

> …you worry that you're being silly, and you don't want to waste people's time, so an app is
> a nice in-between to sort of, 'right, yeah, everything's fine' or 'no, I wouldn't be wasting
> people's time'. I know you shouldn't worry about wasting time, but you can't help
> thinking, 'oh I don't want to be that really neurotic pregnant woman that goes in every
> time anything's wrong', and so in that sense the apps are quite good … (Felicity).

In Felicity's case, her use of the app reassured her enough that she never felt the need to contact her midwife. She described the app as an "in-between", to fill a perceived space between making a personal assessment of everything being fine, and contacting a midwife. This affirms my findings in the previous chapter of the relational value of data generated through fetal movement monitoring apps. My app analysis demonstrated that some apps advised users that data could be

used to show to health care professionals as a way to provide "real data" that corroborated their sense that fetal movement had reduced (chapter 4). From this small sample it is not possible to draw strong conclusions about how widely this practice is used – particularly as the decision to seek further assistance is likely to be contingent on a number of factors, including the level of concern felt, as well as a person's perceptions of and past experiences of interactions with health care professionals.

Ultimately the women I interviewed did report calling a health care professional when they were concerned about changes in fetal movement. Four participants had contacted a midwife regarding a reduction in fetal movement, and three had then been advised to go in to hospital for further monitoring, and had done so. This suggests that the experience of reduced fetal movement is relatively common, as this represents a third of participants interviewed in pregnancy, and some participants were only interviewed at a stage of pregnancy before movements were perceptible, so this may also have occurred for more participants at a later stage. All of those who had reported reduced fetal movement felt that their concerns were taken seriously and they were reassured that they were not wasting time. Some stated that they were advised to make contact again if they had further concerns, and were specifically told that they should not feel nervous about taking up time:

> …sometimes the midwives can be a bit grumpy. But when you get checked, like the monitoring place, they were super friendly there. Obviously like, stillbirth is being prevented, and I think they said they really want to encourage you to come in, if you feel she's moving less, even if it's like later today or tomorrow. And that was really nice as well, because if you feel like you're wasting their time, and that makes you think 'oh maybe I'll wait another day', when actually maybe you need to go in (Hanna).

The positive reports of these interactions with health care professionals are not universal experiences. As established in the literature, women may face structural barriers to accessing care, and interactions may for example be layered with experiences of racism. Racial bias in maternity care contributes to the substantial difference in maternal mortality rates between women from Black ethnic backgrounds and white women in the UK, with stillbirth rates for Black and Black British babies being over twice those for white babies (Anekwe, 2020; Draper *et al.*, 2021). Specific to fetal movement, Smyth and colleagues found that some women did not feel taken seriously when presenting with reduced fetal movements, and some clinicians corroborated this (Smyth *et al.*, 2016). When navigating an issue where making judgements on the need for help can be very difficult to weigh up, these are considerations that apply additional stress and complicating factors for some women. These types of experiences may impact the role of these types of apps for users who do not benefit from positive and privileged health care provision, but this is not possible to determine from this study. Nonetheless, the role of apps as gatekeepers is an important finding to acknowledge, as it is possible that it could lead to reassurance when further action should be taken. A similar hypothesis was made by Daly and colleagues regarding the guidance about decreased fetal movement that appears in pregnancy apps:

> … if recommendations for stimulating fetal movement or kick counting are followed, a critical window of opportunity could be missed for prompt, appropriate action to avert an adverse outcome such as stillbirth (Daly *et al.*, 2019, p. e294).

Due to the limited capabilities of apps to provide a measure of fetal wellbeing beyond helping guide the counting of patterns and offering a means of recording movements (chapter 4), it is important not to overstate their function in allowing women to take charge of their own care. This has been a common theme in the discourse on digital health technologies such as

smartphone apps more generally, for example Topol's argument that the digitization of medicine will be democratizing by allowing patients to take greater control of their own health care (Topol, 2015). The lack of relevance of this argument regarding fetal movement monitoring is in part due to the difficulties involved in recognising fetal movement. Previously in this chapter, participants reported uncertainty in their experiences of fetal movement, for example Beth's description of sometimes being unable to distinguish fetal movement from wind. An existing study of perception of fetal movement found that the number of movements observed by an ultrasound operator was significantly more than those felt by the pregnant woman in the same period (Brown *et al.*, 2016). There is therefore a limitation in the capacity for fetal movement monitoring apps to provide information on fetal wellbeing, as even the most consistent user is likely to record only partial data on fetal movement.[45]

This brings the value of monitoring fetal movement into question entirely. As established earlier in this chapter, there is some debate on whether maternal perception of fetal movement is a reliable indicator of fetal wellbeing (Gidlöf, 2019). Several participants reported an awareness of these types of limitations, both in the capabilities of fetal movement monitoring app functions, and in the parameters of their own embodied knowing. While participants sometimes criticised and challenged the care and advice provided to them by health care professionals, they all treated biomedical monitoring of their pregnancies as necessary and normalised.[46] Among those who chose to rely on their own embodied knowing of fetal movement and reject the use of apps, biomedical monitoring was still seen as superior to their own embodied knowing of fetal

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[45] There is a value judgment here in suggesting that an ultrasound scan is a more valid or accurate measure of fetal movement than the experiences of the pregnant woman. This reflects the views of participants on biomedical monitoring being capable of assessing fetal wellbeing in ways that were more reliable than their own perception of movement. Further discussion of this is beyond the scope of this chapter.

[46] There were multiple criticisms and challenges reported in interviews. This was sometimes a criticism of a particular health care professional – for example a doctor not taking a participant's abdominal pain seriously and misdiagnosing kidney stones. Some participants also expressed that they would prefer to avoid what they deemed to be excessive intervention in the physiological process of childbirth. However, no participants expressed these types of opinions to the extent that they fundamentally challenged the biomedical model of maternity care, and none expressed an intention to give birth without medical supervision.

movement, and by proxy, fetal wellbeing. As mentioned, this was also sometimes a rejection made with direct reference to NHS guidance. This respect for embodied knowing can therefore still be understood as part of accepting a biomedical interpretation of pregnancy, as opposed to an alternative embodied way of experiencing pregnancy (Young, 1984; Duden, 1993). The same was true of participants who did use apps to monitor fetal movement – while participants who used fetal movement monitoring apps reactively as gatekeepers were sometimes reassured by their use of apps, they would still seek advice if they had concerns regarding fetal movement and not rely on the apps as their sole source of care.

Conclusion

This chapter has offered original empirical findings on the use of pregnancy apps for monitoring fetal movement, and how this relates to the ways in which participants understand and experience their bodies during pregnancy. Participants drew upon both conscious and intuitive forms of embodied knowing to monitor fetal movement. Some participants used an app to augment their conscious awareness of fetal movement, and found value in the "partial data" they recorded that allowed them to feel reassured about fetal wellbeing following a perceived reduction in movement. Other participants used or intended to use fetal movement monitoring apps as a form of outsourced memory to capture regular patterns of movement. However, the partial nature of the data collected, and/or the limited functionalities of apps in holding a complete record of the times when movements had occurred meant that this was incomplete. Most participants did not report using a fetal movement monitoring app, with some non-users citing a contrast between embodied knowing, and quantified, app-informed knowing as part of their reasoning for not using apps. Nonetheless, some of these same participants used apps for self-monitoring in other contexts. This contributes towards my overall finding that women's use of pregnancy apps is intermittent, selective and discerning.

This chapter also demonstrates that the use of pregnancy apps relates to the ways in which women understand and experience their bodies in a dynamic process that flows in two directions. Participants chose to use or reject fetal movement monitoring apps in part based on their understanding of their capacity for embodied knowing. In the opposite direction, the use of apps could influence participants' embodied experience of pregnancy by increasing their bodily awareness and enacting particular sensations as fetal movements. This chapter supports the findings of the previous chapter that while different forms of knowledge interact and coexist, personal assessments of fetal wellbeing – whether or not this involves an app – are generally seen to need corroboration by health care professionals to monitor fetal wellbeing. This is a premise supported in the content of apps I analysed, and by the participants I interviewed. Together these chapters on fetal movement monitoring apps both support and nuance the claim made by theorists such as Young (1984) that technologies devalue embodied knowing in pregnancy. Overall, in this chapter I describe intermittent or minimal use of apps reported by participants, limited functionalities of fetal movement monitoring apps, and a wider cultural context of maternity care that enacts awareness of fetal movement as an indicator of fetal wellbeing. The potential influence of these apps for democratising medicine, and for impacting embodied knowing, should therefore be recognised, but not exaggerated.

Discussion

Introduction

In this chapter I draw together my results from across the five findings chapter of this thesis, and explore them further with reference to the existing literature. I begin by detailing a final summary of my main findings, and address the two core research questions, and further supplementary question that guided this study. I then go into greater depth in considering two overarching themes drawn from my findings: bodily knowing; and risk and reassurance.

Summary of main findings

In this study, I aimed to gather new empirical data that would extend the existing literature on fertility and pregnancy apps in a UK context. I utilised a mixed methods, qualitative approach to develop the current body of literature which has mostly relied on content analysis of apps, or on surveys. I recruited interview participants from across the UK, which extended existing UK-based research on pregnancy apps that had been based in London. My guiding research questions were:

1. How and why do women use, or choose not to use, fertility and pregnancy smartphone applications before and during pregnancy?

2. How does the (non-)use of fertility and pregnancy smartphone applications relate to the ways in which women understand and experience their bodies before and during pregnancy.

In Chapter 4 I addressed the supplementary research question:

3. How do fertility and pregnancy smartphone applications shape women's knowledge and/or understanding of pregnancy?

I answered these questions in the following ways. I found that, regarding my first question, women use fertility and pregnancy apps selectively and critically. They may notice weaknesses in the apps they use, and use methods such as cross-referencing to test their validity. They selectively use different features according with their perceived value and utility, and vary their usage across the course of pregnancy. Where participants did use apps for self-monitoring, it was primarily for tracking fertility, and only a minority of participants used the self-monitoring features of pregnancy apps, with the most commonly reported uses being for tracking diet, weight, and fetal movement. Participants used fertility apps to pursue a data-led or scientific approach to their fertility and optimise their chances of becoming pregnant. The primary reasons why some participants resisted certain app features were a perceived lack of utility – which could include not having given particular consideration to using them as they had never felt a need was not being met – concerns about becoming obsessive and anxious around their use of apps, and wanting to prioritise their own bodily knowing over quantified metrics. While existing critical analyses of pregnancy apps offer valuable insights into the ways in which apps construct and reinforce cultural norms, this study of the lived experience of using apps shows high levels of non-use, non-interest, and relative ease in resisting app features. Participants used apps for information seeking more than for self-monitoring, but they nonetheless formed part of their practices of self-management in pregnancy. Consuming the more limited amounts of information daily or weekly allowed them to process information in a more manageable way.

For most participants, their information seeking was centred around understanding fetal development week by week. They used apps to share this information on fetal development with partners, and some partners used pregnancy apps themselves to gain independent access to the pregnancy in some way. I conceptualised some of these dynamics as interactions with a counterpart pregnancy, a virtual pregnancy that develops concurrently to, but separately from,

the physical pregnancy, with the separateness becoming more noticeable where there were discrepancies between the development of the two. Later in pregnancy, some participants used pregnancy apps to assist with their monitoring of fetal movement. They would either use the apps to gain a sense of reassurance by enabling a session of heightened awareness after intuiting a possible change in fetal movement, or over a longer period of time to help build up a sense of what the normal patterns of fetal movement were. However, it was more common for participants not to use apps for monitoring fetal movement.

As I will describe in this discussion chapter, all of these uses of apps related to themes of risk and reassurance. Participants demonstrated that they felt pregnancy required monitoring and that they should alter their daily practices to avoid risk. They reported feeling some reassurance through various aspects of their app use, which was interesting given the lack of personalisation and insight that the apps could offer into the development of their own pregnancies. Some participants spoke of feeling isolated, particularly in early pregnancy, and the app was something that helped them to feel reassured and offered some sense of a shared experience of other women going through or having gone through the same things, for example through the video updates on some apps. Based on the dynamics of use of apps for fetal movement monitoring that some participants reported I offer a new emerging conceptualisation of pregnancy apps as gatekeepers that some women refer to while deciding whether to contact a health care professional. I suggest that this was in part a social role, rather than a medical or diagnostic one, in reassuring users whether or not they would be justified in seeking additional help, but that this could have the consequence of offering a user false reassurance.

Turning to my second research question, I found a number of ways that fertility and pregnancy apps related to the ways in which women understand and experience their bodies before and during pregnancy. For fertility apps, I suggest that the categories they allow users to record has

the potential to expand users' understandings of what constitutes fertility. I found that participants responded to this differently, with some accepting a broader definition of what was relevant to fertility, and others wishing to focus on a restricted number of factors to track that they felt correlated to fertility. The suggestions of the app made some participants physically more aware of their own bodies in encouraging them to look for or feel factors that might indicate they were ovulating. Some apps used techniques of gamification to reinforce this, which some participants felt was inappropriate and unfair given the lack of control they ultimately had over their bodily processes. The apps defining what constituted fertility was evident in how some participants trusted the fertility app's definition of ovulation and interpretation of their changes in basal body temperature over their own physical experiences that they related to ovulation. Additionally, the emotional significance of self-monitoring was evident, for example with some participants becoming obsessive about fertility tracking, or feeling fear around the practice of tracking when they had gone through a previous miscarriage and associated changes to data with the potential to experience another loss. As with fertility apps increasing bodily awareness, pregnancy apps had a similar effect for some participants. They reported being on alert for particular symptoms at particular times as they mapped the weekly updates onto their own pregnancies. Users retain the capacity to own knowledge and awareness of their own bodies, and may choose to reject the conclusions of data if they question the validity or relevance of this data, or more generic advice provided by apps where it is not relevant to their body or does not match with their embodied experience. For fetal development, the development of the counterpart pregnancy made them feel more pregnant and helped them understand their bodies, what it contained, and the body of the developing fetus.

I offer a unique contribution to the literature by providing an in-depth analysis of fetal movement monitoring apps both as an app analysis and through interview data. Considering my third research question, I found that some pregnancy apps themselves suggest that quantified

and embodied knowing are compatible, rather than always suggesting bodily knowing is secondary, which complicates existing literature on pregnancy apps. Nonetheless, I found that in practice some users reject quantified measures of fetal movement in favour of trusting their own bodily knowing. This type of perspective informed how participants used apps – the above findings explain how apps can influence users' understanding of their bodies, but if they understand their bodily knowing as more significant than the metric knowing of the app this informs how they choose to use, or not use apps. In this thesis I have emphasised the experiences and perspectives of participants on intuitive knowing, which is a contribution of this study enabled by my inclusion of non-use and selective use of apps. This gives further insights into how participants view and experience different ways of knowing.

Bodily knowing

As I have reasoned throughout this thesis, participants make judgments about the value of different forms of knowledge in different contexts, and different ways of knowing coexist and interact. Some existing scholars' work on self-monitoring apps (including pregnancy apps) has claimed that they suggest that quantified knowing is regarded as more "objective" and therefore more valuable than more subjective, embodied forms of self-knowledge (Sharon and Zandbergen, 2017). I contribute new empirical material to these discussions, particularly in chapter 5, where I explored the nature of embodied knowing, which some participants described as memory, and how some participants experienced intuitive knowledge and therefore resisted quantified self-monitoring.

My study has commonality with some existing research on fertility apps that shows the relationship between the objective and subjective to be nuanced. Grenfell and colleagues write:

While we observed the privileging of disembodied, quantifiable data that Lupton and others have described, we also found that women's bodily and affective engagements with the technology and, at times, continued reliance on felt, bodily understanding allowed for a certain (re-)centring of embodied knowledge (Grenfell *et al.*, 2021, p. 128).

I too found evidence of "the privileging of disembodied, quantifiable data" – for example, in chapter 1 I described how one participant used her fertility app to define what constituted ovulation, and believed the app that demonstrated that she had not ovulated based on basal body temperature readings over her own physical symptoms that led her to believe that she had ovulated (chapter 1). I used Mol's concept of the body multiple as an explanatory tool, arguing that this practice of using a fertility app to monitor basal body temperature enacts different versions of ovulation (Mol, 2002). An original contribution of my study is that I extend this discussion to include pregnancy apps, rather than solely fertility apps, and provide a case study of fetal movement monitoring which I have not found looked at in depth in any qualitative interview study of pregnancy apps. Additionally, through my focus on different app functionalities I was able to explore dynamics of selective use, which helped give more insight into ways of knowing from user, or non-user, perspectives than in the existing literature on fertility and pregnancy apps which has mostly focused on users.

When exploring fetal movement monitoring, I found that the ways in which participants used apps links to how they experienced and perceived different ways of knowing. Participants described drawing upon a conscious awareness of fetal movement that fluctuated in intensity, being at some times at the forefront of their attention, and at other times falling into the background. For some participants, this was compatible with using pregnancy apps for tracking, as it could supplement this form of embodied knowing and serve either as a tool to augment their own awareness, or as an outsourced memory, which is how some participants intended to

use it (with some limitations to this being in place due to the lack of functionality of some apps to record the specific timings of episodes of fetal movement). For participants who used (or intended to use) apps for fetal movement monitoring in this way, the apps served as a way to remember the timings of the movements they had experienced. Both embodied knowing and quantified knowing on an app are complementary here, and the app relies upon bodily data perceived by the user, rather than challenging this bodily knowledge through a metric that has been measured using an external tool. Additionally, a new finding of my analysis of fetal movement monitoring apps is that many apps themselves account for the coexistence of different forms of knowledge, and promote embodied or intuitive knowing as a valuable source of knowledge. In the case of fetal movement, the use of apps is often positioned by the apps themselves as a means for users to strengthen their own embodied knowing so that they might be able to identify fetal distress without using an app (chapter 4). Some of the apps suggested that their fetal movement monitoring tools could be used to improve the user's self-awareness of fetal movement, and develop this sense of normal patterns of fetal movement (chapter 4). This develops existing literature on pregnancy apps that suggests that the rhetoric of apps positions metric knowing as superior to embodied knowing (Lupton, 2015).

Some of the existing literature on self-monitoring refers to embodied knowing and has demonstrated this nuance in terms of user perspectives, rather than app content. Grenfell and colleagues found that some participants would prefer to rely on their embodied knowing than the advice they received on an app – though in my study, I found that where some participants had a strong feeling that their embodied knowing of fetal movement was more important than quantifying episodes of fetal movement on an app, they would resist this feature entirely and not use it, rather than the report of Grenfell and colleagues that participants would use an app, find that the data suggested something that conflicted with their embodied knowing, and choose their own bodily knowing as more reliable than the data (Grenfell *et al.*, 2021). However, while the

existing literature on self-monitoring has examined the use of technology in relation to embodied knowing, these findings add more insight into intuitive knowing.

The model of use that some apps recommend would align with some existing work on health technologies and self-awareness, such as Mol and Law's observation that measurement tools can help "train inner sensitivity", using technology for what they what they referred to as "introsensing" (Mol and Law, 2004, p. 48), as well as other work on self-monitoring tools that emphasises the role of digital tools in helping users develop bodily awareness, rather than superseding bodily knowing (Nafus and Sherman, 2014; Ruckenstein, 2014; Sharon and Zandbergen, 2017). However, in practice some participants also spoke of a more intuitive or instinctual sense of fetal movement that they felt could potentially indicate to them that something was wrong. They suggested that this could not be quantified or recorded, for example referring to a qualitative sense of something feeling "normal", rather than being something they quantified internally when they focused on fetal movement, let alone using an external app to record this in data form. Unlike the complementary, dualistic use of technology to record bodily sensations and in turn augment bodily awareness as has been described in some of the existing literature, this suggests that there is a level of intuitive knowing that is not possible to link to the use of digital health technologies. Furthermore, I show how those different types of knowing are aligned. Some participants resisted the use of apps for monitoring fetal movement, choosing to trust in this sense of intuition. Not only did some participants value intuitive knowing over quantified knowing, the two were considered by some participants not to be complementary. Smith and Vonthethoff argue that among the Quantified Self community of individuals engaged in self-monitoring

the will for greater self-knowledge and bodily enlightenment was framed around an inherent dissatisfaction with – and distrust of – the sensing, feeling, and intuitive organic

body as a bounded instrument of illumination and as a vehicle of change (Smith and Vonthethoff, 2017, p. 15).

In my study, where individuals resisted self-monitoring they suggested the opposite to be the case, trusting in the intuitive body. Smith and Vonthethoff describe the organic body as "sensing, feeling, and intuitive", and my findings suggest that these categories of knowing are interrelated but somewhat distinct – some knowing is based on sensing and feeling, but is not necessarily intuitive. There are some parallels here to Polanyi's germinal work on knowledge. He suggests that there are two dimensions of knowing, explicit and tacit knowing. Explicit knowing is based on focal awareness, and developed through focusing on or paying attention to an object (Polanyi, 1969, p. 128). Tacit knowing is based on subsidiary awareness, that may not be explicitly known and is therefore not possible to describe or share with others. As Polanyi describes it, "…we can know more than we can tell" (Polanyi, 1983, p. 4). Knowledge of fetal movement falls into both categories – participants described a subsidiary awareness of fetal movement that fell into the background when they were working or otherwise busy, and at times they paid attention to this movement with focal awareness, sometimes aided by the use of an app. Based on explicit knowing of fetal movement they could describe movement patterns across a day, for example as one participant reported "…as I get into bed he wriggles a lot". This could be recorded on an app. There was also a level of tacit knowing that participants described – even when focusing on specific fetal movement, some participants described deciding whether something was normal, or not normal, the specifics of which they may not be able to describe and communicate. Additionally, they discussed possible instances of "just knowing" something might be wrong. Some apps also alluded to this, advising users to "trust your intuition". These types of tacit knowing, of which intuition is one aspect, cannot be recorded on an app. Participants blended these ways of knowing together, some using apps as well as their own tacit knowing, whereas some relied on their embodied knowing, some of which was tacit.

The terms that participants, and the apps, often used to describe this were intuition or instinct. I suggest that perhaps this is at some level more prevalent in a study of fertility and pregnancy than other areas of health (which I suggest given that I have not found intuition or instinct to be dominant concepts in the literature on digital health technologies), as the idea of intuition, or what is sometimes described as maternal instinct is normalised in some discourses. In chapter 4 I drew upon Warland and colleagues' definition of intuition – specifically maternal intuition – as "…natural inborn intelligence that guides and supports the pregnant mother to deeply know, without external influence, about her unborn baby's wellbeing" (Warland *et al.*, 2018, p. 175). This idea of specifically maternal instinct or intuition is somewhat problematic. Innately associating the female body with reproduction and childrearing in this way has been used to subjugate women, with the coding of women as "…somehow *more* biological, *more* corporeal and *more* natural than men" being used to suggest women are more physical and intellectually inferior to men who operate at a higher conceptual level, with concerns of this variety leading to some initial reticence about theories of embodiment among feminist scholars due to the grounding of the body as essential to experiencing the world (Grosz, 1994, p. 14, emphasis in original). Nonetheless, the idea of maternal instinct or intuition is relatively familiar in discussing fertility, pregnancy and birth. Some childbirth educators assert that women have intuitive knowledge or inner wisdom about childbirth (Savage, 2006). In Warland and colleagues' study about intuition and stillbirth many women described a gut instinct that something was wrong, with some even referring to dreams or feelings of premonition (Warland *et al.*, 2018). Some of the literature on breastfeeding and sleep emphasises the connection between breastfeeding mothers and babies, observing that they will "instinctively" form a protective position if bedsharing, sometimes in their sleep while barely conscious (Ball, 2006). How participants used apps depended in part on how they chose to merge these different ways of knowing, with some not able to be captured through an app.

Furthermore, there are echoes here of work that suggests that self-monitoring apps fail to capture the intricacies of human experience – in Thornham's study of parenting apps she reported that while apps may neatly record the length of a session of breastfeeding, they fail to account for factors such as the pain it causes, and writes that "although nuances and complexities can be added as a note to inputted data, this functions in a non-constitutive way… such notes are a complication and messiness to a clean and simple, 'scientific' and atomized metric" (Thornham, 2019, p. 179). I found that only one app allowed for more qualitative measures of fetal movement, such as the feeling of a swish or a jab, and in general the apps encouraged or allowed users to record the quantity of fetal movements in a specific period of time (chapter 4). This would not account for what participants described as "normal", or how they "just knew", in ways that they could not necessarily articulate (chapter 5).

While some participants emphasised the value of intuitive knowing for monitoring fetal movement, this was only the case for particular types of knowledge, however – in line with how participants viewed some data points as more valuable than others, for instance with fertility tracking where some participants described cervical mucus and basal body temperature as relevant measures to track, and bloating as irrelevant, they were critical and selective in how they chose to use fertility and pregnancy apps. Some participants who subscribed to the view that fetal movement monitoring should not be quantified with an app made use of self-monitoring apps in other areas, for example for fertility or tracking sleep. The perspective some participants held that fetal movement monitoring should be based on embodied knowing of unique patterns of movement appeared to be informed in part by guidelines that recommend that individuals learn their personal patterns of fetal movement, and do not rely on kick counting charts, that had in turn influenced how they understood their own ability to evaluate fetal movement. I infer from the fact that the participants who most vocally resisted the use of fetal movement

monitoring apps referred specifically to guidelines, the guidelines emphasising the value of intuitive knowing meant that some participants felt able to trust in their intuition – though as I have mentioned, this was nonetheless considered less reliable by participants than professional knowledge, care, and technological tools, and their instinctive knowing was only limited to the extent of intuiting a change that might mean they would seek additional help.

My findings also suggest that pregnancy and fertility apps have the potential to shape how users understand and experience their bodies and their own self-knowledge. The above speaks to the role of personal health data in relation to embodied knowing, but I also found that there was significance in the use of pregnancy apps as a source of information that could contribute to similar dynamics. In chapter 1 I explored how by encouraging users to track a variety of factors and integrating these into their design, fertility apps enact different aspects of bodily experience and of practices as associated with fertility. Participants, however, accepted these suggestions to different extents, with some holding clear ideas on what was and was not relevant to their fertility tracking practices (chapter 1). As above, participants were selective in what they chose to track, what they felt was valuable to track, and also they demonstrated critical awareness of the reliability of fertility apps. Some participants cross referenced multiple apps to increase the accuracy of fertile window predictions, or used additional tools such as ovulation tests to verify the apps. Participants were active in how they made sense of fertility, and how they aligned different ways of knowing with their use of apps. Some built the apps' suggestions that multiple factors could be related to fertility into their self-understanding, and others focused on a smaller range of factors as part of fertility. Some participants suggested that they had become more aware of their bodies from their use of fertility apps, and were looking out for particular signs or symptoms that the apps suggested they might experience. This was also true of pregnancy apps. Temporal advice on the symptoms that might be expected at particular points of pregnancy sometimes heightened participants' awareness of their bodies. For example, by framing maternal

experiences of fetal movement as situated along particular temporal pathways, pregnancy apps can influence how women interpret bodily sensations as fetal movement (chapter 2). This phenomenon did not of course diminish the participants' own sense of their bodies, which sometimes did not align with the suggestions of the app – for instance, one participant reported that a pregnancy app suggested her nausea should have passed, but she continued to feel nauseated for a further two weeks. Nonetheless, it could heighten awareness in seeking particular symptoms, and lead to the interpretation of symptoms in particular ways. There are similarities here with the work on self-monitoring cited earlier in this chapter that the practice of self-monitoring can lead to increased bodily awareness (Mol and Law, 2004; Nafus and Sherman, 2014; Sharon and Zandbergen, 2017). Instead here it is generic data applied to the personal that can have this effect if delivered to the user at particular times. This adds another dimension to the literature on self-monitoring, because fertility and pregnancy apps are self-monitoring tools, but the roles they play as sources of information that is minimally personalised reflects some similar dynamics to personal data, even when it is generic.

The fetal development updates on apps could also influence the embodied experience of pregnancy. Several participants also reported that the fetal development updates helped them make sense of and justify the physical symptoms they experienced, while in turn making their pregnancy feel more real. For example, in the early stages when pregnancy was described by many participants as "abstract", seeing the fetal development updates on a pregnancy app made them understand their body as pregnant. This has similarities to work on ultrasound, such as Georges' work that suggests women feel more pregnant having seen an ultrasound (Georges, 1996). Pregnancy apps can therefore shape the embodied experience of pregnancy by influencing how women perceive and make sense of their pregnant body. This also aligns with Rothman's work on "the tentative pregnancy", a term she uses to describe the way that women may not be able to accept their status as pregnant until prenatal tests confirm that their pregnancy is healthy

(Rothman, 1988). For some participants, referring to the comparatively sized objects on pregnancy apps helped them to understand the scale of what they viewed during ultrasound scans, as these could be difficult to comprehend. An important aspect of ultrasound scans for many participants was reassurance about the development of their pregnancies.

Risk and reassurance

Pregnancy apps serve a dual purpose in offering information, and functionalities for self-monitoring. For the majority of participants in this study, the primary motivation they described for using pregnancy apps was as a source of information on fetal development. This supports the findings of existing studies of pregnancy apps. In Lupton and Pedersen's survey of Australian women's use of pregnancy and parenting apps, women reported that apps were chiefly useful to them for accessing information on fetal development, with accessing information on bodily changes in pregnancy also important for most women (Lupton and Pedersen, 2016, p. 371). A much lower proportion of women surveyed used apps for tracking weight gain and diet in pregnancy (Lupton and Pedersen, 2016). This aligns with my findings, as in this study, while the vast majority of participants used a fertility app for self-monitoring while trying to conceive, only a minority used pregnancy apps for self-monitoring in terms of entering data. Participants in my study engaged with updates on fetal development on a more regular basis than any other of the app features they used, and continued to use this feature for the longest duration across the course of pregnancy. Towards the end of pregnancy, several participants described using pregnancy apps on a less regular basis than they had done earlier in pregnancy, but the weekly update on fetal development was something they still enjoyed reading – or watching, in the case of video updates – each week. For some participants, this reduction in the frequency with which they used pregnancy apps was related to how they negotiated risks in pregnancy, and their corresponding desire for reassurance as it changed over time. Participants generally reported

being conscious of risk in pregnancy, and particularly in the early weeks several spoke about their concerns around the risk of miscarriage.

In chapter 3, I explored how understanding and tracking fetal development through an app (using the term "tracking" loosely, given the lack of personal data that is recorded by the user, with tracking generally used by participants to refer to tracking the week by week progression of their pregnancy) was a way for some participants to seek reassurance about the progression of their pregnancies. There was resonance in these findings with the existing literature on ultrasound use in pregnancy, which is interesting due to the different levels of technical capabilities between pregnancy apps and ultrasound. While originally conceived of as a medical technology, ultrasound is increasingly becoming a more social and commodified technology, particularly with the proliferation of private scans marketed both as for reassurance and as part of bonding (Thomas, 2017). There is a large body of work on ultrasound that shows that it often offers reassurance to pregnant women in cases where the pregnancy is developing as hoped (Harris *et al.*, 2004). An original finding of this thesis is that the generic images and advice offered on pregnancy apps offered a level of reassurance to users about the development of their own pregnancies. Written information, ultrasound images of other pregnancies taken at similar points of pregnancy, and illustrations that showed the possible size of a developing fetus all enabled participants to understand what was supposedly developing within. Some participants described this as reassuring to them in terms of making them feel that things were developing or happening as they should be, even though the app could not provide specific information on their individual pregnancy. As noted in chapter 3, Han reported a similar phenomenon with US women's consumption of illustrations printed in pregnancy advice books, with illustrations being described as reassuring by participants in Han's study (Han, 2013, p. 38), but this finding has not to my knowledge been reported in existing studies of pregnancy apps. Participants confirmed that images on pregnancy apps did not offer the same level of reassurance offered by an

ultrasound scan, and they did not relate to them in quite the same way. Additionally, as noted in chapter 3, where there were discrepancies in measurements reported within the app and those taken during antenatal care this could cause anxiety. Nonetheless, the practice of using a pregnancy app and learning about the fetal development updates purportedly taking place had a role of companionship that allowed participants to feel somewhat more secure in the development of their own pregnancies.

My framing of the fetal development updates on pregnancy apps as a counterpart pregnancy is also a contribution of this thesis. Like Ruckenstein's (2014) conceptualisation of data doubles in self-monitoring, I used the term counterpart pregnancy to describe how a virtual assemblage is enacted and develops in parallel to the user's pregnancy (chapter 3). I suggest this a useful concept to unpack the interactions users have with pregnancy apps, including the emotions that arise when users encounter discrepancies between the development of the counterpart pregnancy and their own physical pregnancy. Some participants shared that the continued development of the counterpart pregnancy after they had experienced a pregnancy loss added to their distress, which also confirms some existing literature that notes that pregnancy apps do not account for miscarriage effectively (Ley, 2016; Andalibi, 2021). This is also reminiscent of Ebeling's investigation into her "marketing baby", a term she uses to describe the baby enacted in the marketing materials that she continued to receive tailored to the due date of her pregnancy that no longer existed (Ebeling, 2016).

The counterpart pregnancy is a concept I also found useful to explore partners' interactions with pregnancy apps. For some partners, downloading a pregnancy app independently enabled them to take some level ownership of a counterpart pregnancy, adding to their experience of otherwise "experiencing it by proxy" (chapter 3). While participants rarely used the term "bonding", the ways in which they used pregnancy apps as a means to learn about and imagine their growing

baby, spoke affectionally about them, and used the app as a means to mediate relationships between their partner and the fetus aligns with Hamper and Nash's conceptualisation of the "bonding work" associated with pregnancy apps (Hamper and Nash, 2021). They argue that "pregnancy apps are bonding devices…", and that bonding is "…tied to intensive parenting discourses that are child-centred, knowledge-driven, and consumerist, and often fall heavily on women through the naturalisation of motherhood as paramount in child development"(Hamper and Nash, 2021, p. 595). They note that this intensive mothering begins before birth. They also found that pregnancy app use was predominantly led by women, and found that

> …many women use the apps to share pregnancy information with their male partner in the hope that this will encourage paternal bonding and thus encourage their partner's contribution to and investment in the practical and emotional work of childcare (Hamper and Nash, 2021, p. 595).

My findings confirm many of the conclusions of their study, particularly with the impetus for app use mostly being taken up by women. The level of partner involvement with pregnancy app use varied among participants, with some expressing enthusiasm and a desire to be involved, and others having little to do with their partner's use of pregnancy apps. I did not find that partners explicitly described their sharing of pregnancy app updates with their partners as a means of initiating investment in active fatherhood as articulated by some of Hamper and Nash's participants, but some participants in this study did depict their partner's independent app use as part of their overall approach of aiming to establish equity in their child rearing roles and duties. My findings support the argument of Hamper and Nash that much of the discourse in pregnancy apps, and more broadly, places the onus of action and behaviour change on women, with them being responsible for the avoidance of potential risks to the fetus and thereby the future child.

Accordingly, participants in this study often reported changing their behaviours during their pregnancies. For example, many participants described avoiding consuming potentially harmful foods and alcohol, and aiming to eat sufficient nutrients despite feeling nauseated (chapter 2). They discussed their concerns surrounding potential changes to fetal movement that I explored in chapters 4 and 5, and that I will return to later in this chapter. The avoidance of risk of harm to the unborn child also underplayed many of the interactions I had with participants as recorded in my field notes. I noted a participant with a congested nose lamenting at the beginning of our conversation that she could not take the cold medicine she would usually drink to ease her symptoms, a participant requesting that I order her a decaffeinated coffee at the café where we met, and a participant mentioning to me as we crossed the road together that she had become more cautious about traffic since becoming pregnant.[47] The expectation that certain practices were to be cautioned or avoided in pregnancy was categorically prevalent among all participants. Some participants reflected upon the validity of specific guidelines, noting for example the differences between international guidelines, and the paucity of evidence to justify particular recommendations, such as the level of alcohol consumption that is considered to be safe in pregnancy. Nonetheless, their acceptance of the recommended need for their behaviour to protect fetal wellbeing reflects the considerable body of literature that has been developed on risk avoidance in pregnancy, and the ideology that Hays defined as "intensive mothering" (Hays, 1996; Burton-Jeangros *et al.*, 2013).[48] Much of the existing literature on pregnancy apps demonstrates that they emphasise a need for self-surveillance in pregnancy, and in particular that they underscore narratives of pregnancy as risky in proposing the need for women to track their bodies and behaviours in pregnancy at a minute level of detail (Johnson, 2014; Lupton and

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[47] Some research suggests that decongestants may not be safe during pregnancy, particularly the first trimester (Stanley *et al.*, 2019). High levels of caffeine consumption in pregnancy have been linked to miscarriage (Weng, Odouli and Li, 2008). I am not aware that pedestrian road traffic accidents are any more common among pregnant people than in the general population, but the phenomena of generally feeling responsible in pregnancy and avoiding day to day risks is supported by the literature (Burton-Jeangros, 2011).

[48] As noted in the literature review, Johnson linked the use of pregnancy and parenting apps to Hays' work on intensive mothering (Johnson, 2014).

Thomas, 2015). Some participants did make use of pregnancy apps for self-monitoring, for example tracking their diet or their weight as it changed during pregnancy (chapter 2). These participants who used apps for self-monitoring, however, did not tend to use apps for self-monitoring consistently and were selective in choosing what to track, aligning with Oudshoorn's concept of "selective use" and Wyatt and colleagues' classification of non-use which includes the term "resisters" (Wyatt, Thomas and Terranova, 2002; Oudshoorn, 2008). A key finding of this study is the importance of non-use, partial use, and resistance of pregnancy apps. The readiness with which the majority of participants resisted self-monitoring features on pregnancy apps does somewhat temper claims about the level of influence of pregnancy apps exert to encourage this focus on minute details of the body and of user practices. Nonetheless, my findings do ultimately support the notion that pregnancy apps highlight potential risks in pregnancy in their promotion of such features as food safety searches, and the content of fetal development updates and other written pregnancy information that highlights risk. Some participants reported using app food safety search features, or directly aiming to follow nutrition recommendations from an app (chapter 2). I argue that while pregnancy apps may not be used for self-monitoring by all users, pregnancy app use is nevertheless a practice of self-management that involves and enacts self-surveillance. The dynamics of risk and reassurance are interwoven with how participants made use of pregnancy apps, both in informing why they used them – in seeking guidance that would reassure them, and ensuring that they were mitigating risk – and in the advice that the apps then provided them with.

Seeking reassurance is a theme that also surrounds the use of pregnancy apps for monitoring fetal movement. While users may use fetal movement monitoring apps to seek reassurance following a possible decrease in fetal movement as I found in chapter 5, my analysis of apps in chapter 4 suggests that the responsiveness of apps, and the functionalities they provide may limit their capacity to reassure. The apps I analysed offered mixed advice on alarm limits, which could

be confusing to users. Additionally, the apps left much of the interpretation of data to users, and did not directly advise them in identifying potential changes to fetal movement. Only 1 app out of 20 was actually responsive to a user recording what was, based on its own metric, below the normal range of fetal movement (chapter 4). The limited range of functionalities they provide means that they do not enable participants to do significantly more to monitor fetal movement than they might otherwise without the use of an app, other than being a convenient, digitised way to record and visualise data. Some fetal movement monitoring apps suggested that users might use their data to show to a health care professional if discussing concerns about potential changes to fetal movement. One app suggested it empowered users to advocate for themselves by having "real data" to show their health care provider to evidence their claims about reduced fetal movement. When I went on to explore the lived experience of using – or not using – such apps in chapter 5, I did not find evidence of participants using fetal movement monitoring apps to show data to health care professionals. However, the idea that individuals may have concerns about being taken seriously when reporting their concerns about reduced fetal movement was corroborated by several participants. While no participants reported using app data on fetal movement to show a health care professional, a minority of participants did on occasion use an app as a first step when assessing whether or not to call a midwife when they had perceived a possible reduction in fetal movement. One participant described the app as an "in-between" between herself and a health care professional, a first stage in deciding whether or not to make a call in order to avoid being perceived as "neurotic" or wasting time.

I conceptualised the position of the app in this usage as a gatekeeper, which is a contribution of this thesis to the literature on self-monitoring. The gatekeeper does not give advice in itself, but the user refers to the gatekeeper to ascertain whether they should seek additional support. Rather than being a tool for independent self-care, however, the app in its role of gatekeeper appeared to serve a social purpose, being used to reassure participants that they need not be concerned, or

reassure them that they have grounds for their concerns and should seek extra advice. The app is an entity that some participants used to verify whether they should go on to seek professional advice, as an "in-between" of another source they could go to in order to assess their concerns. The user draws the app as gatekeeper into the circle of people or entities responsible for decision-making. This is significant for some users, as there were occasions when participants reported having a concern about movement, using the app, and therefore being reassured – which as I note in chapter 5, could mean they are reassured when perhaps they should seek additional help, with this potentially being an example of false reassurance. Conversely, the app could also make a user more concerned when they may otherwise not have been, and therefore make use of additional health care resources.

In this study, while some participants used a pregnancy app in the gatekeeper role described above, most participants did not use these features. A number of reasons were given for this – a lack of perceived utility, concerns about becoming obsessive or experiencing more anxiety as a consequence of using this feature, and a preference for embodied knowing over quantifying fetal movement with an app as described earlier in this chapter. I explored these reasons using Weiner and colleagues' concept of partial data – some participants felt that the partial data they were able to record using a fetal movement monitoring app enabled them to achieve their aims in seeking reassurance, whereas others felt that the partial data was a limitation of the apps (Weiner *et al.*, 2020).

Conclusion

Overall this contributes to our understanding of how and why women in the UK are using fertility and pregnancy apps. In the course of this chapter and thesis as a whole I have situated this understanding in the existing literature on self-monitoring, fertility and pregnancy. In the

following concluding chapter I consider the strengths and limitations of this study, and provide

recommendations for future research.

Conclusion

Introduction

In this thesis I have explored the use of fertility and pregnancy apps by women in the UK. In this concluding chapter I will consider some strengths and limitations of the study, and offer some suggestions for future research.

Strengths

This study contributes new in-depth, qualitative empirical data in a UK context to the literature on fertility and pregnancy apps, and self-monitoring more broadly. I have extended some of the existing literature on fertility apps to include more focus on pregnancy apps. Within this focus I contribute an original investigation into the use of apps for monitoring fetal movement. My analysis has developed and nuanced existing research on self-monitoring, adding new insights into how different ways of knowing interact in the use of fertility and pregnancy apps. The inclusion of selective users (as a facet of non-users) allowed for new insights than offered by research that includes only users. Additionally, I have developed new emerging concepts, notably the counterpart pregnancy and gatekeeping, that contribute to our understanding of the use of fertility and pregnancy apps.

Limitations

As with any study of technology, the object of study is moving as technologies develop in new ways. While I offer a rich picture of the use of fertility and pregnancy apps within a recent period of time, and hope that the findings I present here will be applicable to informing understandings

of this going forward, I acknowledge that the technology itself and the ways in which people make use of it are continually changing.

As a small qualitative study, it was not the intention of this project to generate generalisable data, but it is nonetheless a limitation of this study that the sample size was small, and while coherent, the findings are not generalisable. This is particularly the case due to the lack of diversity of the sample, which was a majority white, middle class sample. If approaching the project again I would aim to be more strategic about sampling and try alternative ways of recruiting, for example adding in-person recruitment methods, or using different gatekeeper organisations. A further limitation of the study related to the small sample size is that the types of usage of apps that participants engaged with varied quite widely. There were many commonalities that I was able to draw together in my analysis, but it would be interesting to target users of specific features to be able to go into greater depth, and gain a wider variety of experiences of users of particular functionalities of apps. Finally, while I explored the role of partners from the perspective of pregnant women, the study does not include direct data on the experiences of partners of using fertility and pregnancy apps.

Recommendations for further research

I have four key recommendations of areas for further research. First, a future study could usefully examine whether the gatekeeper concept applies to other uses of apps, for example contraction timers. The involvement of contraction timers in women making judgements about contacting professionals or seeking admission to hospital in early labour, and defining whether labour is established based on the app's algorithm would be a valuable area for future research. Second, research could study the impact of the COVID-19 pandemic on the role of fertility and pregnancy apps and other technologies, particularly given limits to access to fertility clinics, and

the restrictions on partners attending antenatal appointments, ultrasound scans and births (Lalor *et al.*, 2021). My third and fourth suggestions relate to future research addressing some of the limitations of this study. It would be valuable to conduct research with a more diverse sample of participants, and consider the experiences of individuals who have different experiences of health care access, as this may impact the role that consumer technologies play. Finally, I suggest more research with users of fetal movement monitoring apps, as most participants in this study were non-users, and this is an area that has been understudied where new insights could be developed.

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Appendices

Appendix 1: Example recruitment advert

I am a PhD student at King's College London, and I am currently researching how and why women in the UK use digital technology – particularly pregnancy apps – during pregnancy and childbirth. As part of my PhD research project, I am looking to talk with pregnant women aged 18 or above about their use of pregnancy apps. If you would consider volunteering to be interviewed, or would like to know more about the study, please take a look at the project website. There you will find further information of what participation would involve, as well as my contact details: (*website link*)

Interviews can take place in person somewhere local to you, or via Skype if you prefer. Participation will be kept confidential, and all information shared will be anonymised, meaning you will not be identifiable in any way. Thank you very much for considering participating in this project, and please feel free to get in touch if you have any questions!

Appendix 2: Example message to group administrator

Dear [name],

I hope this message finds you well. I am a PhD student at King's College London, and I am currently researching how and why women in the UK use digital technology – particularly pregnancy apps – during pregnancy and childbirth. As part of my research project, I am looking for pregnant women in the UK aged 18 and over who use pregnancy apps to take part in interviews. (There are further details of the project on the study website *website link*)

I am getting in touch as you are the creator of the Pregnancy Chat group, and I wondered if you would be willing to share a post about my study in the group to see if any members based in the UK might be interested in volunteering to be interviewed (or if they know anyone else who might be interested).

I would not want to disrupt the dynamic of the group and would understand if you do not think this would be appropriate, but I would be grateful if it were possible to post about the study. Please feel free to let me know if you have any questions about the project, and the type of message that might be posted.

Many thanks,

Philippa

Appendix 3: Example online registration form

Pregnancy App Study Interview Registration Form

Please enter your details below to register your interest in participation in the study "A mixed methods study of the role and influence of digital technology in pregnancy and childbirth in the UK (REC Reference Number: LRS-16/17-4739)". By submitting the form you consent to being contacted by the researcher, Philippa Machin, to discuss arranging an interview, but you are not committing to participation and will be free to withdraw without giving a reason. Your responses to the questions below will be kept securely and treated as confidential.

1. Full name
2. Email address
3. Town/City (this is requested to help arrange the location of an interview)
4. Please enter your pregnancy due date, or how many weeks pregnant you are. An estimate is fine if you are unsure.
5. Where did you hear about this study?
6. I confirm that I am aged 18 or above, and consent to being contacted by email to discuss arranging an interview.

INFORMATION SHEET FOR PARTICIPANTS

REC Reference Number: LRS-16/17-4739

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of study

A mixed methods study of the role and influence of digital technology in pregnancy and childbirth in the UK.

Invitation Paragraph

My name is Philippa Machin, and this study forms part of my PhD research at King's College London, funded by a studentship awarded by the Economic and Social Research Council. I would like to invite you to participate in this research project, but before you agree to do so, it is important that you understand the purpose and nature of the research and what your participation will involve, if you agree. Please read the following information carefully, and please do ask if anything is not clear, or if you want more information.

Contact details are given at the end of this information sheet.

What is the purpose of the study?

The purpose of this project is to gain a better understanding of how women in the UK use digital technology (mainly pregnancy apps) during pregnancy and childbirth. I am particularly interested in how this relates to choices women make about giving birth.

Why have I been invited to take part?

You have been invited to take part as I aim to recruit pregnant women in the UK who use pregnancy apps.

Due to the timeframe of the project I am particularly interested in interviewing women who are in the first three months of pregnancy, but you will still be eligible to participate if you are at a later stage of pregnancy.

You will not be eligible to participate if you meet any of the exclusion criteria listed below:
- Under the age of 18
- Have an acute physical or mental health condition
- Do not speak English
- Not willing and able to give informed consent for participation in the study

Do I have to take part?

Participation is completely voluntary, and you are under no obligation to take part in this study. Even if you have decided to take part, you are still free to stop your

participation at any time during the interview without giving a reason. You can also have research data/information relating to you withdrawn without giving a reason up to 3 months after your final interview.

What will happen to me if I take part?

If you decide to take part, you will complete a short online registration form which will confirm whether you are eligible to participate in the study. If you are eligible, and willing to participate, you will arrange to attend an interview, at your convenience, which will last around one hour. This will take place either in person at the location of your choice, or via Skype. You will be invited to attend two follow-up interviews, one at a later stage of your pregnancy, and one after you give birth. In the interviews, you will be asked questions about your attitudes towards and experience of using digital technology, and your views and experiences regarding pregnancy and childbirth. You will be able to refuse to answer any question and may end the interview at any time. The interview will be audio recorded, but the audio file and resulting transcript will be kept securely and anonymised.

What are the possible benefits and risks of taking part?

There are no significant risks to taking part in this study. If you do find that the interview is distressing or upsetting for any reason you will be able to leave at any time. The main disadvantage of taking part in the study is that you will be donating one to three hours of your time to take part.

I will provide you with a summary of the final report describing the main findings, but there are no direct benefits to taking part.

Will my taking part be kept confidential?

Yes. Your involvement in this project will not be disclosed to anyone other than me, and the audio file and transcript will be anonymized. Any identifying statements in the interview will be altered for the report, and you will be referred to using a pseudonym. In exceptional cases – for example, if you were to disclose an experience of abuse – I may be obliged to report this to the appropriate authority, but I would discuss this with you first. All data will be handled in accordance with the terms of the UK Data Protection Act 1998, and the European General Data Regulation (from May 2018).

How is the project being funded?

This project is funded by a PhD studentship awarded by the UK Economic and Social Research Council.

What will happen to the results of the study?

The results of this study will be written up in my PhD thesis, which will be accessible in print and online. Results may also be disseminated in conference presentations, and published articles. In all instances, any information that has the potential to identify you will be anonymised.

Who should I contact for further information?

If you have any questions or require more information about this study, please contact me using the following contact details:

Philippa Machin
Department of Global Health and Social Medicine
King's College London
philippa.machin@kcl.ac.uk

What if I have further questions, or if something goes wrong?

If this study has harmed you in any way or if you wish to make a complaint about the conduct of the study you can contact King's College London using the details below for further advice and information:

Professor Barbara Prainsack
Department of Global Health and Social Medicine
King's College London
barbara.prainsack@kcl.ac.uk
07912622901

Thank you for reading this information sheet and for considering taking part in this research.

Appendix 5: Example participant consent form

CONSENT FORM FOR PARTICIPANTS IN RESEARCH STUDIES

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: A mixed methods study of the role and influence of digital technology in pregnancy and childbirth in the UK

King's College Research Ethics Committee Ref: LRS-16/17-4739

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

I confirm that I understand that by ticking/initialling each box I am consenting to this element of the study. I understand that it will be assumed that unticked/initialled boxes mean that I DO NOT consent to that part of the study. I understand that by not giving consent for any one element I may be deemed ineligible for the study.

Please tick or initial

Please tick or initial

1. I confirm that I have read and understood the information sheet dated 18/09/17 Version Number 3 for the above study. I have had the opportunity to consider the information and asked questions which have been answered satisfactorily.

2. I understand that I will be able to withdraw my data up to 3 months after my final interview

3. I consent to the processing of my personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998, and the European General Data Regulation (from May 2018).

4. I understand that my information may be subject to review by responsible individuals from the College for monitoring and audit purposes.

5. I understand that confidentiality and anonymity will be maintained and it will not be possible to identify me in any publications

6. I consent to my interview being audio recorded.

7. I understand that I must not take part if I fall under the exclusion criteria as detailed in the information sheet and explained to me by the researcher.

_____ _____ _____

Name of Participant   **Date**   **Signature**

_____ _____ _____

Name of Researcher   **Date**   **Signature**

Appendix 6: Example topic guide

- Talk through information sheet and consent form (if already signed then restate key points), sign two copies
- Ask permission to audio record for purposes of transcript
- Reiterate that they do not need to answer anything they are not comfortable discussing and can stop at any time
- Confirm happy to start the interview

General
- Can you tell me a bit about how your pregnancy has been so far?

Apps
- Can you tell me about the first time you considered using a pregnancy app?
- Which pregnancy app(s)do you use?
- Do you like the app(s) you use?
- How often would you say you used them?
- What do you find useful about apps/what do you use them for?

- Do you enter information about your pregnancy into apps?
- What type of information do you enter?
- What is this information used for?
- Is it important to you that you do this?

- Is there anything you found particularly surprising or interesting about the apps?
- Do the app(s) you use send you notifications?
- When was the last time you received a notification? Can you tell me about it? How did it make you feel? Do you tend to respond to them?
- Has anyone else in your life been involved at all with using pregnancy apps in relation with your pregnancy? E.g. partner, family member, friend?
- Do you link up the apps you use with any social media accounts?
- Have you ever used any other types of app, such as fertility apps, before?
- Do you use any other health or wellness apps, for example a fitness app, or a wearable device like a Fitbit?
- Do you keep any journals or other type of records?

Information-seeking
- What is your first port of call when you need information about your pregnancy?
- What other sources of information do you use in connection with your pregnancy?
- What is important to you when deciding where to find information about pregnancy?
- How do you decide which information to trust?
- Have you ever disagreed with your doctor or midwife?
- Have you ever disagreed with what the pregnancy app suggested to you?

Birth
- Have you made any plans about your birth?
- Why does that appeal to you?
- Is there anything you have been doing to prepare for birth?
- How are you feeling about it?

- What was important to you when thinking about this?
- Have you made any decisions that have been informed by information you've found online or through an app?

Supplementary questions:

Health care
- Have you spoken to your midwife or doctor about apps?
- Did your midwife/doctor give you any information about apps?
- Did you show them your data?
Data
- Did you read the privacy policy?
- Have you thought much about data privacy and using this app?
- Did you notice x y z in the privacy policy?

Wrap up

- Is there anything else you think is important that we haven't discussed?
- Ask permission to contact for follow up interview
- Ask permission to send demographic survey

Appendix 7: Demographic survey results

As noted in the methodology section, 7/13 participants completed this survey and 6/13 did not, therefore these results are not fully representative of the entire sample.

(Options with no responses excluded from tables i.e. "less than secondary school qualifications", other age brackets and UK regions)

What is your age?

25 to 30	1
31 to 35	4
36 to 40	2

What is the highest level of school you have completed or the highest degree you have received?

Foundation degree	1
Bachelor degree	2
Post-graduate degree	4

Please describe your race/ethnicity (open-ended/free text question)

White	1
White British	6

Please describe your current relationship status (open-ended/free text question)

Married	7

In which region of the UK do you live?

London	1
North West	2
Scotland	1
South East	1
South West	2