

Prototyping a Mobile App for Pregnancy During the COVID-19 Pandemic:

Using Information Design to Strengthen Information Landscapes

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PROTOTYPING AN APP FOR PREGNANCY DURING COVID-19

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Abstract

When the COVID-19 pandemic struck the United States in early 2020, pregnant people faced challenges unlike what would be expected while pregnant during “normal times.” Studies found this population to be overwhelmed by rampant misinformation or a lack of information, decreased access to health care, and uncertain social support. This project investigates and addresses the preferences of pregnant people by designing a prototype of a mobile application that seeks to increase both accessibility and availability of credible information about pregnancy and postpartum during the COVID-19 pandemic. Methods include a literature review, questionnaires, interviews, personas, current app research, wireframing, and prototyping. They identify a gap in the mobile app toolbox for navigable, credible information on COVID-19 for pregnant and recently pregnant people. They also find that, contra to the goals of the project, it isn’t feasible to incorporate into the app a social support feature, due to the potential for misinformation. The project also concludes that a successful mobile application employs information design to lessen the cognitive load of users and to integrate their geographic confines; elements that support a user’s agency also strengthen the user’s information landscape. Further research ascertaining the specifics of what might be needed to make an app usable for particular marginalized or underserved populations is still needed. Finally, one of the more intriguing questions raised by this project might be how to integrate the social support identified as an important need by pregnant people into an app that values the integrity of information.

The prototype is accessible at this link:

<https://www.figma.com/proto/INPJrqGD31f5sqcdzb7AuR/Baby-Sage?node-id=1%3A3&scaling=scale-down&page-id=0%3A1>

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During times of crises, people seek out information to guide them forward and shed light on the bumps they may encounter while navigating the path ahead. When the COVID-19 pandemic struck the United States in early 2020, pregnant people, who often rely on regular and frequent information distributed by their health care professionals, instead found themselves overwhelmed by rampant misinformation or a lack of information, decreased access to health care, and uncertain social support. This contrasts with what might be expected during pregnancy in “normal times.” In July of 2020, researchers investigated the experiences of pregnant people living in the U.S. and how the pandemic is impacting their lifestyles, relationships, and well-being through an online survey (DeYoung & Mangum, 2021). Two respondents described the challenges associated with information during their pregnancy journeys:

Pregnancy during a pandemic was stressful in a thousand big and small ways: the lack of data on outcomes for pregnant people and fetuses of a [COVID-19] infection, going to prenatal appointments alone and masked, cancelled and telehealth appointments, cancelled prenatal classes, keeping up with changing labor and delivery policies...the collapse of in-person support networks, weighing the risks of going in for monitoring when something felt off or the baby wasn't moving much in-utero with the risk of exposure, and huge uncertainties...

(p. 6)

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It's been hard to go through 20 weeks of pregnancy without really seeing family or friends, and we have a lot of questions about what our delivery in November is going to look like, and the support we will have with our newborn and toddler. It's been very frustrating for me and my OB, she feels like she doesn't have enough good information to give me guidance on staying safe during my pregnancy beyond the standard "social distance, mask, etc." recommendations.

(p. 6)

These experiences highlight the challenges imposed on pregnant people because of the lack of available and accessible information on how to navigate pregnancy while staying safe during the COVID-19 pandemic. There is an evident lack of credible, relevant information available to pregnant populations during this pandemic—information essential to health and well-being. Though it isn't desirable to quicken the pace of research or forfeit tested, reliable information for more readily available information, that information can be made more accessible and available to the populations that need it.

This project will address the preferences of pregnant people by designing a prototype of a mobile application that 1) contains useful features relevant to the lived experience of pregnancy during the pandemic, 2) is accessible, navigable, and usable, 3) allows for social connection between pregnant users, 4) compiles reputable, medically sound sources (such as websites and organizations) for information about pregnancy during COVID-19, and 5) maintains updated information regarding pregnancy and the ongoing pandemic.

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For the purpose of both gender inclusivity and the consideration of contemporary parenting dynamics, this paper will use the term “pregnant people” to refer to all those experiencing pregnancy; however, much of the research referenced refers to self-identified “pregnant women.”

Pregnancy and COVID-19

Ever since the COVID-19 pandemic paralyzed the world over a year ago, researchers have been tenacious in studying how the SARS-CoV2 virus affects pregnancy. As new research on the physiological effects of the virus continues, there has also been an increased focus on the psychological and emotional experiences wrought on pregnant populations by the pandemic (Schwartz, 2020; Moyer et al., 2020). A recent study involving almost 3,000 pregnant women in the United States found a significant number of respondents are experiencing psychosocial-related anxiety factors amidst the pandemic; in addition, those who reported a high level of COVID-19-related stressors had greater changes in pre-to post-COVID-19 pregnancy-related anxiety (Moyer et al., 2020). The study includes such psychosocial-related anxiety concerns as running out of food; job loss; childcare loss; tension or conflict in house; and getting infected (including infecting their unborn child) with COVID-19: notably, over 93% of respondents reported increased stress about getting infected.

Moyer and colleagues’ cross-sectional study (2020) corroborates earlier observations of pandemic-induced health anxiety in pregnant women: a letter to the editor published in the *European Journal of Obstetrics & Gynecology and Reproductive Biology* states that the authors’ questionnaire (conducted between March 16-27 2020) found that over half of respondents, all of

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whom identified as pregnant patients, had significant health anxiety at the time of the questionnaire. It should be noted that their primary concerns regard their older relatives, their children, and their unborn child (in this case, distinct from their own health), respectively; notably, they ranked their own health as their lowest-ranking concern at the time (Corbett et al., 2020).

According to Moyer et al. and Corbett et al.'s studies, pregnancy-related health anxieties and psychosocial anxieties have been exacerbated by the COVID-19 pandemic, exceeding the stress levels pregnant populations are anticipated to face during "normal" times. While these health concerns and stress levels may necessitate both structural changes and professional help, at a smaller scale, the pregnant population's stressful experiences have the potential to be mitigated through improved guidance and access to reliable information. Accessible, credible guidance is vital to these populations' well-being, both during the pandemic and in moving forward amid this widespread uncertainty.

To help assess the best path to building such guidance, we may look to previous epidemics and pandemics: Shorey and Chan (2020) conducted a meta-synthesis of qualitative studies with samples of pregnant women, midwives, and nurses who experienced pandemics or epidemics between 2000 to 2020. Although pregnant women made various behavioral changes to adapt to the potential danger of such public health crises as the 2015 Zika virus epidemic, they also reported that they "wished to receive more information about the diseases or epidemics that they were living through and better accessibility for timely healthcare services." Shorey and Chan state that both the internet and social networks were pregnant women's preferred mediums for accessing information; however, "many women were concerned about the credibility of the available information" (2020).

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Technological tools enable credible, relevant information to be accessible to those who need it. In addition, technological tools may assist in offering emotional support during behavioral changes in response to public health crises. Shorey and Chan (2020) referred to a 2019 study which observed postpartum mothers who sustained technology-based peer support whilst staying primarily at home over a three-month period: participants felt that technology provided them with “ ‘companionship’ when they felt ‘isolated’ during the confinement periods at home.” The authors point to technological advancements as a way to both support emotional well-being as well as access to important information, stating these results suggest “the need for hospital administrators and clinical stakeholders to develop educational resources that are specially catered during epidemics and pandemics to readily reach out to pregnant women and their families” (Shorey & Chan, 2020).

In the same vein, Wu and colleagues (2020) suggest technology-based care be utilized to support the antenatal needs of pregnant populations during the COVID-19 pandemic: their published viewpoint posits that online antenatal care is cost-effective, convenient, and has the capacity to both diminish inequalities in health care and “limit potential risks of infection among this vulnerable group [pregnant populations]” by reducing unnecessary hospital visits. More specifically, they propose implementing an online program which guides pregnant women (without special health needs) to take a number of steps: monitor and upload their daily blood pressure; perform regular blood, glucose, and urine tests; and participate in online conferencing to ensure better labor preparedness and postpartum outcomes (Wu et al., 2020).

The authors do not outline which types of online systems would be ideal for such functions, though they note that online conferencing could be done through video or voice calls, and they point out this online care should be administered through medical experts and

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institutions (Wu et al., 2020). Ideally, any online platform distributing medical services will be informed and vetted by expert medical professionals. Progressing beyond moral and social responsibility, we must also construct an online platform distributing such vital information to be accessible, comprehensible, and relevant. To guarantee a platform which meets these standards, we may look to Lloyd's work in information studies.

Information Landscapes, Information Literacy, and Literacies of Information

Information landscapes are described by Dr. Annemaree Lloyd, an information studies researcher, as “constituted through social, epistemic/instrumental and physical corporeal information modalities which reflect the stable and established knowledge domains of a social site (information environment)” (2017). This is to say, an information landscape is a space which contains various sources and modes of information (both corporeal and social); links these components with respect to their interrelatedness; and maintains the landscape's connections to outside, correlated landscapes. Sources for information landscapes need not be published or peer-reviewed like other forms of learning: Lloyd writes that “[i]nherent within a landscape are practices, which reflect sayings and doings and relatings” (2017). Information does not exist in a vacuum and will be drawn from various sources to develop a holistic understanding of an experience.

In a health setting, information may be presented in the forms of formal medical knowledge, technical knowledge, social knowledge, institutional knowledge, and corporeal knowledge (Lloyd, 2017). When applied to pregnancy during the COVID-19 pandemic, these modalities might appear as health information from the Centers for Disease Control and Prevention (CDC) (formal medical knowledge), an understanding of how the SARS-CoV2 virus

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spreads and infects (technical knowledge), experiences of friends and family who are also pregnant during the pandemic (social knowledge), the rules guiding health care providers during the pandemic (institutional knowledge), and experiences of either one's own individual body or the observed experiences of others' bodies (corporeal knowledge). When pregnant people move through the pandemic, they are steadily developing their information landscape from diverse sources, and integrating these different modalities into their way of knowing, doing, and being.

Interwoven with information landscapes is the theory of information literacy, a concept also discussed by Lloyd. Lloyd differentiates the concept of *information literacy*, which refers to the skill of determining information needs, accessing, and ethically using information, from *literacies of information*, which reference the various practices of information literacy as reflected through contextual, social sites (Çoklar et al., 2017; Lloyd, 2017). Lloyd writes: “literacies of information may, therefore, depend on the acceptance of some material practices over others, which is also reflected in the privileging of some information skills over others” (2017). This is to say that literacies of information acknowledge and create space for how people, or users, absorb and engage with information according to context and to their own information landscapes; it also notes that people develop different information literacies relevant to their experiences and needs.

Lloyd's approach to literacies of information offers a more holistic understanding of what it means to be information literate; when applied to contemporary culture during the COVID-19 pandemic, we may consider such matters as the shift in access to information during social distancing; the reality that many present-day pregnant people are more comfortable with using digital technologies than previous pregnant populations were; and aspects both contextual (such as health literacy) and material (such as digital literacy). As outlined in the previous section,

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those pregnant during epidemics and pandemics are documented as reporting both an increased reliance on information found online and a distrust of information found online as well as an increase in health anxieties. To improve the information literacy of those pregnant in the United States during the COVID-19 pandemic, we may use these literacies of information to create an information landscape that both better suits pregnant populations' needs and supports their well-being during uncertain times. Research into available digital technologies offers insight into their relevance and capabilities in improving such information literacy.

Mobile Application Considerations

The popularity of pregnancy-related mobile applications is significant: on a global scale, there are more pregnancy apps than there are apps for any other medical topic (Hughson et al., 2018). A 2014 study examined over 1,000 pregnancy-related mobile apps developed for Apple iOS, analyzing both their purpose and popularity. The researchers organized four different categories for app function: 1) *informative* apps were described as reference-based, presenting as an encyclopaedia of facts, advice, and guidance to expecting mothers; 2) *interactive* apps were determined to be that if they allow data input and offer personalized, “gestation-specific information” specific to users' needs; 3) *tool* apps were single-function, manual input applications, such as date of birth calculators or fetal kick counters; and 4) *social media* apps were defined by their ability to instantly share information through taking photos and connecting to the internet (Tripp et al., 2014).

Though Tripp and colleagues' research does not engage with live human subjects, their analysis of user reviews and average user ratings found that of those apps targeting pregnant users, the most popular mobile applications' functions were: informative (40%), interactive

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(30%), tools (19%), and social media (11%). The researchers point to the potential risk of misinformation due to lack of medical regulations imposed on app development, recommending that such systems be closely monitored by healthcare experts and policymakers alike. They speculate that this shift in reliance from health care professionals to interactive applications might aid in patient empowerment and accessibility (Tripp et al., 2014).

More recently, a cross-sectional survey of pregnancy-related app users investigated the relationship between pregnant or recently-pregnant individuals and mobile applications. Researchers' findings demonstrated that while most users' preferred apps had multiple functions—rather than falling within a single category as Tripp et al. (2014) presents—users found the two most useful functions to be the informative function and the social networking function, respectively (Lee & Moon, 2016). Notably, users reported that sharing experiences with others in similar situations through social media functions relieved their pregnancy-related anxiety; a significant number of users (approximately 45%) also responded that these apps are in need of “[e]xpert opinions and opportunities for question and answer sessions on diet and medication administration during pregnancy” (Lee & Moon, 2016).

Lee and Moon's (2016) findings align with many of the critiques and concerns regarding pregnancy-related apps raised by users, healthcare professionals, and researchers alike: mobile app design should be informed by expert medical advice so as to reduce misinformation and support the maternal health of users (Tripp et al., 2014; Hughson et al., 2018; Lee & Moon, 2016; Shorey & Chan, 2020; Wu et al., 2020). Through an information literacy lens, we may assume that many pregnancy-related app users rely on both social knowledge as well as formal, medical knowledge and utilize them differently according to the users' needs in order to develop their information landscapes. Nonetheless, there appears to be a significant absence of expert

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medical knowledge within these mobile applications, suggesting users who primarily rely on these apps for support may be developing skewed information landscapes (Tripp et al., 2014; Lee & Moon, 2016; Hughson et al., 2018).

A 2017 study by Australian researchers sought to design a prototype of a mobile application that would culturally, linguistically, and medically accommodate the large Vietnamese pregnant population in Melbourne. Researchers worked with local health professionals to design the prototype so that it was capable of being integrated into the clinical maternal health setting, investigating the potential effectiveness of mHealth (mobile health sources of information) in these health settings (Smith et al., 2017). In addition to adding bilingual features implemented by interpreters, the professional obstetricians and midwives involved in the design process also implemented such notable features as a care pathway for navigation (in contrast to a week-by-week navigation, which would limit the availability of information), and short chunks of textual information to increase usability (Smith et al., 2017).

When the prototype underwent an evaluation by a Vietnamese focus group, the group reported preferring the online prototype to printed information (such as pamphlets) because of the ease of accessibility, but the respondents thought the prototype itself could be improved with more images and videos, rather than primarily textual information. In addition, they perceived the mHealth prototype as something that would be used only at home, instead of as supplemental to a clinical setting, stating they would “read that [the app prototype] first and if we need more [information] we’d see the doctor” (Smith et al., 2017). The difference between designer intention and user experience in this study demonstrates the importance of incorporating users’ experience in the design process and subsequently adjusting according to user feedback to ensure usability; this will be further discussed later on. These results also remind us that we must strive

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to ensure mobile apps, especially those that may offer relevant, credible medical information, effectively accommodate their users' preferences and accessibility needs.

A narrative review of pregnancy app usage by women, including culturally and linguistically diverse (CALD) women, discussed the most valued mobile app features and pointed to areas for improvement of app design. In the U.S., a dichotomy exists between pregnancy app use by white women and low-income, non-white (predominantly Black and Hispanic) women; Hughson and colleagues found that the practice of active information-seeking during pregnancy was lower for non-white women than their white counterparts. There appears to be a difference in health and/or digital literacy between these two groups: non-white participants indicated a need for training to be able to manage existing digital resources, particularly in the realm of digital health management (Hughson et al., 2018). The research suggests that pregnancy app design, then, is underserving a large population of American women. Future developments must reevaluate their design to accommodate this gap in information literacy, perhaps beginning with more bilingual features.

Likewise, the commercialization of pregnancy apps has decreased their usefulness to health care professionals: less than 6% of these mobile apps were considered "potentially useful" by health care providers, according to two separate studies, as the apps lacked significant antenatal content. This conclusion extended to postnatal content as well: researchers specified that there was a lack of postpartum contraception planning information, which, notably, is included in the guidelines of the American College of Obstetrics and Gynecology prenatal care (Hughson et al., 2018). Researchers suggest a lack of health care professional guidance in these apps' development may contribute to pregnant women's anxiety levels through excess information seeking and "scare mongering," particularly for first-time mothers (Hughson et al.,

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2018). An app which is influenced by health professionals and prioritizes the same information one would get in a traditional medical setting, rather than one which profits through marketable data, would likely be beneficial to expecting parents. These considerations heavily inform how such an app should be designed, and shift our focus to mobile application usability.

Mobile Application Design for Usability

A recent study analyzed the design features of several mobile pregnancy apps and the potential of mobile health apps to make personal health records such as Electronic Maternity Records (EMRs) accessible via mobile applications as an “alternative personal antenatal care information system” for monitoring patients’ pregnancies (Fonseca et al., 2019). Of the eight popular pregnancy apps analyzed (in both Android and iOS) , all contained weekly information on fetal development and/or the mother’s body changes as well as a birth date calendar. Other features, such as manual input of symptoms, fetal movements, appointment dates, and glucose levels, were available in one or more of the applications studied. Only one of these apps lacked offline capabilities (Fonseca et al., 2019).

In their study, Fonseca and colleagues discussed Progressive Web Apps (PWAs), a web app structure introduced in 2015 that enables offline functioning, push notifications, and running in full-screen mode like native and hybrid apps (that is, apps designed for a specific platforms), but is made with web technologies and is therefore “easier and quicker than developing a native and a hybrid app.” At the time of the study, PWAs were less visible to users, as they were not available in the app store and were not supported by every browser (thus limiting compatibility); despite this, the researchers concluded that this app structure is ideal for developing a scalable and complex app that can handle maternity records and monitoring tools (Fonseca et al., 2019).

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This study is undoubtedly important for considering back-end mobile application development; however, we may shift our focus to front-end design features, which are especially relevant to usability.

While the term “stickiness” is typically used in the context of commercial mobile application development--where developers design an app so as to ensure its consumers’ regular use--it can be considered, more broadly, to signify how worthwhile an application is for its users. Hsu and Tang (2020) investigate the factors found to determine mobile app stickiness: that is, users’ revisiting and time spent using an app. Their study discusses various commercial mobile applications--not those specifically pertaining to health or pregnancy--and found that across the board, determinants of users’ self-efficacy (“perceived usefulness,” “perceived enjoyment,” and “perceived ease of use”) ranked highly in terms of app stickiness (Hsu & Tang, 2020).

In terms of mobile health applications, Liew and colleagues (2019) drew similar conclusions after conducting both quantitative surveys and qualitative interviews with users and “app insiders”: they found that participants prioritized traits related to usability, such as the satisfaction, learnability, and efficiency of mobile health applications. Notably, this was the same for both digital natives (those who were already familiar with technology) and digital immigrants (those who were not experienced or familiar with technology) (Liew et al., 2019). Researchers used the Nielsen usability model to analyze usability: this model includes five usability themes, including the three prioritized stated previously (satisfaction, learnability, and efficiency); the remaining two, which were not prioritized by participants, are errors and memorability (Liew et al., 2019).

Elberzhager and Holl (2017) discussed the importance of feedback in the development (and revision) of mobile apps: they pointed out direct and indirect feedback commonly collected

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through textual information (such as a user's manual input) or usage feedback by app interaction (such as users tapping one button excessively). In order to avoid negative feedback from users, the researchers suggest "using personas during requirements elicitation" during the app development phase (Elberzhager & Holl, 2017). Personas, as will be discussed in depth later on, are fictional users flanked with realistic qualities which are represented in a visual format in order to guide subsequent design decisions; these are informed by user research and insights. Elberzhager and Holl's research emphasized the usefulness of user feedback and the various channels it can be shared through, reiterating the consequences of not implementing early and frequent methods of user feedback in mobile app development.

While I was unable to find pregnancy-related mobile apps available for download in Apple iOS that were developed with the COVID-19 pandemic in mind in my own research (as of April 2021), some apps are adapting to their users' needs and offering information specific to COVID-19 and pregnancy. The mobile app iMumz, an India-based and newly U.S.-accessible pregnancy application, has added a chat engine and livestreaming feature in wake of the COVID-19 lockdown: through these features, the app hosted more than 160 senior doctors who answered thousands of questions for the app users. Dr. Jaideep Malhotra, a gynecologist assisting in the app's pandemic adaptations, stated that it will be shifting "towards a personalization of the program for the expecting and new mothers through their health information," responding to the various obstacles the pandemic has inflicted on pregnant and recently-pregnant people (Mali, 2021).

Considering the historical and contemporary context of mobile pregnancy applications discussed previously, future work in the field should adapt to the COVID-19 pandemic to ensure the well-being of pregnant populations both during and beyond this pandemic. This project will

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address the preferences of pregnant people by designing a prototype of a mobile application that 1) contains useful features relevant to the lived experience of pregnancy during the pandemic, 2) is accessible, navigable, and usable, 3) allows for social connection between pregnant users, 4) compiles reputable, medically sound sources (such as websites and organizations) for information about pregnancy during COVID-19, and 5) maintains updated information regarding pregnancy and the ongoing pandemic. While later public health crises might build on this prototype, this project is confined to the current public health crisis. This app will work to strengthen the information literacy and holistic information landscapes of pregnant populations while acknowledging the needs of underserved populations.

Mapping the Current Information Landscape: Users

Building an application prototype which incorporates Lloyd's approach to information literacy for a certain population necessitates understanding the layout of that population's current information landscape. Over the course of two months from November to December 2020, I conducted semi-structured interviews with and collected feedback from both pregnant or recently pregnant people and health care providers in the maternity field through an online questionnaire. These were administered with two goals: gaining insight into respondents' relationships with (that is, their trust in and usage of) information and with mobile pregnancy applications during the COVID-19 pandemic; and then translating this insight into mobile application development. I conducted one semi-structured interview virtually through Zoom and was able to conduct two additional, less intensive interviews in person with recently pregnant parents; additional information was collected through a questionnaire accessible on Google Forms. Five pregnant or recently-pregnant people and one health care provider responded. Three individuals participated

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in the interviews, and six individuals participated in the questionnaire, totaling nine participants providing input. Personally identifiable information, such as names, was not relevant and therefore not used for either of these methods of collecting information. Because both the interviews and the questionnaire were used only to collect input and guide the later prototype development, not to make generalizable claims, these methods did not require review by the Institutional Review Board (IRB) (N. Peddibhotla, personal communication, November 27, 2020).

Respondents were recruited through midwife Vicki Nolan Marnin, who provided a number of patients with a paper containing my contact information, the goal and outline of my project, and a link to the Google Form questionnaire (see Appendix A) with this recruitment information attached; respondents were also recruited via a post in the Facebook page “Birth & Beyond,” maternity care local to the New Haven region of Connecticut, where Vicki Nolan Marnin works, which contained the same information. Respondents were asked to either email me or access the questionnaire via the attached link.

The interviews and questionnaires asked participants to reflect on their use of mobile pregnancy applications, on information regarding pregnancy, and on information regarding pregnancy during COVID-19, as well as about how any of their usage of the aforementioned components might have changed from the beginning of the pandemic in March 2020 to the present (November to December 2020). Two sets of questions were created, one for pregnant and recently-pregnant participants, and one for health care providers (see Appendix B).

While the semi-structured interviews were guided by the same questions included in the questionnaire (see Appendix B), their nature allowed participants to provide insight beyond the questions asked of them. Because only one health care provider participated in either of these

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methods, much of my insight regarding reliable and medically sound information derives from observatory fieldwork with Vicki Nolan Marnin (which also took place from November to December 2020) and a literature review of the information currently available. This fieldwork immersion deepened my understanding of the lived experiences of the process and cycle of pregnancy and health care and reinforced the significance of accessible, valid information, particularly during the COVID-19 pandemic.

After gaining insight into pregnant people's information landscapes during the COVID-19 pandemic through the above methods, I began constructing personas, a technique of representing users' preferences through visual, narrative, and archetypal traits. Personas help organize and humanize users into digestible blocks of information, synthesizing various traits and behaviors embodied by real users which are relevant to their user experience (Miaskiewicz, 2011). This is to say, a persona does not represent one person, but rather is an archetype made up of characteristics extracted from various people (Chang et al., 2008). User personas have been considered particularly useful in mobile application development, notably in mapping the characteristics and preferences of health care technology users (LeRouge et al., 2013). The resulting personas (see Figures 1-3), represent the various pregnant or recently-pregnant people which provided insight through interviews or by responding to my questionnaire.

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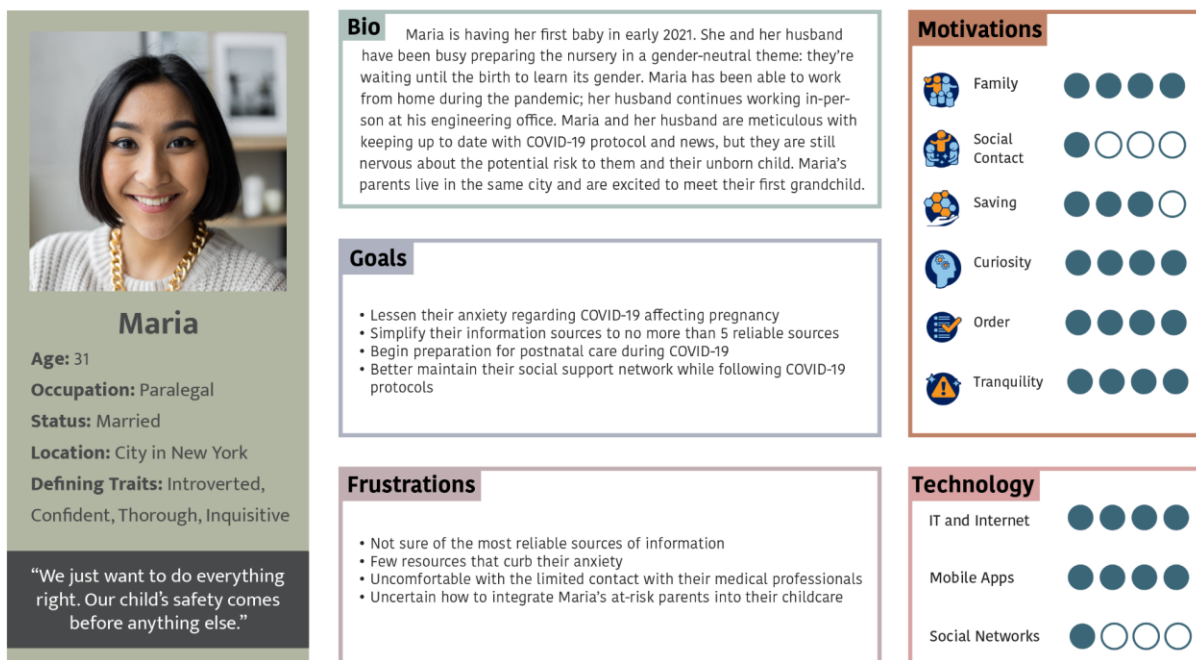


Figure 1

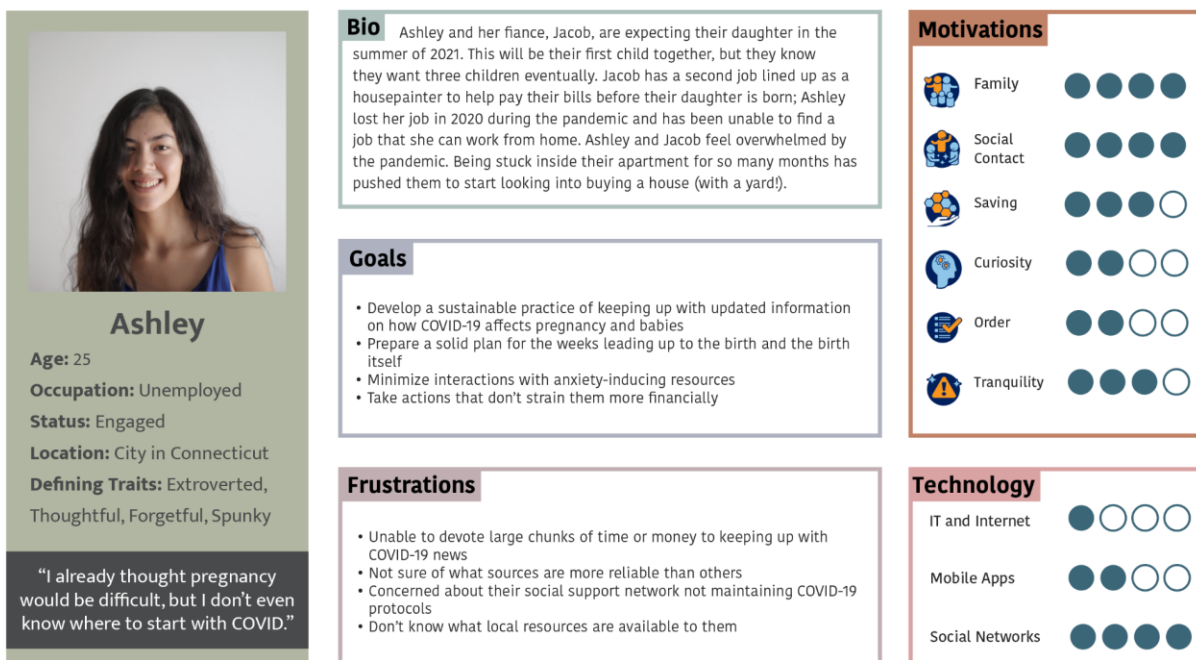


Figure 2

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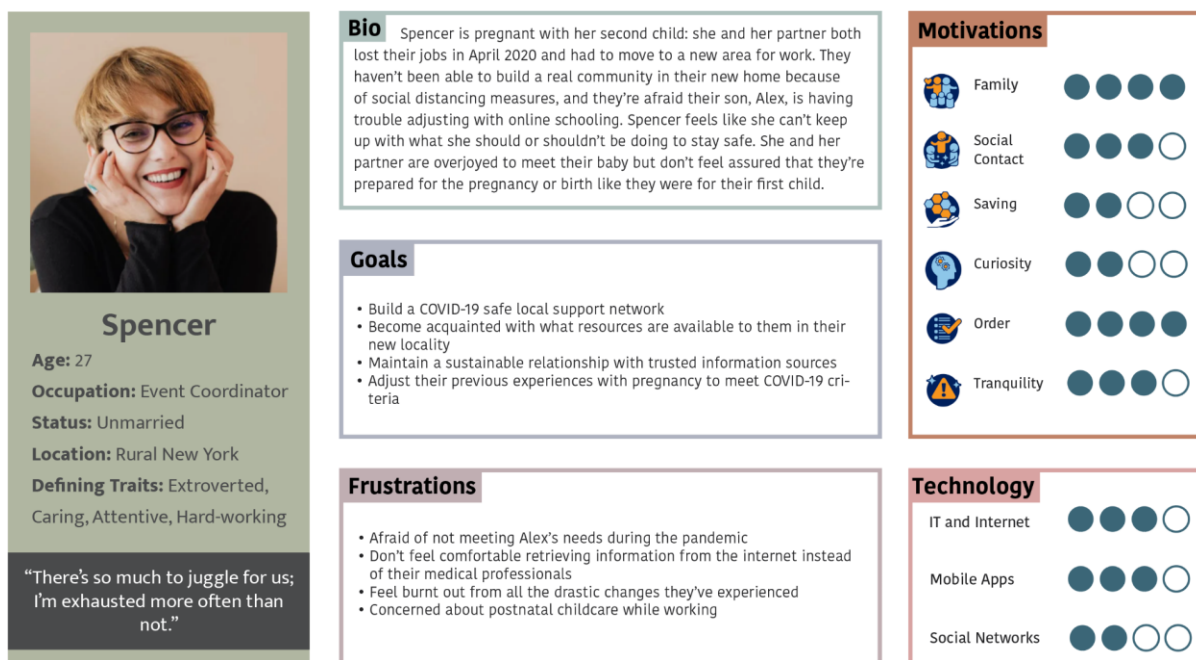


Figure 3

Mapping the Current Information Landscape: Current Pregnancy App Research

As outlined in the literature review, earlier peer-reviewed studies analyzed various design features found across pregnancy mobile applications in Android and Apple iOS. My own research into pregnancy apps supported these previous studies’ findings: after downloading seven popular Apple iOS pregnancy-related apps (Baby2Body, Hello Belly, Mama, Peanut, Pregnancy +, Sprout, and What to Expect), I found that all had multiple functions.

Each of these apps contained both an informative function and an interactive function as defined previously by Tripp and colleagues, while three also contained a social media function (Tripp et al., 2014). One app, Pregnancy +, contained a kick counter or contraction timer tool function, four apps contained visual renderings in order to communicate the size and development of the user’s baby at different weekly stages (Hello Belly, Pregnancy +, Sprout, and

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What to Expect), and all seven apps contained a birth calculator tool, which is to say they all contained at least one tool function (Tripp et al., 2014). Notably, each of these apps require the user to calculate their due date upon initial use of the app following download. I observed that while four of the apps required a premium, paid subscription to the app to access certain functions, the three that did not require paid access in any form were also the only apps with social media functions in the sample.

Of the seven applications, only two—Baby2Body and What to Expect—featured information specific to the COVID-19 pandemic. This information, it should be noted, is neither in-depth (relative to the breadth of internet search engines or news outlets) nor accessible on the app’s home; users must manually search keywords in the app’s search engine to discover information specific to COVID-19. The What to Expect application’s informational segments are written by professional journalists, while Baby2Body’s informational segments are attributed to the app itself (“By Baby2Body”), potentially raising concerns about reliability.

From this sample, the current information landscape of many pregnancy-mobile application users appears to be severely lacking in accessible and reliable information, particularly regarding the COVID-19 pandemic as it relates to pregnant and recently-pregnant people (see Table 1). Taking into consideration the current information landscape of these users and the needs of my own users as demonstrated through my personas, I sought to create a prototype which serves primarily as an informative application. As defined by Tripp and researchers, informative pregnancy apps are reference-based applications which present an encyclopaedia of facts, advice, and guidance to expecting mothers (2014). Various design features were considered and integrated into the design to ensure this information is accessible, usable, and appealing.

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Table 1: Functions of Existing Pregnancy Apps

Existing Apps	Informative	Interactive	Tool	Social Media	Paid Access	COVID-19 Features
Baby2Body	✓	✓	✓		✓	✓
Hello Belly	✓	✓	✓		✓	
Mama	✓	✓	✓	✓		
Peanut	✓	✓	✓	✓		
Pregnancy +	✓	✓	✓		✓	
Sprout	✓	✓	✓		✓	
What to Expect	✓	✓	✓	✓		✓

Building the App: The Wireframing

To properly organize features relevant to pregnancy mobile applications, wireframing should precede prototyping. Thornsby (2016) writes: “[t]he purpose of wireframing is to focus on things such as functionality, usability, behavior, and the positioning and priority of your content.” A mobile application wireframe presents the bare bones of the app prototype; it outlines which functions and content will be included and shows their visible layout on the screen. Wireframing produces an adaptable layout which guides the subsequent prototyping process and is integral to building a consistent, user-friendly application.

I created a wireframe in the online tool Figma, which allows the designer to integrate user interface components into their wireframe design. I decided to create an app which functions in Apple iOS, due to there being over twice as many pregnancy apps available in the Apple iOS

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system than in the Android system (and thus, significantly more peer-reviewed research is available on this system) which informs the process of building the app (Tripp et al., 2014).

Wireframing allows for resolving design issues early on in the prototyping process, encouraging an efficient process overall, and brings considerations of navigation to the forefront, encouraging a user-centered final product; these considerations are particularly relevant to organizing large chunks of information for users to navigate through with ease (Thornsby, 2016).

Cognitive load theory states that a person has finite working memory, and to increase the efficiency of this working memory, cognitive load must be lessened: this may be done through decreasing the intrinsic load (level of difficulty of the information), the extraneous load (how the information is presented), and the germane load (how the information is processed and learned) (Athilingham et al., 2016). Because the goal of my prototype is to compile information, it is consequently susceptible to overloading users with said information; therefore, cognitive load theory is especially salient to the design process.

Athilingham and researchers reviewed how cognitive theory influenced their own health-centered mobile application development, which sought to educate patients with health failure. To lessen the intrinsic load, they reduced the complexity of information; to lessen the extraneous load, they provided short summaries of information in the form of bulleted lists; to lessen the germane load, they reduced the amount of information presented at one time to improve memory processing (Athilingham et al., 2016). Their mobile health application contains a predetermined set of educational modules which allows the researchers complete control over the content being distributed; in contrast, my mobile health application functions in accordance with the constantly updating news relevant to pregnant and recently-pregnant parents during COVID-19, so reducing the complexity of information and summarizing published information into a bullet point format

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in order to lessen the intrinsic and extraneous load within the app, respectively, is not viable whilst maintaining frequent updates.

With this in mind, it should be noted that the function of my prototype is to lessen the extraneous load of information relevant to pregnant and recently-pregnant parents overall, though the load may not be decreased within the app itself. When users enter their questions or concerns regarding this topic into a search engine outside the app, or peruse a news website searching for relevant content, they may be overwhelmed with the amount of information presented to them and suffer from cognitive overload. This prototype aims to reduce the extraneous load by funneling reliable, relevant information into one cohesive, readily available source. In the same vein, the germane load within the app prototype may be lessened through the presentation of a limited number of informational components at one time and by attaching imagery to each component in order to improve users' memory processing (Athilingham et al., 2016).

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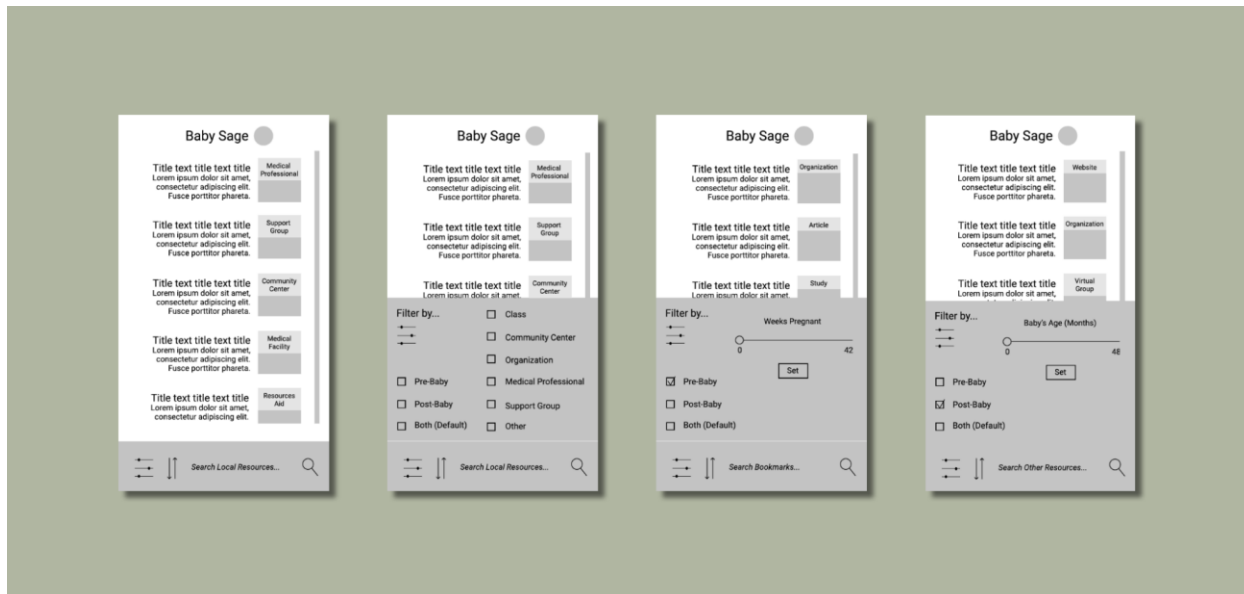


Figure 4

These design considerations are reflected in my wireframe examples (see Figure 4 above), which portray the title of the information link, the author or source information for the informational link, and an image associated with the informational link in a columnar grid layout. In order to reduce germane load, no more than five informational links are visible at one time on each screen. Below these components lies a navigation bar with a keyword search tool, an option to filter information by “Pre-baby,” “Post-baby,” “Both (default),” and the medium of the informational link (article, video, website, and so on). Within the “Pre-baby” filter, users may slide the scale anywhere from 0 to 42 weeks of pregnancy; within the “Post-baby” filter, users may slide the scale anywhere from 0 to 48 months of age. This helps narrow down their search entry if they are seeking timeline-specific information. The medium of the informational links varies according to the different type of information (COVID-19 Updates, Local Resources,

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Other Resources, or Bookmarks) in order to reduce the number of options presented at one time, while keeping in mind the risk of cognitive load. Each type of information may be sorted either alphabetically or by date, allowing the users more control and the ability to organize content according to their needs. Such design considerations seek to both promote information literacy and reduce the chance of cognitive overload.

Building the App: The Prototyping

The process of prototyping this application integrates the previous research methods and their findings into one product. This final stage demonstrates how the product will function and appear in its final form: the methods of prototyping are guided by both Dr. Annemaree Lloyd's information literacy theory and the concept of literacies of information, as discussed in the literature review, as well as by the uses and gratification theory. In the context of mobile applications, uses and gratification theory posits that users selectively engage with an app based on their psychological and social environment, needs and motivations to communicate, perceptions and expectations of the app, alternatives to the app, and the outcomes of their behavior (Gerlich et al., 2015).

A 2015 study examining the views of women and health professionals toward mHealth (mobile health sources of information) did so by applying uses and gratification theory after conducting interviews and focus groups with women and health professionals (Willcox et al.). The researchers were interested in the viability of mHealth in supporting pregnant women and offering postpartum care, and in implementing mHealth to support healthy lifestyle advice. The researchers concluded that women users held a positive perception of mHealth, especially in terms of accessible, supplementary information to traditional medical care, while also perceiving

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a risk of significant amounts of their time being invested in adopting a program that's new to them (Willcox et al., 2015). Notably, many women respondents "saw themselves as having the capacity to evaluate and select information to suit their situation and the ability to sift out non-credible information" (p. 5). This contrasts with the significant risk medical health professionals perceived of harmful or incorrect information being implemented in these apps. Medical professionals did, however, appreciate the perceived benefit of broadening access to medical care to a wider audience, particularly to at-risk patients who may not be able to receive medical care as needed (Willcox et al., 2015).

These perceived uses and gratifications corroborate the strengths and limitations discussed in the literature review, all of which informed the process of prototyping. Creating an app which adequately accommodates users' preferences, such as those discussed in my personas and in similar studies such as Willcox et al.'s (2015), necessitates thoughtful and methodical design considerations to ensure accessibility and usability. The prototype was built in the program Figma, allowing me to directly translate my wireframe structures into a functional piece. In designing my prototype, I wanted the information to be accessible to various populations, especially those that are underserved: historically, this population overlaps with those who are immigrants, refugees, and those who don't have the privilege of traveling, even beyond their city limits. To accommodate this, I first included a Local Resources category which compiles support groups, medical professionals, medical facilities, and other regional resources available to users according to the zip code they manually enter. The links present in this category lead to the resources' websites outside the app when users tap on the title or image, while including the most relevant information--such as their name, address, description, and phone number--within the app itself.



Figure 5

I sought to accommodate users who aren't fluent in English by including an option on the enter screen to function the app in a language of their choosing: ideally, users would have access to all the same languages available in Apple products (approximately 40), though the prototype image pictured above (see Figure 5) only portrays a few of these options to demonstrate that non-Latin alphabet languages are supported as well as Latin alphabet languages (such as English, Spanish, French, Portuguese, etc.). This choice influenced the font decision as well: I used Noto Sans for the bulk of the textual content, a sans-serif, legible font which supports over 60

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languages and promotes modernistic and unambiguous feelings which are ideal for an app focused on reliable information. In the same vein, I opted for a simple layout that heavily utilizes white space and draws users' focus to the informational content. This is meant to appear straightforward and reduce cognitive load that may arise in users when faced with textual information.

The color scheme of muted, desaturated colors was implemented to reduce anxiety and maintain users' focus on the content itself. In *Universal Principles of Design*, Lidwell, Holden, and Butler advise designers to “[u]se desaturated colors when performance and efficiency are the priority” and note “desaturated, bright colors are perceived as friendly and professional” (2010, p. 48). Consistently using a different color for each of the four categories (COVID-19 Updates, Local Resources, Other Resources, and Bookmarks) seeks to reinforce the organization of the elements without cluttering up the space with extraneous visual elements. To reiterate users' position within the app, the search bar function at the bottom of the screen changes with each category from “Search COVID-19 Updates,” to “Search Local Resources” and so on.

The application name, Baby Sage, connotes wisdom, sensibility, and a wealth of experiences, and is intended to evoke a sense of reliability and functionality. The application logo, a scalable vector graphic which I created in Adobe Illustrator, portrays a single sage leaf growing in a terracotta pot: this brings to mind nurturing and caring for the growth of a living being whilst aligning with the theme of the application. While these design considerations are meant to be aesthetically pleasing, they also aim to appeal to users' need for calming and assuring information when investigating a topic that is (potentially) inherently worrisome.



Figure 6

Each of the three categories which provide updated information (COVID-19 Updates, Local Resources, and Other Resources) is intended to draw exclusively from sources deemed reliable, such as peer-reviewed journals, credible news organizations, and officially recognized medical institutions whose information is accessible via the web (see Figure 6). This is done in order to lessen the concern, held by both users and medical professionals, that a pregnancy app will spread misinformation to its users; in addition, this approach helps strengthen information literacy for users who may not be familiar with credible sources of information on this topic. The three categories were chosen because they encapsulate the primary motivations users may have for using an app centered on pregnancy and the COVID-19 pandemic: accessing actively

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updated information (COVID-19 Updates), accessing information local to them (Local Resources), or accessing supplementary information which improves their understanding of pregnancy and COVID-19 (Other Resources).



Figure 7

In order to ensure that users experience control and feel empowered when using the app, each category contains various filter and sort options. Information may be filtered according to content medium and to “Pre-Baby,” or “Post-Baby,” defaulting to “Both [pre-baby and post-baby]” because some users may not know if the information they’re seeking applies to one or the other (see Figure 7). The content in each category defaults to showing the most recent information at the top of the list, but users may also sort by “oldest” or “alphabetically” if they choose, which may be helpful in the event they come across content that they had intended to

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return to but hadn't saved to the Bookmarks feature. Users may also search within each category by keyword, which is vital in searching for specific content.

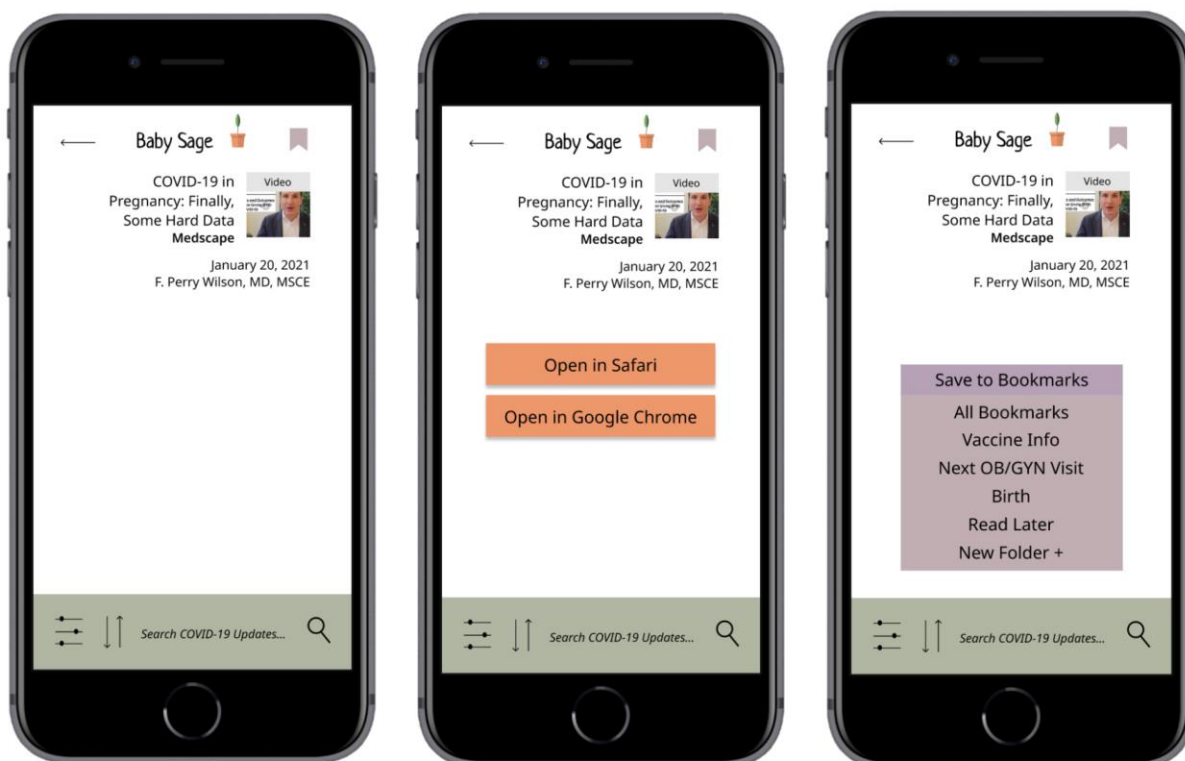


Figure 8

The Bookmarks feature allows any informational item the user taps to be saved offline to the application itself. Because users must exit the app and access informational content in either their Safari or Google Chrome application--a feature which prioritizes providing updated information as soon as possible--accessing the information itself may be more difficult for users who have limited wifi or cell service capabilities. Being able to bookmark content ensures users will be able to access it at a later point; it also allows users to compile their own groups of

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information personal to them in the Bookmarks folder option (see Figure 8). As stated in the wireframing section, each piece of informational content features an image associated with it adjacent to it (typically the logo of the source, or a screenshot of the video): this helps users to remember and differentiate between information, as the layout is inherently text-heavy.

After an extensive prototyping process, the app was shared with a currently pregnant person who agreed to provide feedback in order for me to make appropriate adjustments. This informant did not contribute to either the questionnaire nor the interview, so any insight regarding usability and functionality of the app was not influenced by previous discussions. This respondent reported finding the prototype “very clear” and easily navigable, commenting that it had the potential to “help a lot of mothers.” No further adjustments were made to the design based on their feedback.

Findings

My initial methods—that is, interviewing and collecting feedback through questionnaires—provided invaluable insight into which features my target audience finds most relevant and useful. None of my eight pregnant or recently-pregnant informants stated they heavily rely on pregnancy apps; for those who use them, apps were usually used for one specific feature, even if they contained multiple functions. Similarly, none of these informants found these apps useful in the context of COVID-19; this corroborates my own app research. In terms of the broader context of access to information on COVID-19 and pregnancy, none of the respondents who actively sought out such information found it particularly helpful, one even noting they found it difficult to “determine [what] guidelines I should trust” because of the constantly updated and conflicted information published online.

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The health care provider who participated in the questionnaire stated that information on COVID-19 that's accessible to pregnant and recently pregnant patients "...scares mothers as opposed to being supportive." One informant, over a month postpartum at the time of our interview, noted they found information on postpartum care--particularly postpartum care in the context of COVID-19--severely lacking in mobile applications: "I'm craving information more, but it's harder to find information postpartum." This comment encouraged me to place equal weight on the "Post-Baby" information as on "Pre-Baby" in the filter feature. Of course, the amount of antenatal and postpartum information that is available will vary according to the research and news published online. Each of these insights informed my prototype design: an app with the goal of providing credible information on COVID-19 as it pertains to pregnant and recently-pregnant people must take care to be palatable, digestible, and unambiguous, while still providing ample support so as to promote information literacy among its users.

My initial goals for this prototype were that it 1) contain useful features relevant to the lived experience of pregnancy during the pandemic, 2) be accessible, navigable, and usable, 3) allow for social connection between pregnant users, 4) compile reputable, medically sound sources for information about pregnancy during COVID-19, and 5) maintain updated information regarding pregnancy and the pandemic.

While each phase of this project has demonstrated the importance of these goals in strengthening information literacy and holistic information landscapes of pregnant populations during COVID-19, my project shifted for the third goal, allowing social connection among pregnant users. That's because the risk of misinformation and conflicting information is much more likely to occur in an app where users may share their unvetted thoughts with each other; this raises a very legitimate concern of credibility, and recalls the principle of reliability

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underlying this app. With this concern in mind, I decided to not include any form of social connection within the application itself, so as to ensure Baby Sage's reliability is not compromised. However, vetted virtual groups and local support groups *are* accessible through the app's "Local Resources" and "Other Resources" categories, which seek to offer users a form of social connection that doesn't threaten their own information landscape with non-credible information. So while the third goal was not met in the final product, the process itself helped me understand that goals three and four were, in fact, in conflict. The goal of information literacy allowed me to prioritize clean information over building a community in which the information might be unreliable.

When researching the existing, popular apps revolving around pregnancy, I made the discovery that the only apps in my sample which didn't require payments to access the full breadth of their services were those operating predominantly as social media apps: Mama, Peanut, and What to Expect. These applications did contain informative components, but offered significantly fewer informative components than their paid-access counterparts did. This raises the question of accessibility to information to pregnant and recently-pregnant people: if mobile health apps have the opportunity to reach a wider audience, as Willcox and colleagues suggested (2015), ideally they would prioritize distributing (reliable, medically sound) information to that audience, especially in the context of a global pandemic. Of course, providing free services is not always viable in the face of commercialization; however, it should be sought after as a worthwhile goal.

I was surprised that none of the apps in this sample contained forward-facing information on COVID-19: the only two that featured any information on it (aside from user-made social groups discussing the topic on their own accord) had a few articles requiring a manual search by

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users. This falls short of the needs and expectations presented through peer-reviewed studies in the literature review which demonstrated the widespread anxiety and need for more accessible information in the face of epidemics and pandemics (Moyer et al., 2020; Shorey & Chan, 2020; Corbett et al., 2020).

As demonstrated in the user personas previously discussed (see Figures 1-3), the interests and perceived uses of Baby Sage by users may focus on filtering out any extraneous or inaccurate information on COVID-19 as it relates to their and their baby's health, and having features which promote sustainable, accessible relationships with that information. The goal of creating an "accessible, navigable, and usable" app was met in a number of ways (discussed more specifically in the "Prototyping" section). The personas reinforced the need to simplify the actual number of choices available for the user and highlighted the reliability of the materials offered. In other words, the users' needs were met by focusing on the design and the content.

Conclusion

The Findings section above discussed the value in and the issues surrounding the creation of the prototype. The Baby Sage prototype is worthwhile in the context of addressing its previously outlined goals; still, further research is needed. Looking forward to what might be next for app developers interested in working with pregnant and recently-pregnant people, it seems clear that a great deal of research could and should still be done.

For example, ascertaining the specifics of what might be needed to make an app usable for particular populations--be they underserved, or non-native English speakers, or otherwise devalued in American society--is important and necessary. With researchers having noted a

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difference in information literacy between white and non-white populations, the question of how to address, or perhaps redress, this discrepancy arises (Hughson et al., 2018).

Finally, one of the more intriguing questions raised by this project might be how to integrate the social support identified as an important need by pregnant people into an app that values the integrity of information: how can an app build and support social connection while valuing some information more than others? Is it the role of the app developer to decide to embed a moderator to ensure only credible information is distributed, or is this the task of another societal institution? The process of conceiving, studying, and developing this project sheds a light on the complicated relationship of and the challenges between the technology we hold in our hands and the society we live in, particularly during a time of widespread crises and uncertainty such as the COVID-19 pandemic.

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Appendix A

1. Do you use apps to help you through your pregnancy? If so, which apps? What do you find most helpful in using them?
 - 1a. Do you find these apps are useful for being pregnant during the COVID-19 pandemic? Why or why not?
 - 1b. If you don't use apps during your pregnancy, why not?

2. Who or what do you primarily rely on for information regarding pregnancy (for example: websites, news networks, organizations, online forums)? Do you also rely on these same sources for information regarding pregnancy during COVID-19?

3. Do these sources correspond with the care and advice provided by your healthcare professionals?

4. Do you rely on any online communities for support during pregnancy? Has your relationship with online communities changed during COVID-19?

5. How has your relationship with information regarding pregnancy changed from the beginning of the pandemic (March 2020) to now?

6. Do you feel the information you have access to regarding pregnancy during COVID-19 is helpful? Do you feel it is easy to access? How would you improve upon its accessibility or helpfulness?

Health care providers in the maternity field

1. Do you suggest that those under your care utilize apps to help them during their pregnancy? Have these suggestions changed during the COVID-19 pandemic?
 - 1a. If yes to either question, what apps do you suggest?
 - 1b. If no to either question, why do you not suggest this?

2. Who or what do you primarily rely on for information regarding pregnancy (for example: websites, news networks, organizations, online forums)? Do you also rely on these same sources for information regarding pregnancy during COVID-19?

3. How has your relationship with information regarding pregnancy changed from the beginning of the pandemic (March 2020) to now?

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4. Do you feel the information you have access to regarding pregnancy during COVID-19 is helpful? Do you feel it is easy to access? How would you improve upon its accessibility or helpfulness?

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Appendix B

Hi there! My name is Anna Woodworth. I'm a graduate student studying Information Design and Technology at SUNY Polytechnic Institute in New York.

I am looking for participants willing to answer a series of questions about their relationship with pregnancy-related phone apps and information during the COVID-19 pandemic. My goal and purpose is to build an app designed to fit users' needs.

For my capstone thesis, I will be building an app that:

- Acts as a community for pregnant and recently-pregnant people to share experiences, concerns, and advice with one another
- Compiles reputable sources (such as websites, organizations) for information about pregnancy during COVID-19
- Maintains updated information regarding pregnancy and the pandemic

This is meant to be an accessible source and support network for pregnant and recently-pregnant people. Interviews will take no longer than 45 minutes and may be conducted via Zoom, over the phone, or through email. Please note that if conducted via Zoom or over the phone, I would prefer to record our discussion to reference later. However, no identifying information will be used in my research and your personal information will not be shared with anyone.

If you are interested or have any questions regarding participation, please contact me at:

woodwoag@sunypoly.edu
Thank you for your consideration!

I am looking for pregnant (and recently pregnant) people and healthcare providers to answer 5-7 questions through the questionnaire link below about their relationship with information during the COVID-19 pandemic.
My goal is to build an app designed to fit users' needs.

Thank you for your consideration.
Anna Woodworth

forms.gle/TFMKDf9BDgMdxAL39