UNIVERSIDADE CATÓLICA PORTUGUESA

THE INTEGRATION OF *mHealth* INTO PRENATAL AND PEADEATRIC CARE IN BRAZIL

DISSERTATION

Dissertation submitted to Universidade Católica Portuguesa to obtain a Master's Degree in Communication Studies – Communications and Digital Transformation

By

Luísa Lopes Lisboa Tibana

Faculty of Human Sciences
April 2025

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Resumo

Do avanço da telemedicina à ampla adoção de *wearables* e *mHealth*, o impacto da saúde digital no setor da saúde pode ser visto ao redor do mundo. Nesse contexto, ferramentas como aplicações médicas tornam-se cada vez mais presentes na vida de pacientes. Este estudo explora a integração de aplicações de gravidez e desenvolvimento infantil em cuidados pré-natais e pediátricos no Brasil, um país onde tanto iniciativas privadas quanto públicas encontraram solo fértil para desenvolver soluções digitais para a saúde. Por meio de uma abordagem mista, com maior foco em aspetos qualitativos, este estudo debruça-se em sete aplicações de gravidez e desenvolvimento infantil relevantes no mercado brasileiro. Para além disso, é explorada a perceção dos profissionais na área relativamente tal solução digital, para perceber os possíveis benefícios e desafios que o seu uso traz para os pacientes. Os resultados desta investigação sugerem que, por um lado, tais aplicações podem complementar práticas tradicionais de cuidados com a saúde através da promoção da adoção de hábitos mais saudáveis, da redução da ansiedade e do fortalecimento do senso de comunidade. Por outro lado, tais soluções digitais também são objeto de preocupação. A falta de regulação tal como o excesso de informação podem impactar os usuários de maneira negativa. Este estudo destaca a importância do diálogo entre os vários *stakeholders*, tal como colaboração, regulação e cuidado ao desenvolver, manter e guiar pacientes na utilização dessas tecnologias.

Palavras-chave: mHealth, gravidez, transformação digital, cuidados pediátricos

Abstract

From the rise of telehealth to the larger adoption of wearables and mHealth, the impact of digital health in the healthcare sector can be seen around the world. In this context, tools such as medical apps become increasingly more present in patient's lives. This study explores the integration of pregnancy and baby apps into prenatal and paediatric care in Brazil, a country where, driven by both public and private initiatives, digital health solutions have found fertile ground to bloom. Through a mixed method approach with a greater focus on its qualitative side, this study dives into seven relevant pregnant and baby apps available for the Brazilian market and, through the lenses of specialists, assesses the challenges and benefits that come with using such digital health solutions. The results suggest that, on the one hand, the apps can complement traditional healthcare practices by promoting the adoption of healthier habits, reducing anxiety and fostering community. On the other hand, these digital health solutions are also subject of concern. The lack of regulation as well as information overload can impact the users in a negative way. This study highlights the importance of dialogue between the various stakeholders as well collaboration, regulations and caution when developing, maintain and guiding patients through these tools.

Key-words: mHealth, pregnancy, digital transformation, paediatric care

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Introduction

As the world becomes increasingly more digitized, people have found new ways to interact with each other as well as with different spheres of their lives. Digital transformation in healthcare offers unique opportunities in terms of patient-management, access to medical information, in addition to a wide range of other aspects of healthcare innovation. In this context, pregnancy and baby development mobile applications came to being, and as they are getting increasingly more utilised, understanding its strengths and limitations becomes essential. This study assesses the main pregnancy and baby development apps available for the Brazilian market and dives into their features and their perceived impact on users through the lenses of specialists in the field. It explores the extent to which such digital health tools can be integrated into prenatal and paediatric care, taking into account their risks, benefits in ways in which they might lack. Furthermore, it examines the often-overlooked perspective of the non-pregnant partner, acknowledging how they are impacted by parenthood, their supportive role during pregnancy, how apps accommodate their perspective as well as how they can also benefit from using such digital health solutions.

Within the scope of this study, it was observed that the majority of literature on the topic dive into the overall quality and user experience of pregnancy and baby apps. This research is an attempt at contributing to fill a gap by building a bridge between app usage and clinical practice. The objective of this study is to analyse the most relevant pregnancy and baby apps available in the Brazilian market as well as to assess the perception specialists in the field have on such digital health solution. This research seeks to provoke a reflection on the use of pregnancy and baby apps baby based on the studies of authors such as Brusniak et al. (2020), Goetz et al., (2017) and Lee & Moon (2016), while considering Kostkova's (2015) conceptualisation of digital health as well as Donelle et al.'s (2021) study on the impact of technology in the transition to parenthood and Deterding et al.'s (2019) definition of gamification, among others.

In order to reflect upon the question *to what extent can pregnancy and baby apps be integrated into prenatal and paediatric care?,* this research follows a mixed-method approach with a greater focus on its qualitative side. The data collection was divided into

two stages: a content analysis and a questionnaire. For the content analysis, seven of the most relevant pregnancy and baby apps in Brazil were selected and thoroughly analysed. Following that, a questionnaire was sent out to psychologists, obstetricians, paediatricians and other healthcare professionals who work closely with expectant parents, new parents, babies and toddlers. Examining
the mobile applications alongside assessing the perspective of specialists gave essential insight on what it is available for the users, what are the benefits and concerns that come with integrating technology into healthcare practices, and in what ways such tools can improve the experience of new and expectant parents.

This research is divided into five parts, structed as follows. Part I provides context and a foundation to this study's findings by exploring the existing literature on the topic. The literature review not only dives into the main concepts within the scope of health communications, but also explores the studies on digital parenting and the impact of parenthood in one's life and gives an overview of studies focused on pregnancy and baby development apps. Part II is the methodology section, where the research strategy is outlined. As for Part III, all of the results from both the content analysis and the questionnaire are brought together. Part IV is the discussion, which relates previous studies to the findings to this research. Lastly, the study is wrapped up in Part V with the conclusion.

Part I: Literature Review

1. Health Communications

Health communications is defined by the U.S. Department of Health and Human Services (2000) as "the art and technique of informing, influencing, and motivating individual, institutional, and public audiences about important health issues" (Parrott, 2004, p. 751). Health communications operates on a community level to inspire individual actions and behaviours. The scope of the field encompasses a myriad of practices. The sphere of health communication "includes disease prevention, health promotion, health care policy, and the business of health care as well as enhancement of the quality of life and health of individuals within the community" (U.S. Department of Health and Human Services, 2000, as cited in Parrott, 2004, p. 751). Having the skills to not only comprehend but to also apply knowledge on health matters is what conceptualises health literacy (Ishikawa & Kiuchi, 2010).

Communication goes far beyond comprehension, it also about stablishing and fostering meaningful connections. Consumer-centred or, in the context of healthcare, patient-centred communication strategies "include secure mail messaging between patients and providers, and mobile health apps" (Ricciardi et al., 2013). At its core, it means understanding the patient's perspective on what they are going through as well as showing empathy towards them (Hashim, 2017). "Understanding the patient's perspective entails exploring the patient's feelings, ideas, concerns, and experience regarding the impact of the illness, as well as what the patient expects from the physician" (Hashim, 2017, p. 29). As for expressing empathy, the physician can show it to the patient through support, respect, and by exploring the patient's emotions (Hashim, 2017).

Although the impact of technology will be deeper explored in the next chapters, it is relevant to mention the impact of digital technology in consumer-centred health communication strategies. A study conducted by Vijayasarathi et al. (2019) analysed how digital tools could improve patient-focused communication in the context of radiology, a field that has historically relied on printed reports. The study suggests that a more direct approach when it comes to the physician-patient communication as well as the integration with digital platforms could not only reduce errors but improve patient satisfaction. In this process, there

are also challenges to be faced, including time constraints, rise on patient's anxiety levels, and issues on the physician's part when giving bad news (Vijayasarathi et al., 2019).

During the global pandemic of COVID-19, a myriad of aspects ordinary to human life had to be reinvited and resignified. The field of health communications not only went through some transformations, but it also experienced one of its most important moments in human history. "An emerging infectious disease event like coronavirus (COVID-19) pandemic demands careful communication of public health messages to diverse audiences" (Vraga & Jacobsen, 2020, p. 233). Vraga & Jacobsen (2020) highlight the following challenges: information overload, information uncertainty, misinformation. As for information overload, the authors stated that "because so many decisions were being made and announced quickly, it was difficult for the details about these policies and the justifications for implementing them to be carefully explained to the public" (Vraga & Jacobsen, 2020, p. 234). The second challenge – information uncertainty - referred to the unpredictability that consumed the beginning of pandemic, when not much was known and the guidelines were imprecise (Vraga & Jacobsen, 2020). In this context, "discussing uncertainty as part of the messaging strategy is a challenging undertaking, but in the long term that openness may support the credibility of the organization disseminating the message" (Vraga & Jacobsen, 2020, p. 236). The third challenge – misinformation –, according to the authors, can be dealt with two different approaches: through the dissemination of correct information and minimising misinformation. The study concluded that "communication strategies that account for the potential for information overload, information uncertainty, and misinformation among the public will be most successful in promoting personal and public health" (Vraga & Jacobsen, 2020, p. 239).

1.1 Digital Health (E-Health)

Despite the fact that digital health is still an evolving concept (Mathews et al., 2019), for the purpose of this research, this study will follow Kostkova's (2015) definition, which states that "digital health is defined as the 'use of information and communications technologies to improve human health, healthcare services, and wellness for individuals and across populations'" (p.1). There is a wide range of opportunities that come with extending - and at times even transferring altogether - medical care to digital environments. "Under the term

"digital health", advanced medical technologies, disruptive innovations and digital communication have gradually become inseparable from providing best practice healthcare" (Meskó et al., 2017, p.1). The healthtech industry, especially during the past decade, has been growing alongside a global desire to adopt and maintain a healthy lifestyle (Yan et al., 2021), and changing how patients interact with the healthcare system (Gordon et al., 2020). "Digital technology offers tremendous potential for improving the prevention, diagnosis and management of disease" (Gordon et al., 2020, p.1). On the one hand, many concerns arise with the larger adoption of health apps, for instance the lack of regulation and lower access to less privileged social groups (Gordon et al., 2020). On the other hand, studies suggest such digital solutions could potentially lessen physician burnout by making follow-up appointments less intensive and streamlining communication (Gordon et al., 2020).

When speaking of digital health, it is important to understand its impact and how it coexists with traditional healthcare practices. In a study conducted in Hungary in 2017, Meskó et al. analysed digital health solutions as transformative forces acting upon what is considered traditional healthcare. "As digital health makes patients the point-of-care, a new status quo and new roles for both patients and caregivers are approaching" (Meskó et al., 2017, p. 2). Not unlike other studies, Meskó et al. (2017) highlights both the positive and the negative sides of such technological advancements. When it comes to the positive side, the researchers highlight genome sequencing and smartphone connected electrocardiograms, as well as the potential of digital health solutions' tools to lessen physician burden and empower patients (Meskó et al., 2017).

1.2.1 Mobile health (mHealth)

This takes us to mobile health (mHealth), whose definition is yet to be universally accepted (Park, 2016). With this in mind, it is imperative to acknowledge the various attempts at conceptualising the term. While mHealth is defined by Istepanian et al. (2004) as "mobile computing, medical sensor, and communications technologies for healthcare" (p.405), The World Health Organisation Global Observatory for eHealth describes it as "medical and public health practices supported by mobile devices" (Rowland et al., 2020, p. 1). The scope of mHealth encompasses health and wellness apps, wearables, patient portals, telemedicine

practices, among others. Such technologies can serve a myriad of purposes, from education to diagnosis to treatment and to countless other related areas (Martínez-Pérez et al., 2013). "Expectations range from overcoming structural barriers to access in low-income countries to more effective, interactive treatment of chronic conditions" (Becker et al., 2014, p. 1). Notwithstanding, there are also considerable limitations, "such as usability, ethics network and management" (Martínez-Pérez et al., 2013, p. 21) as well as challenges related to "psychological perspective, high attrition rates, digital divide of society, and intellectual capabilities of the users" (Becker et al., 2014, p. 1).

This study focuses on mHealth applications, digital solutions with "the potential to hold value for patients when used as part of a clinical workflow" (Rowland et al., 2020, p. 4). There is, however, a gap in evidence of its effectiveness in many clinical settings (Rowland et al., 2020). The apps can be categorised based on its function, for instance: "apps that support diagnostics and clinical decision making, apps that support behaviour change to improve compliance with established treatment pathways, digital therapeutic apps and apps designed primarily to deliver disease-related education" (Rowland et al., 2020, p. 4). It is also relevant to note that many studies have shown the importance of bringing physicians into the loop when developing such tools (Lee & Moon, 2016) as well as thoroughly considering the other stakeholders (Becker et al., 2020). Afterall, "interdisciplinary alliances and collaborative strategies are vital for achieving sustainable growth in the field" (Becker et al., 2020, p. 9)

When studying mHealth, engaging the users is a key factor. In this context and in many others, gamification is a strong promoter of engagement. Gamification is defined by Deterding et al. (2019) as "the use of game design elements in non-game contexts" (p. 10). The game elements in question are implemented as a way to "engage audiences and to inject a little fun into mundane activities besides generating motivational and cognitive benefits" (p. 31). Studies have shown the use and effectiveness of gamification practices in the context of mHealth for oncological patients (Ning et al., 2023), people with hypertension (Cechetti et al., 2019), epilepsy treatments (Rahim & Thomas, 2017) and so much more. King et al. (2013) attributed two trends in the core of the increase in gamification in mHealth. First, the demand for new mobile applications, which expands the target audience of game designers and provides them "more attractive tools to use in designing interactive health interventions"

(King et al., 2013, p. 76). The second trend is “the enthusiasm and willingness of developers to incorporate the latest behavioural insights into electronic interventions” (King et al., 2013, p. 76).

A study conducted by Cechetti et al. (2019) on the use of mHealth constituted of seven stages that culminated in two mobile applications for hypertension monitoring. The first stage consisted of an analysis of the system, in order to understand its purpose. The second one focused on the identification of the target audience and its characteristics. Thirdly, the researchers identified the interaction flows by “mapping all tasks related to user’s data feed and interactions” (Cechetti et al., 2019, p. 129). Following that, the fourth stage consisted of an analysis of the use of gamification in similar mHealth apps. In the fifth stage, they selected the game elements most appropriate to be integrated in the app, them being: a score system, feedback, leaderboard and a progress bar and levels. The penultimate stage was developing the software, able to run across a variety of devices. The last stage was assessing how the app was received by the public by evaluating its acceptance and overall engagement rates. As a conclusion, “gamification proved to be effective for this context, since it did not add complexity to the application and promoted the desired engagement results” (Cechetti et al., 2019, p. 126).

Even though this study focusses on digital health solutions directed to the general public, it is important to note that the use of mHealth technologies is not exclusive to patients, their partner and other family members. A study conducted in the United States in 2018 by Arbour & Stec analysed the use of apps to assist midwives. With new research and sanitary emergencies, such as the Zika virus (Arbour & Stec, 2018) or even the COVID-19 pandemic, healthcare guidelines can change rapidly. In contexts as such, digital tools can be especially useful because, unlike traditional textbooks, webpages and mobile applications can be easily updated, and its information can be quickly distributed (Arbour & Stec, 2018). The study analysed and discussed a series of apps, “including those for evidence-based care guidelines, women’s health care, pharmacologic reference, laboratory and diagnostic guides, as well as apps for information storage apps and management, electronic health records, and client education” (Arbour & Stec, 2018, p. 330). They concluded that with a gradual and intentional implementation of mobile apps, “midwives can increase their comfort levels and

begin to branch out to explore other opportunities to use technology in education, practice, and research" (p. 333).

Within the scope of digital health, there is a myriad of opportunities that come with integrating the main trends in the tech world - such as artificial intelligence (AI) – into digital health solutions. The integration of AI into healthcare can be translated into virtual assistants (Al Kuwaiti et al., 2023), personalised care through the analysis of individualised data and diagnostic tools that analyse medical images (Secinaro et al., 2021), among others. A study on the present and future of AI in healthcare conducted by Jiang et al. (2017), concluded that a successful AI system in the context of healthcare needs to be able to handle structured data through its machine learning component. Another important aspect highlighted by the specialists is the natural language component, which must be able to mine unstructured texts. "The sophisticated algorithms then need to be trained through healthcare data before the system can assist physicians with disease diagnosis and treatment suggestions" (Jiang et al., 2017, p. 241). Despite all the benefits mentioned, the integration of AI in healthcare does not come without its challenges. Although AI has been explored extensively in academic research, there are many obstacles in the way of implementing it to its full potential in clinal settings (Jiang et al., 2019). The challenges include the lack of regulation and the need for constant data updates and exchanges. Studies on the topic have also highlighted a series of ethical issues that AI can represent in this context. "Key ethical issues to emerge with this transformation encompass the accountability and transparency of the decisions made by AI-based systems, the potential for group harms arising from algorithmic bias and the professional roles and integrity of clinicians" (Lysaght et al., 2019, p. 300).

This chapter dove on the basis of this study: the field of health communications, which is responsible for informing various audiences on health matters, and was highly transformed by the global pandemic of COVID-19. Within the scope of the field, there is e-health, enhancing healthcare practices with the use of digital technology. One of its many representations being mHealth, which encompasses many tools, including the focus of this research: mobile apps. The next chapter will further enrich this study by expanding on the subject of health communications exploring the topic of digital parenting.

2. Digital Parenting

Parenting is defined as the "care of the young in preparing them to manage the tasks of life (…), expressed in cognitions and practices" (Bornstein, 2013, p. 258). It is essential to acknowledge, however, that both when speaking of parenting in its most traditional or inclusive form, the impact of technology cannot be overlooked. Afterall, "social and historical contexts shape both popular and scholarly conceptions of children, families, and parenting, so it is important to view our contemporary understanding of family relationships in light of recent history" (Cabrera et al., 2000, p. 127). In the digital era, a new term emerged: digital parent. There are many definitions of "digital parenting", each of them encompasses a different activity that the practice entails. Digital parenting activities include - but are not limited - to exchanging information with fellow parents and accessing a variety of learning resources, including apps and games (Livingstone et al., 2018; Lupton et al., 2016; Fidan & Seferoğlu, 2020).

For the matter of this study, the use of digital solutions for surveillance will not be explored, even though it is such a relevant topic within the practices of digital parenting. The reason behind that is that such technologies do not fall into the scope of digital health solutions and are not used by expecting parents nor in early parenthood.

This study gives significant focus to the transition to parenting, which is defined by Donelle et al. (2021) as the "the journey from preconception through pregnancy and postpartum periods". (p.1). This transformative period impacts one's life significantly, and it is considered "one of the most emotionally charged and information-intense times for individuals and families" (Donelle et al., 2021, p. 1). The role of technology in this transition period is somewhat understudied when compared to its part in child development, teenagerhood and early adulthood (Donelle et al., 2021). Taking this into account, Donelle et al. (2021) conducted a research in Canada aimed to understand the role of digital technologies throughout the transition to parenting, "particularly the role these technologies play in organizing and structuring emerging pregnancy and early parenting practices" (Donelle et al., 2021, p. 1). The researchers held focus groups followed by three individual interviews on invitro fertilization and egg donation with 26 women between the ages of 17

and 35 (Donelle et al., 2021). According to this study, one of the main reasons that lead to the use of digital technology was to get reassurance that what they were experiencing were "normal" (Donelle et al., 2021). Through the data collected, Donelle et al. (2021) were able to identify a duality in the perception of the digital technologies. On the one hand, they "provided participants with convenient means to access health information from a range of sources such as websites, online support groups, and health care professionals" (Donelle et al., 2021, p. 8). On the other hand, participants expressed concern when it comes to the validity of the content due to the lack of transparency of the authority of the sources (Donelle et al., 2021). The results "demonstrate that mothers' use of digital health technologies have the potential to move parents beyond self-care practices and into the scope of clinical practice" (Donelle et al., 2021, p. 7).

2.1 Motherhood and the Allomaternal experience and the brain

In order to understand the role of technology in parenting, one also needs to have an understanding of the impact of parenting in oneself. "Neuroplasticity can be defined as brain's ability to change, remodel and reorganize for purpose of better ability to adapt to new situations" (Demarin et al., 2014, p. 290). Throughout pregnancy and the postpartum period, hormonal changes and interactions with the offspring result in complex changes in one's brain's structure and functionality (Barba-Müller et al., 2018). "These changes seem necessary and adaptive: since the survival of the young is dependent on the mother's efforts, her brain seems to have evolved in ways that promote mother-infant bonding and sensitive caregiving" (Barba-Müller et al., 2018, p. 295).

The influence of motherhood in the brain has been far more researched and analysed than that of fatherhood/allomaternal experience, "in large due to the small number of paternally behaving mammals" (Glasper et al., 2015, p.3), a behaviour observed in only 3–5% of mammalian species (Abraham & Feldman, 2022). "A distinct neural plasticity characterizes the female brain during this period, and dynamic structural and functional changes take place that accompany fundamental behavioural adaptations, stimulating the female to progress from an individual with self-directed needs to being responsible for the care of another life" (Barba-Müller et al., 2018, p. 290). However, recent studies have shown relevant

neurological changes in the partner's brain during pregnancy and the postpartum period, capable of influencing their children's stress management and emotional regulation (Abraham & Feldman, 2022). Researchers suggest that this adaptation is a result of a co-wiring process between the maternal and paternal pathways, which provides "a novel model on the plasticity of the "affiliative brain" that evolves through involvement, commitment and effort and is not triggered by hormones of pregnancy" (Feldman, 2017; Feldman et al., 2019; Rilling & Mascaro, 2017, as cited in Abraham & Feldman, 2022, p. 100).

In a study conducted in the United States, Glasper et al. (2015) "investigated to what extent fatherhood altered regulation and dendritic morphology of the hippocampus using the highly paternal Californian mouse (*Peromyscus californicus*)" (p.2). The hippocampus, which was the focus of the study, is a part of the brain that continues experiencing structural modifications throughout adulthood, and it plays an important role in "emotional regulation, cognition and stress reactivity" (Glasper et al., 2015, p. 2). After running a series of tests on both non-fathers and fathers, and observing their behaviour, Glasper et al, (2015) came to the conclusion that parenthood triggered similar changes in the hippocampus of both maternal and paternal brains.

Among many other things, both its early stages as well as the transition into parenthood are periods in which individuals are highly susceptible to psychological distress. As for the pregnant mother, the process of brain plasticity they go thorough despite being an evolutionary mechanism to promote the survival of baby, "it is not necessarily innocuous and predisposes the mother or mother-to-be to peripartum mental disorders" (Barba-Müller et al., 2018, p. 295). The non-pregnant partners, even though they are not directly influenced by hormones and physiological changes, the transition to parenting can also have a significant impact on their mental health state.

Furthermore, it is important to consider pregnancy-related anxiety. Anxiety is defined by Freud (1936) as a "fundamental phenomenon and the central problem of neurosis" (p.85). According to epidemiological research, comorbidity is an essential factor to analyse when studying anxiety, since "many people suffering from anxiety fulfil the criteria for more than one anxiety disorder" (Michael et al., 2007, p. 138). "Anxiety disorders manifest in a wide range: generalized anxiety disorder, obsessive–compulsive disorder, panic disorder, and

birth-related posttraumatic stress disorder" (Barba-Müller et al., 2019, p. 293). The uniqueness of pregnancy and early parenting experience makes it necessary to distinguish pregnancy-related anxiety to the condition in other contexts. "The isolation of pregnancy anxiety from a background of indices of general anxiety and depression enables clinicians and researchers to address issues of identification, prediction, and prevention and risk reduction more precisely and perhaps more effectively in the future" (Huizink et al., 2004, p. 89). Pregnancy-related anxiety "constitutes a distinct concept from general anxiety and depression and is more strongly associated with maternal and child outcomes" (Bayrampour et al., 2015, p. 116). A study conducted by Huizinik et al. (2004) in the Netherlands found a three-factor model of pregnancy anxiety, divided in 'fear of bearing a handicapped child', 'fear of giving birth', and 'concerns about one's appearance'.

While pregnant mothers tend to experience higher levels of anxiety during the first and the last trimester (Teixeira et al., 2009), for male partners, "the peak of distress seems to be at mid-pregnancy (18%) and decreases steadily in the postpartum period" (Buist et al., 2003; Condon et al., 2004, as cited in Teixeira et al., 2009, p. 142). A study performed by Teixeira et al. (2009) in Portugal involved 300 pregnant women and their partners. The research concluded that anxiety symptoms were higher during the first and the last trimester, and that primiparous couples showed higher levels of anxiety than multiparous men and women.

Another study conducted by Deklava et al. (2015) in Latvia aimed to understand and identify the causes of anxiety during pregnancy. In this case, researchers considered both state and trait anxiety. These two types of anxiety refer, respectively, to "the experience of unpleasant feelings when confronted with specific situations, demands or a particular object or event […], and a personality characteristic rather than a temporary feeling" (Deklava et al., 2015, p. 623). The study found out that "the leading causes of anxiety amongst pregnant women is the possible neonatal development disorders (which causes anxiety amongst 86.5%), possible birth traumas (70.2%) and the newborn ability to initiate breathing (62.5%)" (Deklava et al., 2015, p. 626), and that anxiety symptoms were reinforced by low levels of education and lack of support.

An additional relevant example is a study conducted by Rubertsson et al. (2014) in Sweden, which aimed to understand anxiety in early pregnancy and its prevalence. A total of 916

Swedish-speaking women, patients from all 25 antenatal care clinics in a county in mid-Sweden, took part in the study. To access the patient's mental state, Rubertsson et al. (2014) used the Hospital Anxiety and Depression Scale-Anxiety (HADS-A). The study came to few conclusions. First of all, the results indicate that anxiety is not only a common illness in pregnant women, but it also overtakes depression when it comes to prevalence in early pregnancy. Moreover, in this study, women whose highest level of education was high school, who were unemployed, used nicotine prior to getting pregnant, had a history of mental problems and reported a language other than Swedish as their mother tongue were at higher risks of presenting expressive anxiety symptoms during early pregnancy. Rubertsson et al. (2014) consider that the strongest contributing factor is a history of anxiety that preceded pregnancy. Results have also shown that younger mothers, especially those under 25, were more vulnerable to experiencing high levels of anxiety during early pregnancy.

"Since a pregnant woman is the environment for the developing fetus, psychological alterations or mental disorders may further affect the fetus" (Huizink et al., 2004, p. 82). It is also worth noting that women of childbearing age are disproportionally affected by anxiety disorder and other psychopathologies (Qiu et al., 2009). "Anxiety during pregnancy is associated with prematurity, low birth weight and foetal growth restriction which in turn, are risk factors for impaired cognitive and social developmental outcomes" (Talge et al., 2007; Qiao, et al., 2012; Fishell, 2010, as cited in Deklava et al., 2015, p. 624). Studies even reported a connection between anxiety and postpartum depression (Austin et al., 2007) and postnatal anxiety (Rubertsson et al., 2014). Among other things, antenatal anxiety has also been associated with higher risks for preeclampsia (Qiu et al. 2009), and the increase of physical symptoms (Rubertsson et al., 2014).

A study conducted by Van Batenburg-Eddes et al. (2013) analysed both maternal and paternal anxiety in order to understand possible intrauterine effects. The study was built upon two prospective population-based studies; the Generation R, performed in the Netherlands, and ALSPAC, conducted in the Southwest England. Weaker influence of parental anxiety symptoms on child's attention problems, suggest that "the intrauterine mechanism as a consequence of maternal psychopathology may contribute to several child problems" (Van Batenburg-Eddes et al., 2013, p. 598). It is also worth noting that "in both cohorts, maternal

depressive and anxiety symptoms were correlated with paternal depressive and anxiety symptoms" (Van Batenburg-Eddes et al., 2013, p. 594).

Apart from anxiety, when one speaks of mental health issues related to pregnancy, postpartum depression is one of the first conditions that comes to mind. "Postpartum nonpsychotic depression is the most common complication of childbearing, affecting approximately 10–15% of women and, as such, represents a considerable health problem affecting women and their families" (Robertson et al., 2004, p. 289). The condition is not only prejudicial for the new mother's overall wellbeing, but it can also have a long-lasting impact on the children, since it can "contribute to later emotional, behavioural, cognitive, and interpersonal problems" (Robertson et al., 2004, p. 289) when left untreated. Studies show that early diagnosis is the key to prevent lasting consequences (Robertson et al., 2004).

Even though throughout pregnancy women show higher levels of both anxiety and depression than men (Teixeira et al., 2009), the partner can also experience significant psychological distress. A remarkable example is a condition called Couvade syndrome, also known as sympathetic pregnancy. "The term *couvade* comes from the French verb *couver* which means "to brood" in the sense of a bird protecting its eggs before they hatch" (Devi & Chanu, 2015, p. 109). "Couvade refers to the male experience of pregnancy whether this is manifested in the form of behavioural changes that may or may not be socially sanctioned, or somatic symptoms for which there is no apparent physiological cause." (Mason & Elwood, 1995, p.137). "Anthropologists, psychiatrists, nurses and sociologists have provided explanations for behaviour changes in "pregnant" men in terms of cultural pressure, intrapsychic processes and psychosocial adaptation to a new situation" (Mason & Elwood, 1995, p. 137). A condition as such should not be overlooked, especially considering that "men are rarely isolated as a group with special needs relating to pregnancy, therefore health promotion in the antenatal period tends to be directed to the women or "the couple"" (Mason & Elwood, 1995, p. 146).

In 2007, Brennan et al. performed a qualitative study on the condition with 14 men in a teaching hospital in London that served a large Asian and Afro-Caribbean population. In order to select participants, the group of men was first presented with a questionnaire with symptoms associated with couvade syndrome. Symptoms include nausea, heartburn,

respiratory disturbances, abdominal pain, urogenital irritations (Brennan et al., 2007), and in more extreme cases, postpartum depression, and labour pains (Devi & Chanu, 2015). Those who did not fulfil the study selection criteria "because of language difficulties, having less than 4 physical symptoms and a partner with a high-risk pregnancy" were excluded (Brennan et al., 2007, p. 23). The ones selected to continue were invited for in-person interviews. Results have shown that the syndrome follows the same U growth and decrease pattern (Brennan et al., 2007) as anxiety on expectant mothers (Teixeira et al., 2009); rising on the first trimester, decreasing on the second and increasing again on the third. Brennan et al. (2007) highlight that "a greater awareness of the syndrome is warranted given its physical and emotional consequences not only for the man but also his pregnant partner" (p. 37). It is also worth mentioning that, although the syndrome is associated with men, a case study conducted by Budur et al. in 2005 reported an equivalent condition in a woman during her twin sister's pregnancies (Brennan et al., 2007).

This chapter explored the ways in which technology has transformed parenting practices as well as how transformative becoming a parent is in itself. The transition to parenting is information-intense and comes with socioeconomic and physiological changes on oneself. Both parents are then highly susceptible to emotional distress. Reflecting on the impact of parenthood in one's life and the perks and challenges that come with integrating technology into the experience is essential to understand how digital tools can be expanded to clinical practice. The following chapter will expand on the subject while also introducing the main object of research in this study: pregnancy and baby apps.

3. Pregnancy and baby apps

In the past decade, the number of digital health solutions focused on women's health have increased exponentially. There are many benefits that come with these digital solutions, which "have been formally recognized as a critical strategy to help meet the Sustainable Development Goals and universal health coverage targets" (Labrique et al., 2018, p. 3). Of all the apps that fall into the "health and fitness" category, pregnancy apps are the ones that appear the most (Tripp et al., 2014). Pregnancy and baby development apps can be considered one of the most notable examples, since, according to previous studies, pregnant women "represent a generation of patients eager to experience new technologies and extend medical care in the digital sector" (Bruskiak et al., 2020, p. 2), who place "high value on the information and support received through Web-based sources and apps" (Goetz et al., 2017, p. 2). One of the most relevant advantages of such tools is that they can be regularly updated. Moreover, considering the daily advancement and discoveries of the digital world, mobile tools ensure that information is current and promptly available for the users (Arbour & Stec, 2018).

Pregnancy apps have two main functions: monitoring and informing (Brusniak et al., 2020), focusing on addressing two of the major factors that reinforce anxiety in expectant parents: lack of information and lack of support (Deklava et al., 2015). The expressive presence of such digital solution, however, raises concerns on the quality of their content (Lee & Moon, 2016). Most pregnancy apps provide both educational content and monitoring tools, "based on regular assessments of patient-reported outcomes (PROs)" (Brusniak et al., 2020, p. 2), and the self-report of physical and psychological symptoms (Mo et al., 2018; Brusniak et al., 2020). Many of them include social features, a due date calculator, foetal movement tracking as well as other features (Mo et al., 2018). These tools can add great value to the pregnancy experience, since "digital self-tracking of uterine activity has already been shown to prolong pregnancy and improve baby outcomes" (Brusniak et al., 2020, p. 2).

3.1 The Femtech industry

As aforementioned, throughout the past few decades, the development of digital health solutions targeting women's reproductive health has been growing considerably. "Largely

celebrated by cultural critics and investors, Femtech is seen as a long-overdue corrective to the male-dominated medical and tech industries, with products largely marketed as tools for female empowerment" (Kressbach, 2019, p. 242). Such digital solutions focus on serving women's healthcare needs, from fertility and period tracking to prenatal care to the postpartum period and menopause (Wiederhold, 2021). Through various tools, "knowledge is constructed by transforming users' emotional, physical, and social experiences into data, rendering their symptoms trackable and comparable over time" (Kressbach, 2019, p. 242).

The full extent of the advancements that came with giving greater focus to the particularities of women's health cannot be overlooked. "Without evidence on how men and women are different (or similar) in their health experiences, their health trajectories, their utilization of health care, and their responses to treatment, major barriers to effective evidence-based practice will persist" (Beck & Polit, 2012, p. 9). Especially considering that "most of recorded human history is one big data gap (...), the chronicles of the past have left little space for women's role in the evolution of humanity, whether cultural or biological" (Perez, 2019, XII). It is important to note, however, that studies have also raised a considerable number of critics to the Femtech industry. A study conducted by Kressbach (2019) aimed to analyse two popular menstrual and fertility apps under a different light, as reinforcement of "discourses of menstrual concealment and bodily alienation" (p. 241). The apps studied were Flo and Clue, which are among the most popular ones in the market of menstrual tracking and fertility (Kressbach, 2019). Kressbach (2019) looks into the interfaces as well as the overall tone of the discourse in the apps. Through the data analysis the study concludes that the two apps "oscillate between these two poles: seeking to empower users through self-knowledge, while still reinforcing the perception that menstruation is an uncontrollable abject process that should be managed and suppressed" (p. 256). Another relevant issue presented in the paper is privacy – or lack thereof – and data collection. "The personal nature of this information necessitates better anonymization and new security protocols" (Kressbach, 2019, p. 257).

3.2 Compliance

When discussing education and the digital native brain Eagleman (2020) pointed out, that "without engagement there is little to no [neuro]plasticity" (p. 152). Like in education, for

digital health solutions, high user engagement is a main factor of success (Brusniak et al., 2020) A study performed by Brusniak et al. (2020) in Germany aimed to "examine compliance and its influencing factors among pregnant women in a prospective cohort study". The research was conducted at two university hospitals, and it "took place in addition to standard antenatal care" (Brusniak et al., 2020, p. 3). Researchers designed a longitudinal, bicentric trial with questionnaires delivered through Patient-informiert-interaktiv-Arzt; an online platform. In order to maintain and encourage user engagement, a series of strategies were employed, including frequent email reminders. The questionnaires also included mental health assessments, such as the Edinburgh Postnatal Depression Scale and the State-Trait Anxiety Inventory. At the end of the study, Brusniak et al. (2020) concluded that socioeconomic background and origin were the most relevant factors and that, despite all the engagement strategies employed, maintaining long-term usage of the tool was still a challenge. They also noticed that the patient's mental health state had no influence in compliance, trait anxiety being a small exception.

3.3 Content assessment

A study held in South Korea (Lee & Moon, 2016) with 200 participants analysed the use of pregnancy and childcare apps as well as their content, credibility, and characteristics through a cross-sectional survey. The first questionnaire was reviewed by two nursing professors and contained questions on usage patterns of pregnancy apps and reasons as to why the participants used such apps. The final one "consisted of 6 demographic items, 6 items exploring participants' general usage of smartphones apps, 12 items about pregnancy app usage, and four items exploring the opinion of non-users" (Lee & Moon, 2016). This study came to a few conclusions. "The information most frequently obtained from the apps were risk signs and diseases during pregnancy (16.8%), physical changes related to a normal pregnancy (16.0%), and prenatal education (14.6%)" (Lee & Moon, 2016, p. 75). When it comes to app usage no difference was reported in "age, pregnancy phase, occupation, education or income" (Lee & Moon, 2016, p. 75), however, younger, first-time mothers tended to use it more. The study also suggests that apps could act as an anxiety relief by helping patients realise that their feelings and worries are a normal part of the pregnancy experience (Lee & Moon, 2016). Nevertheless, an important point raised by this research is

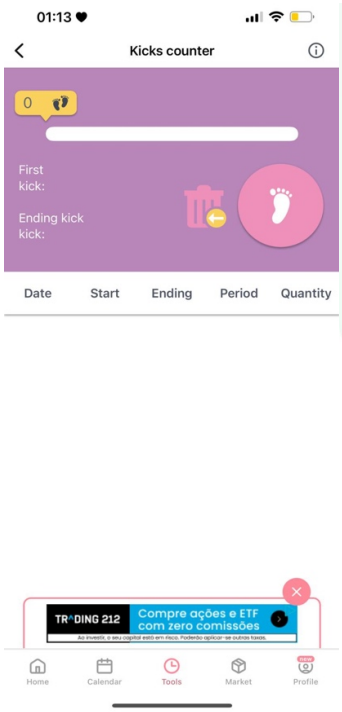
the lack of credibility in some of these apps, and the importance of bringing specialists into the loop when developing such a tool. “There are no industry standards to what is appropriate for these apps, with typical app programming developer guidelines not adhering to any medical-specific regulations” (Tripp et al., 2014, p. 66).

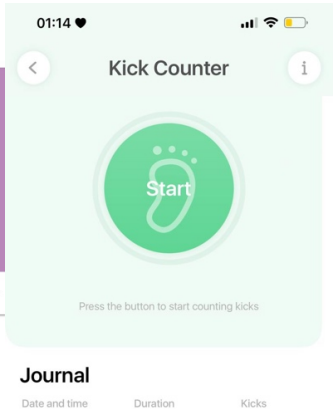
A study conducted in Spain by Muñoz-Mancisidor et al. (2021) aimed to analyse free pregnancy apps available in Spanish in order to identify which ones should be recommended to obstetric patients. Out of the 457 mobile applications that fit the criteria of the study, 25 were assessed, roughly 5.5% (Muñoz-Mancisidor et al., 2021). When it comes to content, the study identified that, most apps focused on foetal development, nutrition, weight gain, physical activity and transformations throughout pregnancy, which can potentially be quite effective (Muñoz-Mancisidor et al., 2021). Most of the apps were also self-monitoring and goal-setting in nature (Muñoz-Mancisidor et al., 2021). Muñoz-Mancisidor et al. (2021) concluded that even though only a small percentage of the applications analysed should be recommended to patients, “apps specifically designed for pregnancy can be very positively evaluated by health professionals and more specifically, by midwives, who monitor low-risk pregnancies in the Spanish health system” (Muñoz-Mancisidor et al., 2021, p. 7).

3.4 Features and functionalities

It is important to note that pregnancy and baby apps go far beyond providing content, they are equipped with a myriad of features and functionalities. A study conducted by Sardi et al. (2020) had at its core the goal to analyse the different tools available in such digital solutions in the context of postpartum care. In the study 48 apps were assessed, and “results of the functional content analysis show that the postnatal apps selected relatively achieved low scores owing to the complexity and the ramification of the postnatal care” (Sardi et al., 2020, p. 1). While approximately 40% of the apps analysed focused mostly on monitoring the development of newborns, 35% provided information on postnatal and newborn care (Sardi et al., 2020). The remaining 15% of the apps centred around losing weight and postanal fitness (Sardi et al., 2020).

Some examples of such features include: Kick counter (Image A & Image B), Bump growth chart (Image C), To-do lists (Image D & Image E), Feeding tracker (Image F), “Is it safe?” (Image G & Image H).





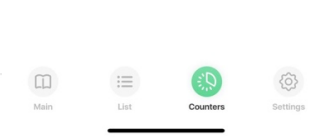


Image 1 (amma) Image 2 (My Pregnancy)

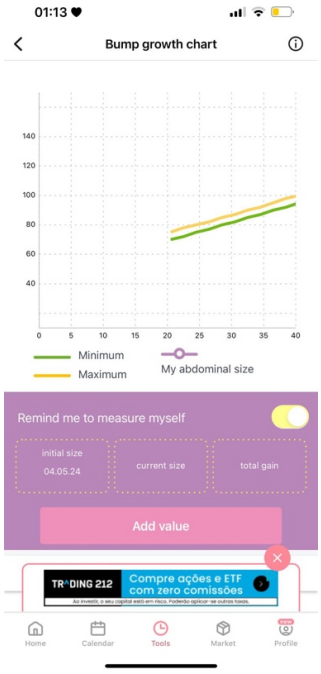


Image 3 (amma)

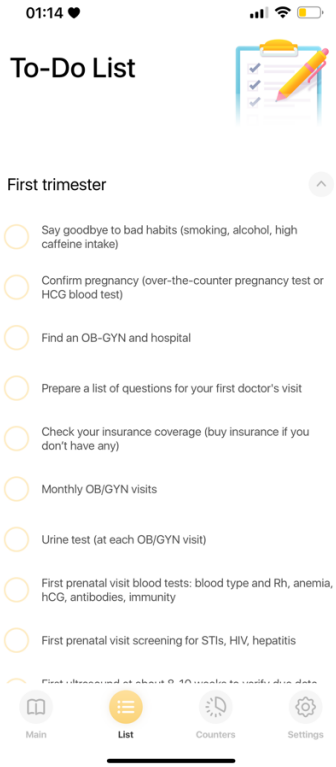


Image 4 (My Pregnancy)

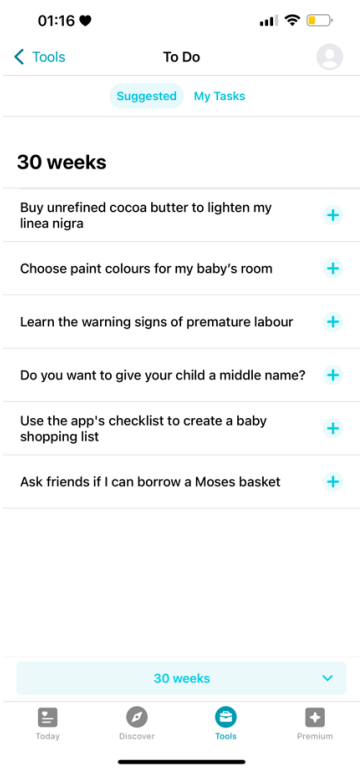


Image 5 (Pregnancy+)

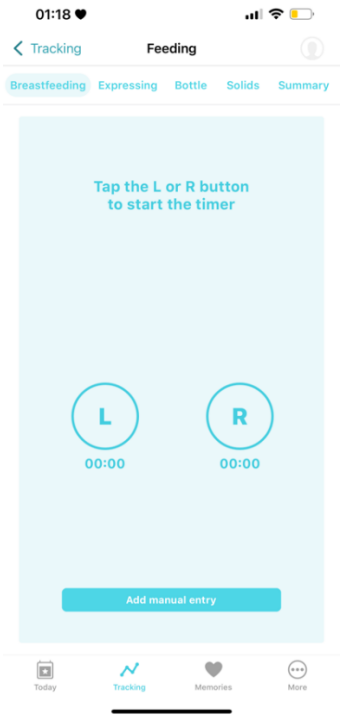


Image 6 (Baby+)

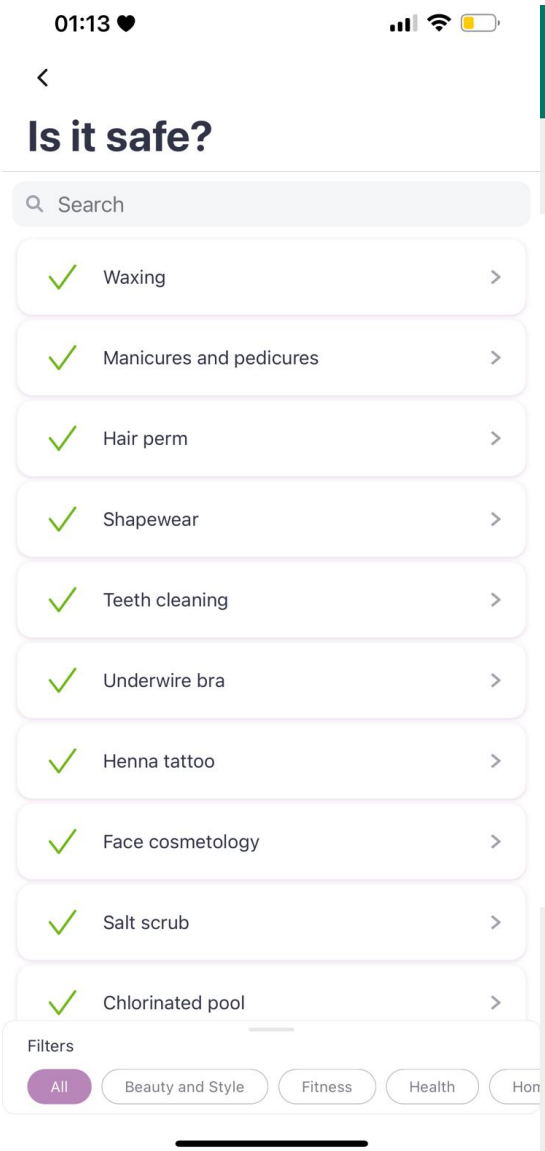


Image 7 (amma)

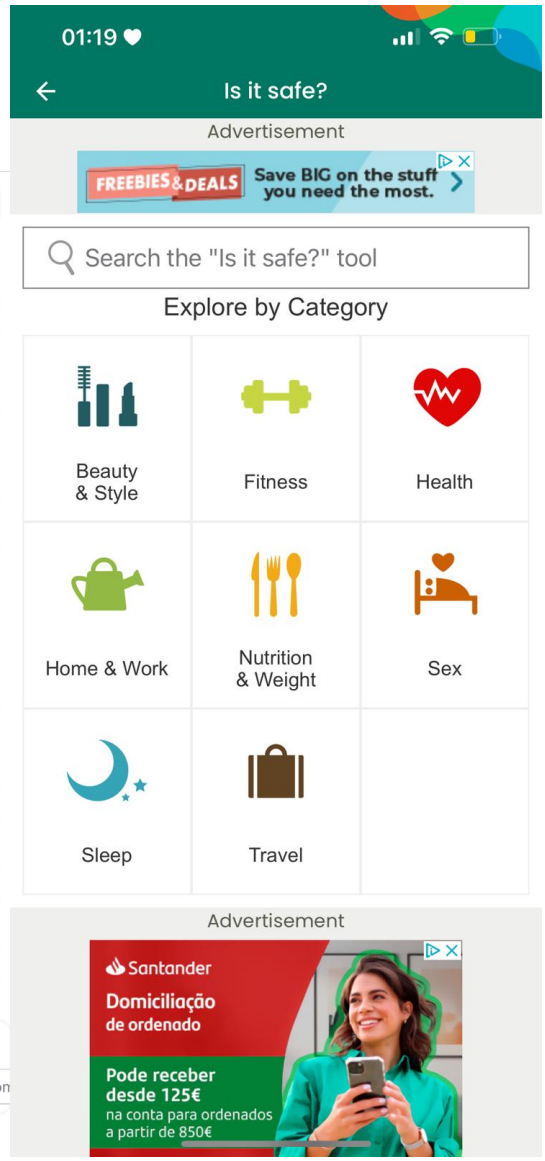


Image 8 (BabyCenter)

3.5 Pregnant mothers

Since those kinds of apps are constructed around the pregnancy experience, most of the content and functionalities of pregnancy apps revolve around the pregnant mother. A study conducted in Australia (Lupton & Pedersen, 2016) aimed to assess Australian women's use of pregnancy and parent apps as well as their attitudes towards the content and what features they search for in such digital tool. The data, collected in 2014, was gathered from an online survey filled out by 410 women who either were pregnant at that moment or had given birth in the past three years. The research found out that almost 75% of the participants reported

that they had used at least one pregnancy app, and 50% at least one parenting app. “Respondents found the apps useful or helpful, particularly for providing information, monitoring foetal or child development and changes in their own bodies and providing reassurance” (Lupton & Pedersen, 2016, p. 368). The study came to the conclusion that apps are becoming an important self-monitoring tool and source of information for Australian mothers and pregnant women; therefore, healthcare professionals need to take their “use into account and recognise both the potential and limitations of these apps” (Lupton & Pedersen, 2016, p. 368).

Having said that, it is also relevant to mention a study conducted in Germany in 2017 by Goetz et al. In order to assess both the perceptions and expectations of pregnant mothers when it comes to pregnancy apps, the researchers conducted a qualitative study consisting of semistructured interviews with 30 women. The study found that “pregnant women considered evidence-based information and interactive tools as the most important features” (Goetz et al., 2017, p. 10), and were interested in the idea of further integrating the digital tool into their healthcare routine. The participants also presented some concerns when it comes to the credibility of the content and data privacy issues (Goetz et al., 2017). Goetz et al. (2017) predict that next evolutionary step is the integration of such evidence-based tools into healthcare practices. “Health care professionals should be committed to guiding pregnant women through these applications, exploring the ability to prevent misguiding through nonvalidated educational information, and thus reduce adverse pregnancy outcomes” (Goetz et al., 2017, p. 10).

3.6 Non-pregnant partner

Even though the focus of pregnancy apps tends to be on the pregnant mother, a study conducted in 2018 by Mackert, et al. in the United States analysed its benefits for the partner. “eHealth apps present a promising avenue to reach new and expectant fathers with crucial parenting knowledge and healthy, supportive behaviour” (Mackert, et al., 2018, p. 1). Data was collected through an online survey answered by 962 men, although 64 were disregarded for being blank or only partially filled out. The study concluded that men were favourable of the digital solution and that “reaching men at the prenatal phase can be considered an early “teachable moment”—where new/expectant fathers are open to information about how

to help their partners have a healthy pregnancy and promote the health of their unborn children" (Mackert, et al., 2018, p. 6).

3.7 Personalisation

Every individual experiences pregnancy differently. "Pregnancy is a unique life experience and evokes a range of emotions from great joy and anticipation to crippling anxiety" (Tripp et al., 2014, p. 65). With that in mind, an important feature of pregnancy and baby apps is personalisation. In a study conducted in the United States in 2014, Peyton et al. (2014) explored the ways in which mHealth solutions could be designed in order to cater to the needs of low-income American women, targeting specifically the issue of obesity. An important term introduced by the study is the one of "individualised pregnancy ecology". "Used in biology, in health and wellness research, and in HCI, ecology as a concept is a description of a changeable ecosystem" (Peyton et al., 2014, p. 580). Pregnancy ecology is defined as what "details the specific experiences of women during pregnancy, making visible the challenges, influences and opportunities for health empowerment" (Peyton et al., 2014, p. 578). The idea of individualised pregnancy ecology targets the specifics of a certain scenario.

3.8 Brazilian context

In Brazil, among the most popular apps that fall into the medical and health and fitness categories, there is an expressive presence of pregnancy and baby apps. Only one application, however, was developed in the country. The app in question is *Meu Pré-Natal* (Image I), and it was developed at the Faculty of Medicine of the Federal University of Minas Gerais (UFMG). According to Faculdade de Medicina da UFMG (2016), "the main objective is to promote information on maternal health and autonomy so that the woman can be the protagonist of her birth" (para. 2). The application came into being in 2016, and it is the result of the work of a multidisciplinary team of computer experts, designers and healthcare professionals (Perez et al., 2021). One of the main objectives of the project is promoting the protagonism of expectant mothers in their own pregnancies (Montoya et al., 2022). Even though the app is available in Portuguese, English and Spanish, 96% of the

users are located in Brazil (Montoya et al., 2022). *Meu Pré-Natal* alongside the most popular pregnancy and baby apps available in Brazil will be further explored in the next chapters.

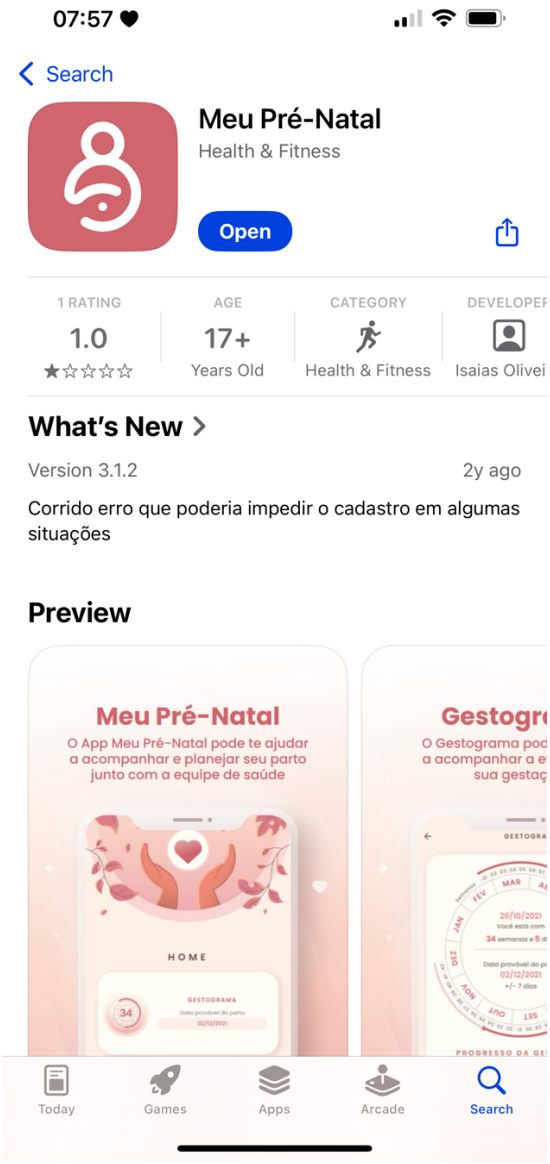


Image 9 (*Meu Pré-Natal*)

Pregnancy and baby apps are popular mHealth tools that have potential to improve maternal and foetal outcomes. The growth of the Femtech industry, and the investments in digital solutions as such represent a step towards addressing the gaps in women's healthcare practices. However, in order to keep moving forward, it is essential to recognise and address some issues, such as content quality and credibility. As a means to make such corrections, a

collective effort is needed. Developers, physicians and researchers should work together when developing and updating the apps to optimise their outcome.

The next chapter will dive into the methodology employed in this study, exploring the worldview guiding this study as well as how data was collected and analysed.

Part II: Empirical study

1. Methodology

In order to reflect upon the research question "to what extent can pregnancy and baby apps be integrated into prenatal and paediatric care?", this study employs a mixed method approach with a greater focus on the qualitative side, gathering its data from a content analysis of apps followed by a questionnaire answered by specialists. The methodology employed in this research as well as its research question came to being after careful consideration, extensive research and a few bumps along the way. At first, the research question was "what is the role of pregnancy and baby apps in the experience of new and expectant parents?". The plan was sending out surveys then interviewing expectant and new parents in Portugal. The research would be constituted of a case study following a sequential mixed approach with greater focus on the qualitative side. In this context, a mixed method approach would expand the research, making it possible to both benefit from the existent quantitative scales to measure anxiety and to dive deep into the participants' unique experiences. While working on the literature review, however, I realised how much previous studies have emphasised the importance of bringing specialists into the loop when developing and maintaining pregnancy and baby apps (Lee & Moon, 2016) and how unique the pregnancy experience is (Peyton et al., 2014). After careful consideration, changing the focus of the study from the users to the specialists came in naturally. Assessing the opinion of physicians working in the field would both fulfil the need of getting more specialist perspectives on the matter, and - since they care for multiple pregnancies and/ or babies - the results could be broader and more systematic. Focusing on specialists rather than patients would facilitate the identification of trends as well as general challenges, benefits and limitations when it comes to integrating technology into healthcare practices.

Later on, the location of the study was also changed. Initially the research was going to take place in Portugal. However, after sending out over 300 emails to specialists around the country, reaching out to clinics, hospitals, faculties of medicine, pre and postpartum educational centres, the *Ordem dos Médicos*, friends and acquaintances with relatives working in the field, and therefore exhausting all contacts and resources, only five people

answered the questionnaire. This unforeseen resistance to the topic, resulted in the migration of the study to Brazil.

1.1 Theoretical positioning

The worldview guiding this study is social constructivist. “Social constructivists hold the assumption that individuals seek understanding of the world in which they live and work” (Creswell, 2009, p. 8), and that people develop subjective understandings of what they experience (Creswell, 2009). As aforementioned, even though, at first, the idea was to focus the study on the users of the app in order to grasp how they could affect their experience, the changes in the research question did not alter its world view in any way. Although the specialists are not the ones using the apps directly - at least not for professional reasons - the digitalization of their field has a significant impact on how they approach their own practices and how their patients behave and interact with information.

1.2 Data collection

The first step of the data collection consisted of a content analysis of the top-rated baby and pregnancy mobile apps available on App Store in Brazil, that fall both into the medical and health & wellness categories, as well as the only pregnancy app developed in Brazil. The apps in question are Pregnancy+, My Pregnancy, Baby+, amma, Flo, BabyCenter and *Meu Pré-Natal*. Apart from *Meu Pré-Natal*, all the other apps were developed abroad. The content analysis will follow a directed content analysis framework as described by Hsieh & Shannon (2005). “The goal of a directed approach to content analysis is to validate or extend conceptually a theoretical framework or theory” (Hsieh & Shannon, 2005, p. 1281). Based on studies highlighted in the literature review, the following table to determine the coding system of the analysis came to being:

Table 1 – *Content analysis' codes*

	Pregnancy+	Baby+	My Pregnancy	amma	Flo	BabyCenter	Meu Pré-natal
Who are the users?							
Structure of the app							
Content localisation							
Partner content and tools							
Proofread articles							
Personalised content							
Sexual-orientation, family structure inclusivity							
Features and Functionalities							
Social features							
Gamification							
Extras/premium features							
Observations							

Each code was carefully chosen in order to identify the key elements of the selected apps. "Who are the users", "Partner content and tools" and "Sexual-orientation, family structure inclusivity" aimed to understand what perspectives were being represented. Considering the main functions of pregnancy apps – monitoring and informing – as mentioned by Brusniak et al. (2020), codes were chosen to assess content, self-tracking tools and other features. When it comes to content, while this study does not dive into the specifics of the information presented to the users, considering the issues of lack of transparency and credibility in some apps raised by previous studies (Lee & Moon, 2016), the code "Proofread articles" was created. Exploring another aspect of content, the codes "Personalised content" and "Content

localisation" were integrated into the coding system, in order to understand in what ways – if any – the apps honour the uniqueness of each pregnancy, the so-called "individualised pregnancy ecology" (Peyton et al., 2014). As for the self-tracking tools and other features, the more general code "Features and functionalities" and the more specific "Social features" – an aspect highlighted by Mo et al. (2020) - were included. As for "Gamification", the code was chosen due to the number of studies that highlighted the benefits that come with integrating gamification strategies into mHealth solutions (Ning et al., 2023; Cechetti et al., 2019; Rahim & Thomas, 2017). Both "Structure of the app" and "Extra/premium features" were chosen, respectively, to assess how the different features are divided and displayed by the apps, and what is available for premium users. Lastly, having in mind that the directed content analysis framework leaves room for flexibility and the emerging of new codes during the analysis, the "observations" section was included. "Observations" accounted for notes that - whenever suitable - were later translated into new codes.

Table 2 – *Content analysis' additional codes*

	Pregnancy+	Baby+	My Pregnancy	amma	Flo	BabyCenter	Meu Pré-natal
Frequency of updates							
Notes and impressions							

This step came in first because assessing what was available on the market was of great importance on the development of the questionnaire. The information from the content analysis combined with the studies explored in the literature review were the foundation for the questions of the questionnaire. The second step of the data collection was constituted by a questionnaire sent out to specialists on the field (Appendix 1). The questionnaire was answered by a total of 50 people; 8 paediatricians, 10 obstetricians, 18 psychologists, and 14 professionals that fall under the category "others", constituted by 6 nurses, 6 physiotherapists, an ER doctor and a maternity speech therapist. The questionnaire was made of a mix of multiple choice and open-ended questions, in order to gather both quantitative and qualitative data.

1.3 Participant selection

The questionnaire was first sent out within my personal network, and initially it was directed to paediatricians, obstetricians and phycologists only. Upon sending it, it was pointed out by one of the participants that when it came to pre and postnatal care there were other professionals who had an important role in carrying for both the mother and the baby. The specialists in question were nurses and physiotherapists. After the first few responses, the participants were then requested to share the link within their own network. Some professionals got the questionnaire sent to them directly, while others came across it on hospital and medical schools WhatsApp groups. At first, the goal was to reach 30 responses. However, only a few days after hitting that mark, the questionnaire had already been answered by 50 specialists.

1.4 Research strategy

The research strategy employed overall in this study was concurrent mixed, the strategy "in which the researcher converges or merges qualitative and quantitative data in order to provide a comprehensive analysis of the research problem" (Creswell, 2009, p. 14). During the analysis of the responses obtained through the questionnaire, however, it was employed a sequential explanatory strategy, "characterized by the collection and analysis of quantitative data in a first phase of research followed by the collection and analysis of qualitative data in a second phase that builds on the results of the initial quantitative results" (Creswell, 2009, p. 211). First, the answers to the multiple-choice questions were analysed. Then, after identifying patterns and general opinions, it was time to dive into the open-ended responses. The qualitative side came in to explain and expand the results of the quantitative data.

1.5 Ethical considerations

"Informed consent, confidentiality, privacy, privileged communication, and respect and responsibility are key elements of ethics in research" (Guraya et al., 2014). It was disclosed to the participants that all the data gathered through the questionnaire was for academic use only. My contact information was also provided, and they were all informed that they should not hesitate in getting in touch if they had any questions. "A core idea of action/participatory

research is that the inquirer will not further marginalize or disempower the study participant" (Creswell, 2009, p. 88). This study does not have by any means the intention of judging one's practice nor imposing implementations to the specialists.

In this chapter, the methodology of this study is outlined, diving into the worldview guiding the research as well as the research strategy and data collection. In the next chapter, the results from both the content analysis of the app and the questionnaires are brought together.

2. Data results

2.1 Content analysis

This study highlights six of the most popular pregnancy and baby apps in Brazil, all of them are on the top chart of either medical apps or health and wellness apps on App Store, as well as the only pregnancy and baby app developed in the country that provides both tools and content. It is important to note that there is one relevant app on the matter that was mentioned by two participants of the questionnaire: BLW Brasil. The reason why that Brazilian application was not analysed in this study lies on the fact that it only contains resources on introducing solid foods, and, unlike the baby apps considered, it does not cover baby development as a whole.

2.1.1 Who are the users?

Upon registration, the user is usually required to indicate who they are. As for both Pregnancy+ and Baby+, the user has the chance to select between a few options, as follows: mother, father, parent, partner, single mother, grandparent, uncle or aunt, friend. The same happens in the app Flo, where the user can select between patient, partner or family member. On Flo, the user also has three sub-options within the option "patient"; wants to be pregnant, wants to better understand their body, and pregnant. On the apps My Pregnancy App, amma and BabyCenter only the "mother" user option is available. Like Flo, BabyCenter also has the following sub-options: trying to conceive, pregnancy or baby, and in this app, multiple options can be displayed at once. Lastly, *Meu Pré-Natal*, although being an app whose aim is to put the mother as the centre of the pregnancy experience, has the option of "my prenatal care" and "someone else's prenatal care" upon registration. It is important to note, however, that by choosing the second option there is no change in the content on the app.

Table 3 – *Who are the users?*

Apps	**Who are the users?**
Pregnancy+	Mother; father; parent; partner; single mother; grandparent; uncle or aunt; friend
Baby+	Mother; father; parent; partner; single mother; grandparent; uncle or aunt; friend
My Pregnancy	Mother
amma	Mother
Flo	Patient (sub-options: wants to be pregnant; wants to better understand their body; pregnant), Partner, Family member
BabyCenter	Mother (sub-options: trying to conceive, pregnancy or baby) *Multiple options can be displayed at the same time
Meu Pré-natal	My pre-natal care; someone else's prenatal care

2.1.2 Structure of the app

As for the layout of the apps, all of them have one feature in common: a feed/home page. In all the apps but *Meu Pré-natal*, the feed/home page is very similar to what can be found in social media platforms, where the user can scroll down to see the content suitable for their stage in pregnancy or their baby's age. In *Meu Pré-natal*, the "home" page has a shortcut to two tools: "due data prediction" and "birth plan" (Image I).

Image 10 (*Meu Pré-Natal*)

In Pregnancy+, apart from the "Today" page, the app also has "Discover", "Tools" and "Premium". The "Discover" page displays all the content available on the app divided by categories; Week by week, Nutrition body, Baby, Feel good, Medical, Exercise, Labour, Feeding, Lifestyle, Relationships, Multiples, Preterm, Fertility. As for the "Tools" page, it is – as the name says – the tools page of the app, which includes the free and premium tools, such. The free tools being a 3D model, Baby names list, Size guide, Scans, Timeline, My bump, My weigh, To-do, Appointments, Questions, Shop and Coming soon. As for the premium tools they are the Kick counter, Contractions timer, Birth plan and Hospital bag. Lastly, the "Premium" page, contains all the tools, articles, videos and audios available for the premium users.

As for Baby+, its visuals and display are quite similar to Pregnancy+. Considering both apps were developed by the same company, Baby+ seems like a natural next step for the users of

Pregnancy+. In Baby+, the tools are divided between the pages “Tracking” and “Memories”. The “Tracking” page has all the self-tracking tools of the app, such as Growth, Feeding, Mum’s weight, Soothing, Healthy and Nappy. In “Memories”, the tools are not health related, they are virtual diaries for parents to collect mementos. Lastly, the “More” page contains all the articles, soothing sounds for babies and the appointments calendar.

In My Pregnancy, other than the “Main” page, the user is presented with “List”, “Counters” and “Settings”. In the “Lists” page, the user can find checklists to which they can add items to. The lists available are: First trimester, Second trimester, Third trimester, Hospital bag and Bringing baby home. As for “Counters”, the user is presented with two self-tracking tools “Weight Tracker” and “Kick Counter” and a shortcut to another application by the same developer: Contraction Timer & Counter 9m. Lastly, “Settings” is where the user can log-in their ”Last period”, “Date of labour”, “Gestational age” and “Date of conception”, either turn on and off app notifications, change measurements to the metric system, access other apps from the same developer through a shortcut, get technical support and read their privacy policy.

In amma, besides the “Home” page, the app is constituted by four other pages: “Calendar”, “Tools”, “Market” and “Profile”. In Calendar, the user will find their gestational age registered, and they can also add events to their calendar. In “Tools” page, the user is presented with six tools: “Kicks counter”, “Weight gain chart”, “Contractions counter”, “Bump growth chart”, “Names list” and “Is it safe? Common questions” list. In “Market”, the user can find shortcuts to links of baby products available online. Lastly, the “Profile” page has the user’s personal data, a button to change user’s goal (“Get pregnant”, “Track pregnancy” or “Track child’s development”), an access to the link to share with a partner, settings, the BabyCash wallet and a support chat.

In Flo, when in pregnancy mode, apart from the “Today” page, the user is presented with “Insights”, “Secret chat” and “Partner”. “Insights” is the content page, where users can find articles and videos on various topics within the scope of pregnancy and postpartum. In “Secret chats”, the user has the option to follow the topics that interest them and leave

comments on posts and interact with other users. Lastly, the "Partner" page has all the resources to connect their account to their partner's.

In the case of BabyCenter, apart from the "Home" page, the app is constituted by "Community", "Calendar", "Tools" and "More". In the "Community" page, the user has access to the social features of the app, where they can join groups, post their stories and questions on various topics as well as comment on other users' posts. As for "Calendar", the user will find an editable calendar tool, where they can track their bump growth, log symptoms and add notes. In "Tools", the user is presented with all the tools available on the app, divided into three categories: Trying to conceive, Pregnancy and Baby. Lastly, the "More" page is where the user can edit their profile and have more information on the app.

In *Meu Pré-natal*, the pages are "Home", "Pregnancy", "Birth plan", "Know more", and the "More" tab. In "Pregnancy", the user can fill out their personal information, including name, age, current IG, estimated due date, pre-natal care center and its contact information, name of physician, maternity of choice (with the option to share data with partner maternities), a prenatal appointments log and the baby's information at birth. The "Know more" page has videos and digital flashcards with information on the following categories: body changes, bag and "stay tuned" (which for some reason, it is empty). Lastly, in the "More" tab, the user can find information on the app, a contraction counter, gestogram, information on the project team in Brazil and in Portugal, a list of scientific references, a comment section to leave suggestions and their privacy policy.

Table 4 – *Structure of the app*

Apps	**Structure of the app**
Pregnancy+	Today; Discover; Tools; Premium
Baby+	Today; Tracking; Memories; More
My Pregnancy App	Main; List; Counters; Settings
amma	Home; Calendar; Tools; Market; Profile
Flo	Today; Insights; Secret Charts; Partner
BabyCenter	Home, Community, Calendar, Tools, More

Meu Pré-natal	Home; Pregnancy; Birth plan; Know More; More

2.1.3 Content localisation

When it comes to health guidelines, despite the existence of organisations such as The World Health Organisation, some specificities can vary from country to country. None of the apps analysed have any kind of content localisation. Pregnancy+ and Baby+ only have localised native adds. In *Meu Pré-natal*'s case, the app was developed in the country in which its being analysed, and its "scientific references" page includes the guidelines of both The World Health Organisation and The Brazilian Health Ministry. The app does not, however, adapt its content to the other countries in which it is available.

Table 5 – *Content localisation*

Apps	**Content localisation**
Pregnancy+	Only for ads
Baby+	Only for ads
My Pregnancy App	N/A
amma	N/A
Flo	N/A
BabyCenter	N/A
Meu Pré-natal	N/A, however, the app was developed in Brazil and has among its scientific references list the guidelines of the Brazilian Health Ministry

2.1.4 Partner content and tools

As studies have shown, the use of pregnancy and baby apps can be beneficial for the non-pregnant partner (Mackert, et al., 2018). While analysing the apps, 3 out of the 7 do not accommodate the partner's perspective. Both Pregnancy+ and Baby+ include it through content, both have articles focused on the partner's side and on the relationship between the

parents. As for both Flo (Image J) and amma (Image K), they also cater to the partner's needs through content. However, when compared to the other two apps, Flo and amma take a step further. Both apps give the expecting mother the opportunity to connect their own profile to their partner's.

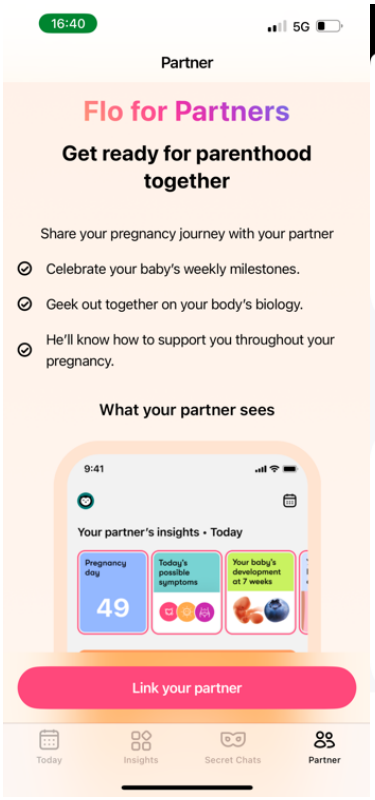


Image 11 (Flo)

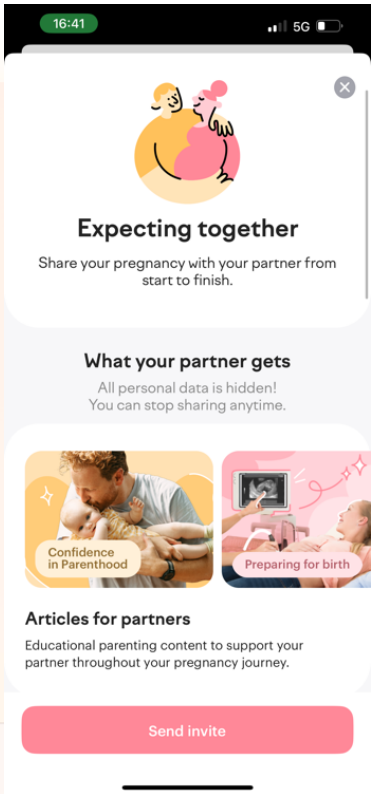


Image 12 (amma)

In *Meu Pré-natal*, even though upon registration the user has the option to be someone else other than the expecting mother, the app does not cater for the other person's perspective, it remains the same as when the user chooses the mother option.

Table 6 – *Partner content and tools*

Apps	**Partner content and tools**
Pregnancy+	- Articles focused on the partner's experience - Articles focused on the relationship between the expectant mother and the non-pregnant partner
Baby+	- Articles focused on the partner's experience - Articles focused on the relationship between the new parents
My Pregnancy App	N/A
amma	"Expecting together" feature - Option to send an invite link with a code to link accounts - Articles for partners - The expecting mother can stop sharing at any time
Flo	- Partner mode available (Flo for Partners) - Option to link the account with partner's account
BabyCenter	N/A
Meu Pré-natal	N/A

2.1.5 Proofread articles

One of the main concerns previous studies have raised is the lack of transparency when it comes to sources of the content available through digital health solutions (Donelle et al., 2021), so it was relevant to check whether or not the apps signalised where the information

came from. In all apps but My Pregnancy App and Baby+, there were lists of scientific references available. In Pregnancy+ at the end of each article there is a list of references as well as a disclaimer that the "information is not intended to replace and advice of a trained medical professional". In BabyCenter and Flo, the articles are also flagged as reviewed by medical professionals. In the case of amma, there is a list of references at the end of each article. As for Meu Pré-natal, under the "More" tab there is a list of general references. It is also worth mentioning that despite not having a list of references at the end of the articles like Pregnancy+ does, at the bottom of each of article the same disclaimer can be found.

Table 7 – *Proofread articles*

Apps	**Proofread articles**
Pregnancy+	- List of references; - Disclaimer: "This information is not intended to replace the advice of a trained medical professional. Philips Consumer Lifestyle B.V. disclaims any liability for the decisions you make based on this information, which is provided to you on a general information basis only and not as a substitute for personalised medical advice"
Baby+	- Disclaimer: "This information is not intended to replace the advice of a trained medical professional. Philips Consumer Lifestyle B.V. disclaims any liability for the decisions you make based on this information, which is provided to you on a general information basis only and not as a substitute for personalised medical advice"

My Pregnancy App	No references list nor specialists' by-lines
amma	List of sources
Flo	- List of references - Articles reviewed by professionals
BabyCenter	- List of sources - "Medically reviewed" badge at the top of the page
Meu Pré-natal	List of scientific references available on the "More" tab

2.1.6 Personalised content

Considering the uniqueness of each pregnancy (Peyton et al., 2014), personalising the app in order to address specific needs can be quite useful for parents. Nevertheless, the analysed apps seem not to have personalisation as a priority. In Pregnancy+, Baby+ and BabyCenter, the feed-page changes constantly to accommodate the new stages of pregnancy or baby development. However, for these apps, the personalisation ends there. The app amma goes a little further, besides having an up-to-date feed, the app also has an AI assistant to answer questions. As for the remaining three apps, My Pregnancy App and *Meu Pré-natal* have no personalisation whatsoever, and Flo only has it available for premium users.

Table 8 – *Personalised content*

Apps	**Personalised content**
Pregnancy+	Feed-page focused on the week of pregnancy the user is currently in
Baby+	Feed-page focused on the age of the baby
My Pregnancy App	N/A
amma	- Feed-page focused on the week of pregnancy the user is currently in and/or the age of the baby - AI assistant available to answer questions

Flo	Available on the premium version
BabyCenter	Feed-page focused on the age of the baby or week of pregnancy the user is currently in
Meu Pré-natal	N/A

2.1.7 Sexual-orientation and family structure inclusivity

Pregnancy and baby apps are advertised as tools that offer support through monitoring and informing (Brusniak et al., 2020). In this context, one could question how many perspectives they take into account. Are apps inclusive of LGBTQIA+ parents? Do they offer support for single parents? Do they accommodate the perspective of adoptive parents? How inclusive are they to more vulnerable groups, such as people with no support system? In the apps analysed inclusion can be seen in three aspects of some of the apps: content, user-options and communities. In Pregnancy+ and Baby+, there are many user options: mother, father, parent, partner, single mother, grandparent, uncle or aunt, friend. In Pregnancy+ and Flo there is content directed to LBGTQIA+ families. As for the perspective of single mothers, the user can find content on the matter on Pregnancy+, and community groups on the subject on BabyCenter. The topic of adoption can also be found on the communities of BabyCenter.

Table 9 – *Sexual orientation and family structure inclusivity*

Apps	**Sexual orientation and family structure inclusivity**
Pregnancy+	- Various user options - Content on being a single mother ("going solo") - Content for LGBTQ+ families
Baby+	- Various user options
My Pregnancy App	N/A
amma	N/A
Flo	- Content for LGBTQ+ families

	*Flo for Partners is designed for male-female couples (but the app claims to be working towards making it inclusive for everyone)
BabyCenter	- Various community groups (topics include adoption, blended families and single mothers)
Meu Pré-natal	N/A

2.1.8 Features and functionalities

One of the main elements of pregnancy and baby apps are tools, most of which are of self-tracking nature. The apps analysed contain the following features:

Table 10– *Features and functionalities*

Apps	**Features and functionalities**
Pregnancy+	For you - 3D Model - Baby Names - Size - Scans - Timeline - My Bump - My Weight - To Do - Appointments - Questions - Shop - [Coming Soon] (new feature) Premium - Kick Counter - Contractions

	- Birth Plan - Hospital Bag
Baby+	Tracking - Growth - Feeding - Mum's Weight - Soothing - Health - Nappy Memories - Diary - Face-A-Day - Moments - Yearbook - Milestones - Teeth More - Guides (content) - Activities - Development - Appointments Sound
My Pregnancy App	To-do List - First trimester - Second trimester - Third trimester - Hospital bag - Bringing baby home Weight Tracker Kick Counter Contraction Timer (shortcut to another app)
amma	- Kicks (counter)

	- Weight gain (chart) - Contractions (counter) - Is it safe? (common questions) - Names (list) - Bump growth (chart)
Flo	N/A
BabyCenter	Trying to conceive - Symptoms tracking - Ovulation calculator - Due date calculator - Babble Pregnancy - Symptoms tracking - Bumpie - "Is it safe?" - Kick tracker - Registry builder - Baby names - Birth class - Birth preferences - Contraction timer - Babble - Weight gain calculator - Gender predictor Baby - Symptoms tracking - Memories - Growth tracker - Sleep guide - Feeding guide Babble
Meu Pré-natal	- Contraction counter

	- Due data predictor

2.1.9 Social features

One of the features available on some pregnancy and baby apps are social features, which builds community by allowing the users to ask questions and exchange information with other parents. Out of the seven apps analysed, only 3 contain some form of social features; amma, Flo and BabyCenter. In the case of amma and Flo, there are no chats or forum, but the user can comment on articles and reply to other user's comments. As for BabyCenter, the users have the option to join community groups in the app, share their stories and interact with others. Such tools will be further discussed later, as it brings to light both benefits and concerns.

Table 11– *Social features*

Apps	**Social features**
Pregnancy+	N/A
Baby+	N/A
My Pregnancy App	N/A
amma	Option to comment under the articles and reply to other user's comments
Flo	"Secret chats" – ability to comment on pages of the app (e.g. 2nd Trimester; Trying to Conceive Journey)
BabyCenter	Community chats
Meu Pré-natal	N/A

2.1.10 Gamification

As previous studies have shown, gamification practices can be quite beneficial in the context of healthcare (Ning et al., 2023; Cechetti et al., 2019; Rahim & Thomas, 2017), especially when it comes to stimulating engagement (Cechetti et al., 2019). Out of the 7 apps, only 2 explore gamification in some way. When using Pregnancy+, the user is presented with a

point system. Points can be earned by reading articles and exploring the various tools available on the app. The points can then be exchanged by access to the premium features, also available through a paid subscription. In amma, the point system is an in-app online currency named "BabyCash". Just like Pregnancy+, the points can be earned by reading articles and using different tools within the app. "BabyCash" can be exchanged for access to premium articles and temporary access to premium tools.

Table 12 – *Gamification*

Apps	**Gamification**
Pregnancy+	Point system - Points can be earned by using the various features of the app - Points can be exchanged by access to premium features
Baby+	N/A
My Pregnancy App	N/A
amma	Babycash ("the internal loyalty bonuses that can be earned and spent later") - Points can be earned by using the various features of the app - Points can be exchanged by access to premium features
Flo	N/A
BabyCenter	N/A
Meu Pré-natal	N/A

2.1.11 Extras/premium features

All of the apps analysed are free to download. Nevertheless, Pregnancy+, amma and Flo offer paid extras. Even though this study does not dive into the premium aspects of the apps,

identifying the ones that do offer paid subscriptions is important to understand whether or not the app is being analysed to its full potential.

When it comes to Pregnancy+, the premium features include extra medical content, yoga classes, recipes, guided meditations and extra tools. As for amma, the premium version include expert articles, and AI assistant and a ad-free experience. The AI assistant is also available in the unpaid version, the app does not disclose in what ways this feature changes when the account is upgraded to premium. Flo premium includes the following: personalised program, PDF health report, in-depth health assistant chats, unlimited health insights, customised avatars and premium support.

Table 13 – *Extras/premium features*

Apps	**Extras/Premium features**
Pregnancy+	"Unlimited access - Build your knowledge with medical experts - Feel your best with yoga classes and recipes - Calm your mind with guided meditations - Support your pregnancy with essential tools"
Baby+	N/A
My Pregnancy App	N/A
amma	Premium version available
Flo	- Personalised program - PDF health report - In-depth health assistant chats - Unlimited health insights - Customised avatars - Premium support
BabyCenter	N/A

Meu Pré-natal	N/A

2.1.12 Frequency of updates

One of the mains advantages of digital health solutions such as mobile apps is the possibility of updating them regularly, and, therefore, the chance to disseminate the most up-to-date information (Arbour & Stec, 2018). Most of the apps are updated somewhat frequently, ranging between once every few weeks to once every four to five months. Meu Pré-natal, however, has not been updated since September 2023.

Table 14 – *Frequency of updates*

Apps	**Frequency of updates**
Pregnancy+	- Updated on average once a month
Baby+	- Years ago, the app used to be updated every couple of months. However, in the past year it was updated once every 4-5 months
My Pregnancy App	- Updated every couple of months
amma	- Updated on average twice a month
Flo	- Updated a few times a month
BabyCenter	- Updated every month or every few weeks
Meu Pré-natal	- Last update was on September 2023

2.1.13 Notes and impressions

Apart from all the pre-established codes, there are some impressions and observations worth mentioning.

Table 15 – *Notes and impressions*

Apps	**Notes and impressions**
Pregnancy+	
Baby+	
My Pregnancy App	- Compared to the other apps, it does not contain as much information, which in a way makes its content more palatable and less overwhelming
amma	
Flo	- The app is mainly advertised as a period and cycle tracker rather than a pregnancy app, however, its pregnancy content is quite extensive and complete
BabyCenter	
Meu Pré-natal	- Upon registration, the app requires the user to inform their CPF, which would limit its usage to Brazilian citizens

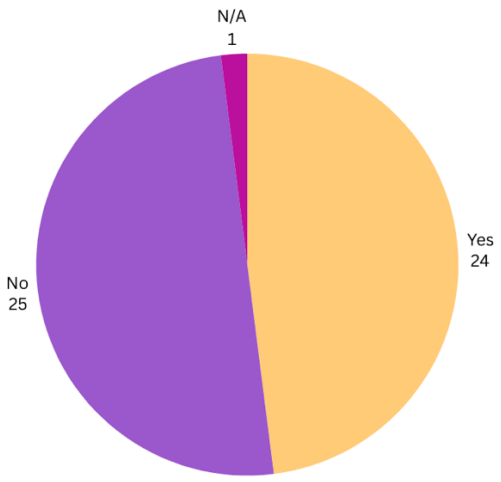
3. Questionnaire

After finalising the content analysis, it was time to elaborate and distribute the questionnaire (Appendix 1). The 50 participants were asked to fill out their basic information (name, speciality, place of work and years of experience), and then answer 21 questions; 13 multiple choice and 8 open-ended. The specialists work in the private and public sector, and they range from having as little as only one year to as much as 47 years of experience in their respective fields.

3.1 Digital solutions

When it comes to recommending digital solutions in general, 24 out of the 50 participants said they recommend some type of digital solution to their patients, while the other 25 do not. One of the participants selected the option N/A. The ones who do recommend digital health solutions gave as examples: health organizations official websites, telehealth platforms as well as a number of apps, such as contraction counter apps, guided meditations, checklists, baby apps, pregnancy apps, among others.

Figure 13 – Do specialists recommend digital solutions to their patients?



Among the paediatricians the recommendations were:

"Vaccination and feeding trackers"

"Nasal wash tutorial videos"

"Breastfeeding, solid food introduction and BLW method apps and websites"

The obstetricians recommended:

"Mobile apps"

"Menstrual and cycle trackers"

"Pregnancy apps"

As for the psychologists, their recommendations

"[the app] Cingulo"

"Online forms, Outlook tools like digital agendas, Teams and WhatsApp for online therapy sessions, online psychotherapy platforms, online medical records"

"[the apps] My Baby, Pregnancy+, BLW Brasil"

"Habit tracking apps, social media blocking apps, Google agenda"

"Instagram, YouTube"

"Cycle tracking apps, child development apps and intrauterine development apps"

"Tests, educational games, digital books, films, series, cycle tracking apps, sleep tracking apps, content about healthy eating habits, physical activities and quality of life"

"Family link app, for parents to control their kids' screentime"

"YouTube, Lojong, Calm"

As for the other healthcare workers working closely with expectant mothers, new parents, babies and toddlers

"Apps to keep track of contractions"

"Health services websites, apps to monitor and track each life stage, et cetera"

"Checklists"

"Workout apps"

"Mobile apps to address specific concerns and workout videos"

"Contraction tracker"

As for pregnancy and baby apps specifically, when asked whether or not their patients typically use such applications – regardless of their recommendations -, out of the 50 specialists, 26 say that their patients usually use pregnancy and/or baby apps; 22 out of the 26 say that only the mothers use the apps, while only 4 say that both mother and partner/family use them.

Figure 14 – Do their patients use pregnancy and baby apps?

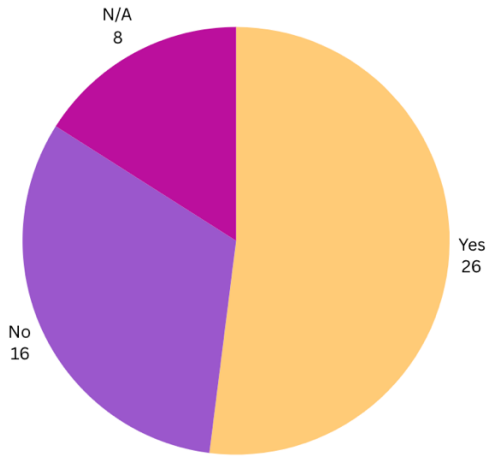
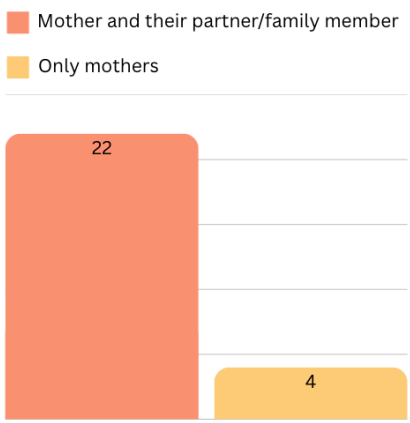
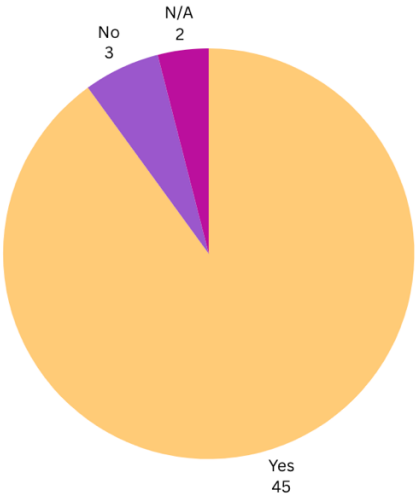


Figure 15 – Who uses pregnancy and baby apps?



When asked whether or not they would recommend the use of pregnancy and baby apps to their patients, 45 of the participants say they recommend them, 3 said no, and 2 selected the option N/A.

Figure 16 – Do specialists recommend pregnancy and baby apps to their patients?

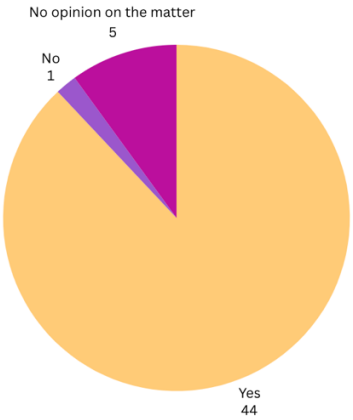


When asked if they had any specific recommendations, the participants mentioned a series of different kinds of mobile applications. However, the only specific recommendations were Flo, Pregnancy+ and BabyCenter, all of them previously analysed in this study.

3.2 Possible benefits

The participants were asked whether or not they recognised pregnancy and baby apps as a factor that could enhance the user's experience, promote the adoption of healthy habits and have a positive impact on new and expectant parents' mental health state. Among them, 44 out of the 50 specialists believe that pregnancy and baby apps have a positive impact on the overall experience of their patients, while only 1 does not agree and 5 do not have an opinion on the matter.

Figure 17 – Do pregnancy and baby apps impact the overall experience of patients?



Such positive impact is attributed to several factors, such as:

"[Apps] provide a sense of security and promote autonomy to follow the medical advice given during appointments" – paediatrician

"Quick responses" – obstetrician

"Health related information decreases anxiety on patients and their family members" – obstetrician

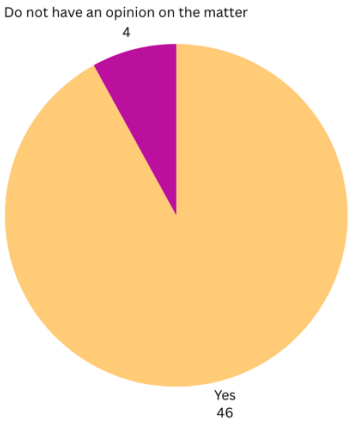
"Apps can clarify questions, help the user register and monitor symptoms, making this tool a support to the expectant mother, new mother and nursing mothers" – psychologists

"[Apps] reduce anxiety" – others (nurse)

"[Apps] make the expectant mothers and their families feel a greater sense of security throughout pregnancy" – others (nurse)

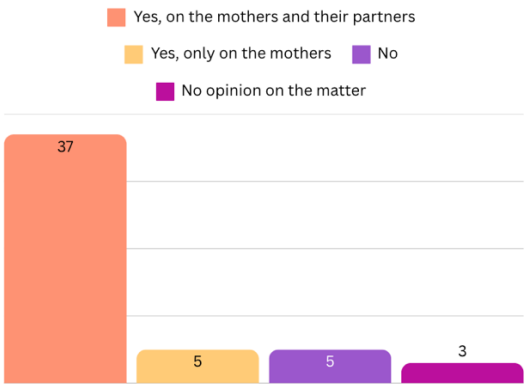
Out of the 50 specialists, 46 see the apps as a tool to help with the understanding of health matters and a good influence when it comes to adopting healthier habits. The remaining 4 specialists did not have an opinion on the matter.

Figure 18 – Do pregnancy apps help users better understand health-related matters?



Another perceived possible benefit is a positive impact on the users' mental health, especially when it comes to easing anxiety. 37 out of the 50 specialists answered that both the mother and partner could be impacted, 5 think that the apps can only impact positively the mothers, and 5 do not see the apps as something that can impact positively the users' mental health. The remaining 3 do not have an opinion on the matter.

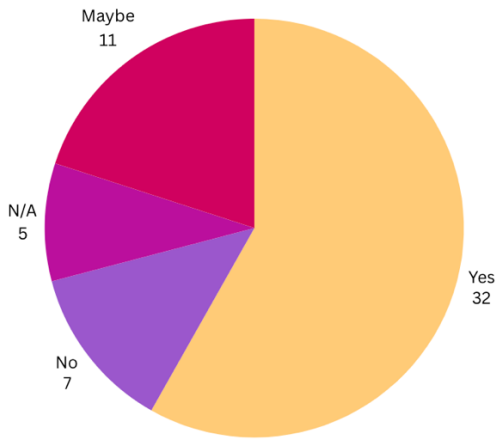
Figure 19 – Who can be positively impacted by pregnancy and baby apps?



3.3 Social features

One of the tools present in some pregnancy and baby apps is social features. 32 out of the 50 specialists said they would recommend their patients to take part in online communities, while 7 would not, and 11 participants were not sure and opted for the "maybe" option.

Figure 20 – Do specialists recommend online communities to their patients?



Some of benefits raised by the participants include:

> "*Relatability and comfort that comes with interaction with people going through the same things" – paediatrician*
>
> *"Mothers need a support system, even if virtual" – paediatrician*
>
> *"[Communities] enable the exchange of information and experiences" – obstetrician*
>
> *"The exchange of experiences between parents is always positive" – paediatrician*
>
> *"Socialization is a human need, and online environments favour the self-recognition within groups and intensify a sense of belonging" – psychologist*
>
> *"[Groups foster] positive interactions" – obstetrician*
>
> *"[Groups] break bubbles of loneliness" – psychologist*
>
> *"During postpartum, the support of people who have been through similar experiences and are living through the same issues help them [the patients] get through this period and be kinder with their own selves" – obstetrician*
>
> *"[Communities] strengthen a sense of identity and belonging" – psychologist*

While the concerns were:

> *"Online communities can spread fake information" – paediatrician*
>
> *"Communities can be interesting for fostering an exchange [of experiences/information], but without a moderator or some type of filter, they can have an anxiogenic effect" – psychologist*
>
> *"Often the topics discussed [by the users] are not scientifically based" – obstetrician*

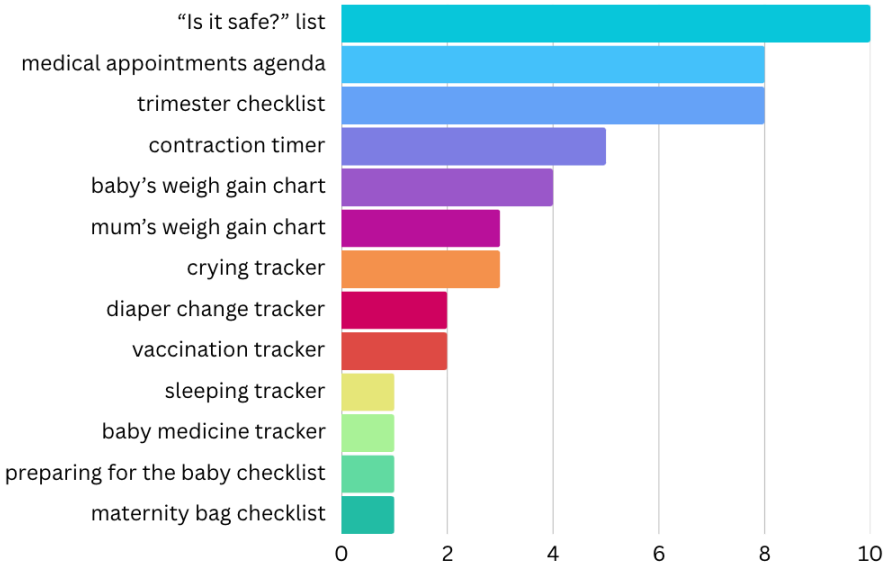
"It's important to be cautious when it comes to the excess of information" – psychologist

"Despite how important exchanging information is, someone's anxiety could 'contaminate' others" – obstetrician

3.4 Features and functionalities

Leaving content aside for a while, when it comes to the tools available on the apps, the specialists were asked which – if any – of the tools could enrich the experience of the user and which ones could be particularly useful for healthcare providers such as themselves. As for the ones which could be considered an asset for the patients' experience, 48 experts responded; 10 "Is it safe?" list, 8 Medical appointments agenda; 8 Trimester checklist, 5 Contractions timer, 4 Baby's weigh gain chart, 3 Mum's weigh gain chart, 3 Crying tracker, 2 Diaper change tracker, 2 Vaccination tracker, 1 Sleeping tracker, 1 Baby medicine tracker, 1 Preparing for the baby checklist, 1 Maternity bag checklist.

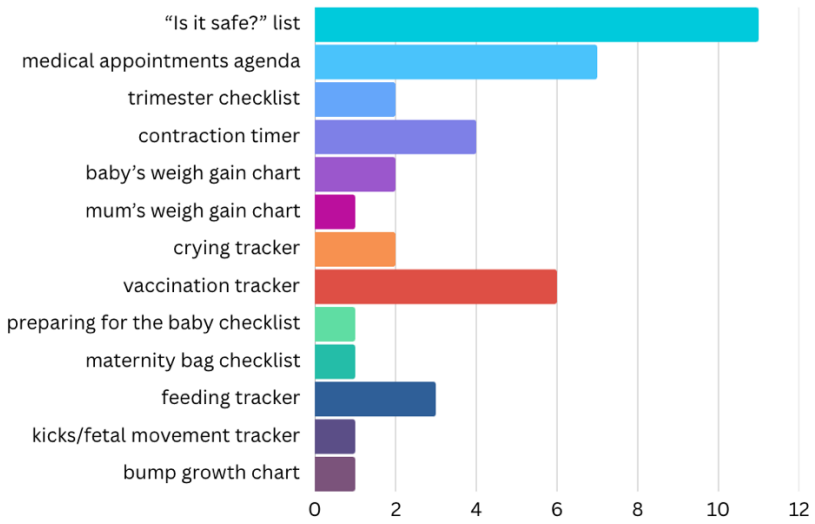
Figure 21 – What are the most useful tools/features for the patients?



As for the feature that could assist the healthcare providers, 45 experts responded; 11 "Is it safe?" list, 7 Medical appointments agenda, 6 Vaccination tracker, 4 Contractions timer, 3

Feeding tracker, 2 Crying tracker, 2 Trimester checklist, 2 Baby's weigh gain chart, 1 Kicks/Foetal movement tracker, 1 Maternity bag checklist, 1 Preparing for the baby checklist, 1 Bump growth chart, 1 Mum's weigh gain chart.

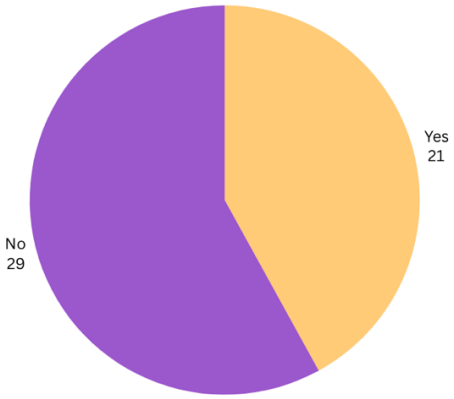
Figure 22 – What are the most useful tools/features for physicians?



3.5 Challenges and concerns

While 29 out of the 50 specialists say they do not have concerns and reservations when it comes to pregnancy and baby apps, 21 of them express some.

Figure 22 – Are specialists concerned about the use of pregnancy and baby apps?



Among the psychologists the justifications are:

"[The apps being] ***anxiety inducing*** *in more immature and insecure patients"*

"Not so much of a concern, but I do fear ***how the patients receive the information****"*

"The ***exclusion of in-person interventions****, with real people"*

"[The need for] ***clear and strict criteria****"*

"An open space circulates ***a myriad of information****, and one needs to be careful"*

*"****Too much generalization****, which can cause frustration in case something does not go as it generally does. Also, augmenting anxiety"*

*"****The need for cultural adequation****. Most of the apps follow an American framework, some of the information may not be fitting for the Brazilian reality"*

"Even though there are many apps that are based on scientific evidence, one needs to be careful ***with those that do not contain references****, and are* ***focused on profit*** *rather than family health"*

*"****Lack of knowledge and individual culture****. [The apps being] a bad influence"*

"Having such quick access to information can cause ***confusion****, making the users anxious and/or insecure"*

'The lack of human interaction"

As for the paediatricians and obstetricians the concerns lie on the credibility of the content displayed by the apps; *"****fake information****"*, *"****veracity [or lack thereof] of facts****"*, the

existence of conflicts of interest, and the *"overload of information resulting extra expectations"*.

Two of the nurses, the ER doctor and one of the physiotherapists, said, respectively:

"[Apps] can cause anxiety, make the user distrust professional opinion, and cause resistance when it comes to following formal professional advice"

"When [the users are] not assisted, [apps] can generate more questions"

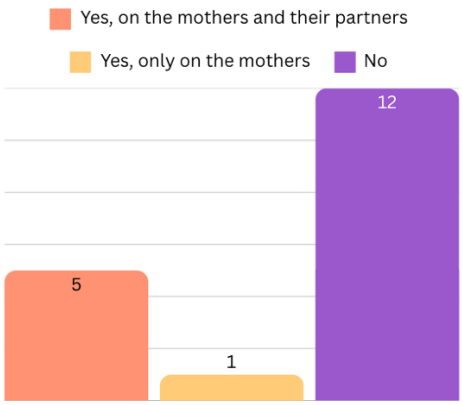
"The overload of information can cause anxiety, and it does not necessarily fulfil the patients' needs for advice from qualified professionals"

"I am worried that [apps] may lead to people diagnosing themselves"

One of the physiotherapists mentioned a concern not explored by previous studies: the digital divide. For the specialist, it is important to keep in mind that not all patients have access to mobile apps.

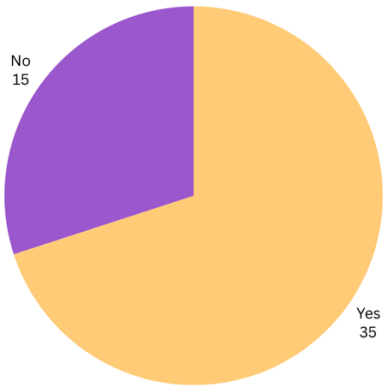
Among the specialists, 4 out of the 50 participants think the apps can have a negative impact on both the mother and partner's mental health, and 1 thinks that the impact only affects the mothers. 12 specialists do not think apps can have a significant impact on the user's mental health, whatsoever.

Figure 23 – Who can the apps negatively impact?



The lack of content localization is also perceived as a problem by 35 out of the 50 specialists. One of the psychologists even included this, as it has been mentioned before, as one of their main concerns *("The need for cultural adequation. Most of the apps follow an American framework, some of the information may not be fitting for the Brazilian reality").*

Figure 24 – Are specialists concerned about the lack of content localisation?



3.6 Future perspectives and recommendations

As previous studies have concluded, it is important to bring healthcare providers into the loop when developing digital health tools (Lee & Moon, 2016). With that in mind, the specialists were asked what recommendations they would give app developers and its content creators in order to better cater for the users' needs. The responses include:

"Access to content should be mediated and regulated"

"Simple and objective language"

"Cultural adaptation"

"No conflicts of interest and scientific based"

"Adaptation to the user's reality"

"Display information in a conscious, human and ethical manner. No generalisation and no sensationalism"

"Take into account the psychological and socioeconomic reality of Brazilian women, especially those who are part of the workforce, have other kids and lack a support system"

“Make apps that are user-friendly”

“Base content on the most up-to-date, scientific base information”

“Keep in mind that on the other side of the screen that will be people full of fear and insecure with will and desire to make sure everything will go right”

“Have an accessible communication channel with the users, so the apps can be updated according to demand”.

“The option to adjust the app according to the user’s level of health literacy upon log-ing”

“Do everything with caution and respect”

“Focus on basic information, without diving too deep into pathologies”

4. Discussion

After gathering 50 responses to the questionnaire, the following step was comparing what had been found through the content analysis with the answers from the specialists. This third step aims to understand in what ways the apps might lack and how their features and functionalities may align with the perceived possible benefits and address existing concerns.

4.1 Users of pregnancy and baby apps

According to the 26 specialists whose patients typically use pregnancy and baby apps, the apps are mainly used exclusively by the mothers. Such statement aligns with the studies that recognise expectant mothers as a generation of patients with great will and interest to embrace emerging digital health technologies and extend their care to digital spheres (Brusniak et al., 2020). While only 4 said that in their experience both parents use the apps, 22 answered that the mothers are usually the sole users. When it comes to the main apps available for the Brazilian market, 4 out of the 7 apps accommodate the non-pregnant partner's side of the parenthood journey in some way. Having all of these data in mind and also considering the neurological impact of parenthood on the non-pregnant partner (Abraham & Feldman, 2022) as well as the educational benefits and promotion of healthy support habits that could come with using the apps (Mackert, et al., 2018), one may conclude that the apps available fulfil demand but lack when it comes to fulfilling potential. Expectant and new mothers are the main target audiences of pregnancy and baby apps, and in every case analysed, their perspective is fully covered. As for the non-pregnant partner, content directed to them and their experience is yet to be further explored.

4.2 Gamification

Studies have shown that one of the main success factors of a digital intervention is engagement (Brusniak et al., 2020), and that gamification practices can be quite effective in the context of healthcare (Ning et al., 2023; Cechetti et al., 2019; Rahim & Thomas, 2017) by enhancing engagement without implementing unnecessary complexity to the tools (Cechetti et al., 2019). Exploring the idea of fulfilling potential even further, gamification

features were only explored in 2 out of the 7 apps, and only to a limited extend. A stablished gamification strategy based on a theoretical framework would make it possible to explore the benefits of gamification to its fullest and provide the opportunity to integrate, benefit and engage various stakeholders.

4.3 Localization and personalisation – or lack thereof – of content

The lack of content localization is a concern for 35 out of the 50 specialists, and in none of the apps analysed there is any kind of content localisation. Considering this information alone, *Meu Pré-natal* would be the most suitable choice for Brazilian users, since the app was developed in Brazil and follows the guidelines of the Brazilian Health Ministry. As for the matter of personalisation, the apps are generally not equipped in tools to cater its content and features to the user's specific situation. Generalisation is pointed out by the specialists as something that can lead to frustration and anxiety. Still on the topic of diving into particularities of one's experience, the apps also lacks in terms of inclusivity. The parenthood journey is a unique experience, and some of the apps do not account for the experience of less traditional family configurations. In Pregnancy+ and Flo, the users can find content for LGBTQIA+ families. BabyCenter has various community groups that include topics such as adoption, blended families and single mothers. The perspective of solo parents is also explored in Pregnancy+ in some articles under the category "going solo".

4.4 Access to information and content credibility

The quick access to content provided by pregnancy and baby apps comes with its perks and dangers. On the one hand, the specialists consider the easy access to information a source of support, that could be particularly beneficial for more unexperienced parents. Studies have also shown that such digital health technologies have the potential to lessen physician burnout (Gordon et al., 2020) and empower patients (Meskó et al., 2017). On the other hand, the participants of the questionnaire, especially the mental health professionals, express concern on the excess of information. Specialists worry about how their patients can receive some facts about what they are going through, since even though the information may be correct, generalisation – as it has been previously mentioned – to an exacerbated level can

be quite detrimental to one's mental health state. When further developing the communication strategies of these apps, information overload needs to be taken into account. After all, as studies conducted during the COVID-19 pandemic have shown "communication strategies that account for the potential for information overload, information uncertainty, and misinformation among the public will be most successful in promoting personal and public health" (Vraga & Jacobsen, 2020, p. 239).

Another concern raised both by the specialists assessed for this study and previous studies is the credibility of the content available on pregnancy and baby apps (Donelle et al., 2018; Lee & Moon, 2016). As for the apps analysed, 5 out of the 7 disclose the bibliographical references of their content. However, another relevant point explored in the content analysis and then mentioned by some of the specialists is frequency of updates. With new scientific discoveries being made every single day, having up-to-date recommendations is essential. Apart from Meu-Pré-natal, that has not been updated since 2023, the other apps analysed undergo updates either every few weeks or every few months. It is important to note, however, that it is not disclosed whether or not these updates are limited to the technical aspects of the apps or also include new articles and guidelines.

4.5 Tools

Studies have shown that self-tracking tools in the context of pregnancy can contribute to improve infants' health (Brusniak et al., 2020). The participants were asked to select among a list of the tools available on the apps which one they thought would be most beneficial for their patients and which one healthcare providers could also benefit from its use. The most selected one in both cases was the "Is it safe?" tool, a feature that is usually presented as a list of foods, products, activities et cetera, and the information of whether or not they would represent a risk for the pregnancy. The second most chosen one was also the same for both questions: the medical appointments agenda. This is an example of how digital health tools can facilitate traditional healthcare practices. The medical appointments agenda is usually constituted by an editable calendar for the users to keep track of their appointments with their physicians. As for the third most selected tool, when it comes to benefiting the experience of the patient the most common choice was the "trimester checklist", a list of the main milestones and appointments the patient will experience throughout each trimester of

their pregnancy. As for the one that could benefit the physician, a vaccination tracker was considered more relevant.

4.6 Social features

Through the eyes of the specialists, social features represent both an opportunity and a concern. Out of the seven apps analysed, only 3 promote some kind of interaction between users. The main benefits mentioned by the participants of the questionnaire were building community and finding support through shared experiences. As for the concerns, they lie on information overload and – not unlike when it comes to the content – the lack of regulations. Both concerns could be addressed through the addition of filters and some kind of moderation to such features.

4.7 Moving forward

In the field of digital health, interdisciplinary collaboration is essential (Becker et al., 2020). The specialists assessed for this study highlighted the main points developers should keep in mind when bringing pregnancy and baby apps to life and when running them. One of the recommendations is having a respectful, ethical and empathetic approach, which relates to the core of patient-centred communication strategies: understanding the patient's perspective and expressing sympathy towards them (Hashim, 2017). Another highlighted aspect is cultural, socioeconomic and literacy adjustments to better relate to the various lifestyle realities that exist across Brazil. The specialists also mention the need for mediating and regulating the apps to protect the users from irresponsible communication and ensure content credibility, since as of now, they do not follow a set of specific guidelines (Tripp et al., 2014). The specialists also mention leaving a gap to be filled by traditional forms of healthcare. According to one of the participants, the apps should focus on basic information, to avoid that the patient attempts diagnose themself instead of looking for medical advice.

In order to move towards a future where pregnancy and baby apps are both fulfilling their potential and coexisting effectively alongside clinical workflows, including and integrating the various stakeholders within the sphere of medical mobile apps would be a key factor.

Since this study focuses on the perspective of specialists on mental health, obstetrics and paediatrics, two ways in which they could be integrated into the loop when it comes to developing and consuming apps would be including app literacy in the education of physicians, which would help them guide their patients through such tools, and having apps periodically fact-checked and analysed by them.

Another important step moving forward is the use of artificial intelligence. Despite the fact that AI was not a separate pre-determined code, its use was identified in two of the apps; Flo and amma. Only in amma the AI assistant is available for non-premium users. With the rise of tools such as ChatGPT, the integration of AI as well as of upcoming trends in the tech world, represent an opportunity for pregnancy and baby apps. Such digital health solutions could benefit from a wider use of AI both through the expansion of the AI assistant chatbot and the integration of AI personalisation tools to cater for the patient's individual needs.

Conclusion

This study holds at its core the question “to what extent can pregnancy and baby apps be integrated into prenatal and paediatric care?”. The results obtained in this research came to being through a content analysis of seven relevant pregnancy and baby apps in Brazil combined with the answers from 50 specialists that work closely with expectant mothers, new parents, babies and toddlers. In many ways, the conclusions of this dissertation align with previous studies as well as bring new opportunities and concerns to light. In order to summarize the key finds of this study, one could divide them in two categories: reflections of their current state and opportunities moving forward.

Despite still being at a newborn state when compared to the whole ecosystem of prenatal and paediatric care practices, pregnancy and baby apps have come a long way already. Their constant updates and improvements have resulted in a myriad of benefits to new and expectant parents. Their advantages include promoting healthier choices and habits, providing easy access to information, easing anxiety symptoms, building community and assisting physicians through the use of self-tracking tools.

All the benefits mentioned not only leave room for improvement, but they also coexist with some considerable challenges and concerns. The lack of regulations and transparency lead to an issue of data accuracy, which is not to say that these applications necessarily disseminate false information. However, it does impact on the accuracy and perceived credibility of their content. The amount of information can also be anxiety inducing, giving the apps a contradictory duality of both enhancing and easing anxiety symptoms. Another relevant concern is mobile applications causing the decrease in in-person activities, which is not limited to pregnancy and baby apps, but applies to the entire scope of digital health solutions. Lastly, it is also worth mentioning exaggerated generalisation, a result of the lack of personalisation, that according to the specialists can result in frustration. Addressing the concerns this study and previous literature have risen would enhance the experience of the user while simultaneously protecting them from possible harm.

Moving forward, while recognizing the current benefits and making efforts to address concerns is essential, one cannot overlook all the unfulfilled potential that can be found in these digital health solutions. In their current state, these digital health solutions have the potential of bringing value to the user's experience. Nevertheless, there are multiple factors that can be improved. The study highlights a few factors that if improved would bring more value for the users' experience: the expansion of non-pregnant partner's perspective, the implementation of gamification strategies, the integration of AI as well as evolving alongside new trends in tech.

The results of this study can have practical implications to healthcare providers, app developers, policy makers and the general public. By understanding what pregnancy and baby apps can offer and their impact on users, healthcare providers can better guide their patients through these digital health solutions, app developers can improve features and functionalities as well as address the main issues, policy makers can have a clear picture of what the aspects could benefit from stablishing regulations, and the general public can understand the limits to which they should extend them into their care.

Lastly, not unlike the apps themselves, the topic of this study can also be further explored in order to improve limitations. Even though this study follows a mixed method approach, the focus is considerably greater on the qualitative side, with that in mind, the topic could benefit from having its quantitative side further explored in order to measure the effectiveness of such tools, as well as from working with a larger sample. The fact that the study was limited to what was available for free on the mobile apps, assessing their premium features would reveal their full potential. Moreover, the topic of privacy was not analysed in this study due to the focus on healthcare providers rather than the user. Notwithstanding, as highlighted by Kressbach (2019), privacy is also an important aspect to be studied within the scope of medical mobile applications. Last but not least, the topic would also benefit from exploring the other stakeholder's perspective on the matter, especially the users. Assessing the user's side – their motivations, how they interact with the technology and so on - would provide a wider view in terms of impact, usability, effectiveness and efficiency.

In conclusion, in an increasingly digitized world, pregnancy and baby apps and other digital health solutions find fertile ground to bloom. Through efforts focused on dialogue and collaborations, mobile apps can coexist and enhance traditional healthcare practices. To put it simply, pregnancy and baby apps can be integrated into prenatal and paediatric care to a significant extent, but that integration requires caution, guidance and balance.

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Appendix

Appendix 1: Online Questionnaire Script

1. Nome
2. Especialidade
    a. Médico obstetra
    b. Médico pediatra
    c. Psicólogo
    d. Outros
3. Anos de experiência
4. Local de trabalho
5. Costuma recomendar alguma solução digital para os seus pacientes?
    a. Sim
    b. Não
    c. N/A
6. Se respondeu sim à pergunta anterior, quais?
7. Seus pacientes costumam utilizar aplicativos de gravidez e/ou desenvolvimento infantil?
    a. Sim
    b. Não
    c. N/A
8. Se sim, quem os utilizam?
    a. Somente as mães
    b. As mães e os parceiros/familiares
9. Acredita que os aplicativos têm um impacto positivo na compreensão de cuidados com a saúde e adoção de hábitos mais saudáveis?
    a. Sim
    b. Não
    c. Não tenho opinião formada
10. Acredita que tais aplicativos têm um impacto positivo na experiência do paciente?
    a. Sim
    b. Não
    c. Não tenho opinião formada

11. Se respondeu sim à pergunta anterior, quais os fatores que acredita que contribuem para tal?
12. Acredita que o acesso à informação através destes aplicativos têm um impacto na saúde mental das mães e/ou de seus parceiros, nomeadamente reduzindo níveis de ansiedade?
    a. Sim, somente nas mães
    b. Sim, nas mães e parceiros
    c. Não
    d. Não tenho opinião formada
13. Se respondeu não, acredita que podem ter um impacto negativo na saúde mental dos pacientes e/ou seus parceiros?
    a. Sim, somente nas mães
    b. Sim, nas mães e seus parceiros
    c. Não, não acredito que haja um impacto significativo no estado de saúde mental
14. Se respondeu sim à pergunta anterior, quais os fatores que acredita que contribuem para tal?
15. Muitos aplicativos de gravidez e desenvolvimento infantil também contam com funcionalidades sociais, você recomendaria a participação em comunidades online para seus pacientes?
    a. Sim
    b. Não
    c. Talvez
    d. N/A
16. Por favor, justifique a resposta anterior.
17. Tem alguma reserva ou preocupação relativamente à utilização de aplicativos de gravidez e desenvolvimento infantil?
    a. Sim
    b. Não
18. Se respondeu sim à pergunta anterior, quais são as reservas e preocupações?
19. Você recomendaria o uso de aplicativos para os seus pacientes?
    a. Sim

b. Não
c. N/A

20. Se sim, recomendaria algum em específico?
21. Dentre as ferramentas listadas (todas self-tracking), quais acredita que podem agregar à experiência dos pacientes?
    a. Contador de chutes/movimentos fetais
    b. Timer de contrações
    c. Checklist mala da maternidade
    d. Checklist de cada trimestre
    e. Checklist compras e preparações para o bebê
    f. "É seguro?" - lista de alimentos, procedimento, medicamentos, atividades e produtos seguros e perigosos para grávidas
    g. Agenda de consultas médicas
    h. Gráfico do crescimento da barriga
    i. Gráfico de ganho de peso (mãe)
    j. Gráfico de ganho de peso (bebê)
    k. Tracking alimentação (bebê)
    l. Tracking troca de fraudas
    m. Tracking de temperatura (bebê)
    n. Tracking de medicamentos (bebê)
    o. Tracking de vacinação (bebê)
    p. Tracking de sono (bebê)
    q. Tracking de choro (bebê)
22. Alguma destas ferramentas pode também ser útil para si e os demais profissionais da saúde que acompanham o/a pacientes?
    a. Contador de chutes/movimentos fetais
    b. Timer de contrações
    c. Checklist mala da maternidade
    d. Checklist de cada trimestre
    e. Checklist compras e preparações para o bebê
    f. "É seguro?" - lista de alimentos, procedimento, medicamentos, atividades e produtos seguros e perigosos para grávidas

g. Agenda de consultas médicas
h. Gráfico do crescimento da barriga
i. Gráfico de ganho de peso (mãe)
j. Gráfico de ganho de peso (bebê)
k. Tracking alimentação (bebê)
l. Tracking troca de fraudas
m. Tracking de temperatura (bebê)
n. Tracking de medicamentos (bebê)
o. Tracking de vacinação (bebê)
p. Tracking de sono (bebê)
q. Tracking de choro (bebê)

23. Dentre os aplicativos mais populares disponíveis na App Store, nenhum foi desenvolvido no Brasil tampouco tem localização de conteúdo, acredita que isto possa representar um problema?
    a. Sim
    b. Não
24. Que recomendações você daria aos desenvolvedores de aplicativos e seus criadores de conteúdo para melhor atender às necessidades dos pacientes?
25. Algo a acrescentar?