

# Improving a Design Space: Pregnancy as a Collaborative Information and Social Support Ecology

Tamara Peyton<sup>1</sup> and Pamela Wisniewski<sup>2</sup>

<sup>1</sup>Harrisburg University of Science & Technology, Harrisburg, PA, USA

<sup>2</sup>University of Central Florida, Orlando, FL USA

tpeyton@harrisburgu.edu | pamela.wisniewski@ucf.edu

**Abstract.** Pregnancy is a major life experience that changes relationships, identities, and home environments. It is a personal, collaborative, and domestic process of health changes, behavioral adaptations, and social adjustments that goes beyond the medical care of a pregnant woman. Using the lenses of information and support ecologies, we examine whether the complexities of pregnancy are reflected in the design of mobile technologies that support this life altering experience. To do this, we analyzed 191 iOS pregnancy applications (“apps”) to understand the types of functionality they supported. We found that the majority provided static medical and birth event information but had shallow functionality for leveraging social support. Almost all apps excluded expectant fathers, used gendered interfaces and information choices, and focused primarily on fetal development or the pregnant woman’s physical health. We call for less gendered and more meaningfully collaborative mobile health technologies to support pregnancy.

**Keywords:** pregnancy; mobile health; information needs; collaboration; parenthood; motherhood; iOS apps; scoping study.

## 1 INTRODUCTION

Globally, there are 208 million pregnancies each year with approximately 7.2 million of these occurring in North America [56,59]. In addition to involving pregnant women, the everyday experience of pregnancy also includes spouses or life partners, and the family and social circle of the expectant couple [26,41]. Pregnancy means a woman and her partner have to quickly come to terms with the social and domestic impact of pregnancy, as well as the co-related processes and identity of impending parenthood. In this way, the larger context of pregnancy bears much in common with other major life events that trigger health impacts, such as going to college, moving to a new state or country, or retiring from employment [27,28,57]. Pregnancy involves a large amount of information seeking and social support, and the ecologies, or collaborative social environments that facilitate these processes is complex and multi-dimensional [45].

Pregnancy is a growing area for technology-supported health and wellness engagement. For example, the World Health Organization targets pregnancy as an area of focus for mobile healthcare tools [31,42], in both developing and developed countries. As part of the patient engagement movement [17], there is a sharp increase in demand for mobile applications to support and improve health behaviors and social support around health events and activities [9]. The turn towards technology tools for health education, health management, and for social support necessitates an examination of the existing technology offerings to support pregnancy as a medical, informational, emotional, and social life event. In the case of pregnancy, when considering digital tools for understanding and managing the medical, but also the emotional and social aspects of pregnancy, do apps adequately address the full spectrum of the experience?

We set out to examine pregnancy apps in order to understand how well existing app features support the holistic experience of pregnancy. We catalogued, audited, and analyzed the design space of 191 iOS pregnancy apps. We scoped the state of information collaboration and social support within these pregnancy apps and delineate the types of technology-enabled social support functions provided by these apps. The research questions that guided our analysis include:

**RQ1:** Who is the target audience and what primary functionality do existing pregnancy apps support?

**RQ2:** From an information seeking and social support ecologies perspective, what are the key weaknesses within these apps?

**RQ3:** How can we design new functionality that better supports the “complete” experience of pregnancy?

In our paper, we discuss our findings and provide an analytical overview and discussion of the instrumental features of existing mobile pregnancy apps. We work toward improving the potential for pregnancy health technologies to scaffold informational, social, and emotional support around pregnancy. We make three primary contributions through our work:

1. *Methodological:* We adapted a structured scoping process commonly used in nursing and health research literature reviews [3,19,37] to build a comprehensive dataset of pregnancy apps for our analysis.
2. *Analytical:* Through this methodical process, we were able to classify and scope the current landscape of pregnancy apps based on their primary functionality and conduct a gap analysis of missing or under-supported functionality.
3. *Design Space Definition:* We find a need for a recalibration of the design space of pregnancy support. We call for a digital design approach that is less focused on medical health and more focused on enabling social collaboration for expectant couples and their support ecologies.

Through our work, we call for pregnancy app designers to consider the larger context of pregnancy as a collaborative information seeking and social support ecology, not just a period of fetal incubation.

## 2 BACKGROUND

Outside of medical management, the experiences and interactions that occur around and throughout a woman's pregnancy cannot be separated from everyday life. Pregnancy represents a significant physical change in a woman's body, but it is also a social and collaborative event that cannot be disentangled from the medical aspects of care.

### 2.1 Ecologies of Information Seeking and Social Support for Pregnancy

Information ecologies are systems of "people, practices, values, and technologies in a particular local environment" [39:49]. Because Nardi and O'Day argue that the focus of information ecologies is "not on technology, but on human activities that are served by technology" [39:49], we see this definition as being about both information collaboration and social support. Therefore, we adopt the term ecology as a way of integrating the practice of social support within the context of domestic and digital information ecologies. As in other health and wellness situations that trigger deep personal reflection, discovering that one's self or partner is pregnant can result in a large amount of collaborative information seeking with one's spouse, family, and peer networks [20,35,36,43]. Pregnancy should be treated as a rich ecology for information seeking and social support. Information seeking and social support around pregnancy become a part of the daily, unanchored work of life management. In addition to searching for information about physiological symptoms and corporeal changes, pregnancy stimulates a desire to understand the changes that being pregnant and having a child will pose on one's life course [4,30]. These transitional changes may be far-reaching, ranging from impacts on finances and career, shifts in social environment and roles, to inward reflections of one's self concept and identity.

In addition to discovering and learning new information, pregnancy is also a strongly social and deeply relational experience. Thus, Bronfenbrenner's theories around social support ecologies [11–14] are also applicable to pregnancy. Bronfenbrenner concludes that the core part of the ecological flow of human life is the ways in which individuals cope with change through "the progressive mutual accommodation between an active, growing human being and the changing properties of the immediate setting in which the developing person lives" [10:71]. He advocated for a broader, more nuanced understanding of the ecological aspects of human life, particularly as it relates to interpersonal development through family members and close friends. Bronfenbrenner urged those who study social processes and social interactions to take note of the impact of change events and change processes on individual identity and on life outcomes. He argued that changes triggered by life events start a chain of transition activities. In that chain, individuals move away from an old status or role, towards a new or redefined one [12,14].

Heeding Bronfenbrenner, we treat pregnancy as a transition process that is profoundly social. Pregnancy has deep impacts to the pregnant woman's relationships with friends, family, and especially with the life partner [22,25,29]. We must also consider the ecologies of social support during pregnancy [48]. For instance, research has shown that integrating the spousal dynamic into collaborative prenatal care improves long-term wellness, including psycho-social, emotional and physiological

healthy functioning [15,26,38]. Father involvement during pregnancy has been cited as a key social need by expectant mothers [7,48] and positively associated to continued involvement in a child's life post-pregnancy [15]. Other studies in the social sciences and medicine [18,47,51] assert that providing pathways to appropriate networks of social support during early pregnancy contributes to higher satisfaction with the experience of pregnancy, lower fetal mortality rates, better subjective sense of well-being (for both mother and father) [47] and improved health outcomes throughout pregnancy [33].

## **2.2 Pregnancy Research within Medicine and Informatics**

Lupton et al. highlight the importance of and issues with the increasing reliance on mobile apps for pregnancy health management. In both her general health-related research [39] and in her recent co-authored pregnancy work [40], Lupton observes that people frequently fail to consider the veracity and reliability of the health information they get via apps. Lupton and Pederson's pregnancy-related work used self-reports from new mothers to retroactively present subjective impressions of moms' uses of pregnancy apps. Their findings deal with both pregnancy and parenting through a baby's first year. For pregnancy, they found that women fail to consider the sensitive nature of the information shared with others through these apps. This is worrisome, given that many of the women they surveyed mentioned that they would like an app "to generate, store and share personal data of some type" [40:17]. While not specific to pregnancy alone, their respondents also mentioned wanting advice and support from women who have already gone through the experience of pregnancy and early parenting. Similarly, Carissoli et al. [16] argue that the multimodal experience of pregnancy highlights the ways in which new supportive technologies for pregnancy have to integrate models of wellbeing that center situated and lived experienced instead of technology. They speak to the need to provide tools for centering both information seeking patterns and social support activities during pregnancy. We take inspiration from this prior literature by integrating it as part of our lens for collaborative information seeking around pregnancy.

## **2.3 Pregnancy within Computing Design Research**

Pregnancy within design research is often subsumed into more general research on motherhood or parenting and technology use [24,44,55]. Further, much of the current body of work around supporting pregnancy through technology continues to focus on the medical aspects, and on the idea of woman as patient. Despite the calls on researchers to consider the larger unanchored work of pregnancy as part of an everyday life experience [52,54], design literature has largely ignored the call. The idea of pregnancy as a rich domestic information and support ecology was first introduced into Human-Computer Interaction ('HCI') and design literature by Peyton et al [49]. They used it to describe personal support networks that form during pregnancy, and which include both health information seeking and social support with known individuals. They interviewed expectant women and couples about their needs and information search patterns by trimester, showing the importance of mobile apps in this larger process [49]. Drawing from their findings, pregnancy care needs included physical (e.g., lack of control over one's body), informational (e.g., relevant

to one's current trimester of pregnancy), emotional (e.g., stress and anxiety around transition), and social aspects (e.g., sharing experiences and milestones, relying on the support of intimate relationships) [49]. Information search processes varied from adjustment during the first trimester, accommodation second trimester, preparation in the final trimester of pregnancy [48]. This prior work focused primarily on information search processes within pregnancy for lower-income women, our current work leverages their framework of pregnancy needs to more deeply explore the social and emotional aspects of pregnancy support across the spectrum of human experience.

Researchers have since built upon this work or the concept of support ecologies to highlight or describe different configurations of pregnancy information and support ecologies, and to describe the lived support ecologies of new mothers, new fathers, and midwives. Barkhus et al [5] examined the information management habits of new mothers and fathers. They point to the different gender-based needs of each parent, and they highlight the necessary role technology plays in addressing the individual support needs post-pregnancy. Almeida et al. [1] focused on after-effects of childbirth, and the ways that topics of self-care and bodily dysfunction are often poorly supported in the medical frame of care, due to the seeming taboo nature around discussing much of the symptomology with one's support networks. Barry et al. [6] highlight the ethical challenges of creating mobile aids for pregnancy ecologies. They consider pregnant women as potentially vulnerable users. They examined how in-app self-reporting of depression may affect psychological well-being.

When designing apps to support life during pregnancy, the literature makes it clear that more focus needs to be given on the specifics of the lived experience of pregnant women and their close supporters. An ecological approach that respects the sociality and collaborative aspects of pregnancy is the most appropriate and respectful way to accomplish this goal. Our study is situated in this thematic vein. Rather than adopting the medical frame that appears in much of the research-led discussion of pregnancy experiences within HCI, we worked instead to better understand the gaps in the existing digital tools offerings for pregnancy management, collaboration, and social support, in order to provide evidence-based recommendations on how to redress the gaps identified by the prior research.

### **3 METHODS**

We systematically catalogued, audited, and analyzed pregnancy apps for Apple Inc.'s iOS mobile platform. The motivation for this study was our desire to go beyond the perceived bias in decision-making heuristics around tool choice, in which users most often simply pick the most highly rated or top of the list option returned in a search, in what has been called a 'Take the First' heuristic [20,32]. We also wanted to assess the depth of potential for a more holistic and ecological approach to the digital experience of pregnancy. Intrigued by previous work which considers collaborative information seeking [50] or social support in social media [2], either generally [46,58] or specifically related to pregnancy and parenting [2,44], we wanted to evaluate how those processes are enabled or ignored in pregnancy apps.

We conducted a feature analysis of iOS mobile pregnancy apps. Previous work has conducted similar feature analyses of mobile apps for other purposes, with the intent of identifying and cataloguing features and mapping how these features support the needs of a particular target audience.

For instance, Wisniewski et al. [60] examined adolescent mobile safety apps on Google Play and found that these apps were largely designed to support the needs of parents, as opposed to teens. In contrast, we focused here exclusively on iOS apps. Prior studies suggested that many target users (i.e., expectant parents) preferred the iOS platform [49], and an initial search showed a large overlap in offerings between the iOS and Android platforms. To build our dataset, we used an automated script to scrape the names, publishers, and associated metadata of all apps in the iOS AppStore that included the search term “pregnancy” in the title or description of the app (N = 497).

### **3.1 Scoping Process**

Our process is represented in Table 1 (next page). Our goal was to implement a rigorous, comprehensive, and methodological approach to cataloguing and analyzing the domain of mobile pregnancy apps to understand audience, functionality, and how these apps supported the needs of end users. We needed an approach for reducing our large, initial dataset (N=497) down to a relevant and manageable subset of pregnancy apps. We searched the mobile HCI literature for examples of applicable approaches but did not locate any research that cited a systematic method for taking the pulse of an entire domain of mobile apps. While such app analyses are found in the mobile health literature [16], the search and filtering method for conducting the analyses is often not made explicit. At the suggestion of a medical doctor who consulted on the larger project, we looked to the health informatics literature, where we found the scoping study approach [3,19,37], as it is commonly used in nursing and health research to structure literature reviews. The purpose of scoping studies in health research is to systematically guide an audit of a domain with the goal of identifying, quantifying, and analyzing key boundaries, themes, and gaps within the assembled dataset. This approach is persuasive because it provides a rapid, rigorous, iterative, and transparent methodology that informs the process of finding, narrowing, and evaluating information identified through research. A scoping approach allows for both a deductive ‘testing’ approach against assumptions, and an inductive ‘understanding’ approach to coming to know the shape of a knowledge area [3,19,37]. Whether it is applied to a systematic literature search or to amass a targeted app dataset, scoping happens through a process of successively asking questions of the data, and systematically reducing the scope of the dataset to only the most relevant data for the study purposes. Each scope reduction deepens the connection of relevance of the successful item to the study’s goal.

Inspired by the scoping approach’s attention to thematic analysis and gap identification, our adaptation of the process provided an analytical method of determining the intent, audience, key functions and features of each application. The scoping and analysis process was conducted in three distinct phases by the first author and two research assistants. The research team used a consensus building process,

which took place as set of discussions with the research assistants and the project investigators (listed authors) around the findings. We maintained the dataset in a spreadsheet, which acted as the primary analytical and tracking tool for the scoping process.

**Table 1: Scoping Phase Assessment Criteria & Count**

Phase 1: App Relevance	(Initial N = 497 apps)
<b>Assessment Outcomes and Exclusions</b>	
Assessed via downloaded meta-data	
If no, note and exclude.	
If yes, code and go to next step.	
<ol style="list-style-type: none"> <li>1. <b>Target Audience:</b> Is it designed for use by pregnant women, their partners, and/or support network? (RQ1)</li> <li>2. <b>Language:</b> Is it intended for an English-speaking Americans?</li> <li>3. <b>Category:</b> Is the app attributed to an appropriate store category? <i>Include:</i> Education; Health &amp; Fitness; Lifestyle; <i>Exclude:</i> Entertainment; Reference; Productivity; Utilities)</li> <li>4. <b>Unique:</b> Is it a unique and non-duplicated app</li> <li>5. <b>Functional:</b> Is Apple Store information complete and is app downloadable?</li> </ol>	
<b>Total Apps Excluded: 306</b>	
Not for intended audience; n=14	
Wrong country or language n=29	
Inappropriate category, duplicate, or not working; n=263	
Phase 2: Analysis of Use Cases	(n = 191)
<b>Assessed via meta-data and Apple Store webpage</b>	
For Q1 & Q2, qualitatively code data using constant comparison approach.	
If Q3 no, note and exclude.	
<ol style="list-style-type: none"> <li>1. <b>Functionality:</b> What functionalities does the app support? (RQ1) (Coded as: <i>Reference; Guide; Tracker &amp; Log; Dashboard; Journal; Social Support</i>)</li> <li>2. <b>Primary User:</b> Who is the intended primary user? (RQ1) (Coded as: <i>Mom or Dad</i>)</li> </ol> <p><b>Information and Support Ecologies:</b> Does the app have at least some functionality that supports collaborative information seeking or social support? (RQ2)</p>	
<b>Phase 2 Results: Total Apps Excluded: 170</b>	
Phase 3: Evaluating Ecological Support	(n = 21)
<b>Assessed via app installation and review</b>	
<ol style="list-style-type: none"> <li>1. <b>Composition of Support Network:</b> Who does the app explicitly include in the support network? (RQ1 &amp; RQ2) (Coded as: <i>Mom; Fetus; Spouse; Close Supporters; Known social network; Strangers</i>)</li> <li>2. <b>Temporality:</b> Does it focus on the entire nine months of pregnancy? (RQ2) (Coded as: Trimesterial focus as applicable.)</li> <li>3. <b>Support Mechanisms:</b> What functional approach to enabling social support? (RQ3) (Coded as: <i>Chat; Forums; Social Media (Facebook; Twitter; Other); Pregnancy Community BirthClubs</i>)</li> </ol>	

### **3.2 Phase 1: Determining Relevance**

During the first phase of the scoping process, we determined relevance by reviewing the metadata for each of the apps in the initial dataset. This initial scoping phase was designed to ensure that the later depth analysis would be done only on apps that were relevant to assessing the state of social support for pregnancy within the app dataset. The initial dataset was split in two, and each research assistant independently coded half of the scraped dataset.

The results from the initial scoping were individually reviewed by the primary investigator and then discussed in team meetings. Each app was evaluated based on a series of cascading inclusion/exclusion questions with binary yes/no responses. If the answer to the question was no, the app was eliminated from further analysis. If the answer to the question was yes, the assessment continued to the next question. If the questioning cascade resulted in yes responses, the app was retained for the Phase 2 assessment. For example, if the intended user (i.e. target audience) was not a pregnant woman and/or her partner (e.g., midwife, medical professional, or community care worker) the app was excluded. In respect to category, an initial search found that certain categories produced search results but that they were not within the scope of this research. For instance, apps categorized under the category Reference were mostly reference guides on how to get pregnant. Therefore, we refined the search to the categories that were most relevant to this research (Education, Health & Fitness, and Lifestyle) and excluded those that were only providing false positives during our initial search (Entertainment, Reference, Productivity, and Utilities). If an app was found to have a duplicate set of entries for both the free and the paid versions, the duplication was noted and only the paid version was retained. Finally, if we tried to access the Appstore webpage for the app and the page was not available, the app was coded as inactive and was excluded. If there was a note from the developer or the AppStore on the app webpage that informed us that the app was not being maintained (i.e. was a 'dud'), the app was coded as inactive and excluded. At the end of Phase 1, 306 apps were excluded due to irrelevance.

### **3.3 Phase 2: Assessing Use Opportunities:**

In Phase 2, our examination looked at each of the remaining app's (n=191) detailed listing page in the web version of the AppStore. Each research assistant independently coded half of this reduced dataset. The results from the use case analysis was reviewed in-depth by the primary investigator and then discussed in team meetings. Each app was coded based on the functionality it supported and the primary intended user. This coding process allowed us to address RQ1 regarding target audience and primary functionalities supported for the 191 apps in our initial dataset for Phase 2. We then applied our lens of collaborative information seeking and social support ecologies to identify any and all apps that included features to that supported these functions. Otherwise, codes were assigned and the app was excluded from the dataset. After Phase 2, we were left with 21 apps.



### 3.4 Phase 3: Collaborative and Social Support Features:

In this phase, our activities moved away from scoping activities based on assessment and reduction and towards an in-depth analysis of the remaining apps in the scoped dataset (n=21). Each app in the scoped dataset was installed onto both an iPad Air, an iPhone 5S, and an iPod Touch. The primary investigator acted as the primary analyst in this phase. Findings derived in the analysis were discussed in the project team until consensus was reached.

To analyze the apps, the PI used a purposive and constant comparative analysis coding approach within each case and cross-case, directed at identifying commonalities, differences, patterns and structures within the dataset [1]. This approach was previously adapted by HCI researchers to assess features within and across different social networking sites to benchmark their privacy controls [2]. We considered the way each app addressed the temporality of pregnancy in its content and functionality, throughout the weeks of pregnancy, and across all trimesters. We looked for indications of which people might be enabled to be supporters of the primary app user. We investigated the way interactivity generally, and information collaboration and social support specifically, was enabled or ignored in each of the final dataset apps. We also considered general questions of interface design choices, such as color, layout, word content tone and slant.

## 4 RESULTS

After removing all of the irrelevant apps from our dataset in Phase 1, thereby reducing our dataset (n=191), our scoping work in Phase 2 (minus the apps retained for Phase 3) allowed us to identify a potential total of 170 apps that were designed for pregnancy support but did not include any social or collaborative features. Here, we briefly summarize the main functionality and key findings related to these non-collaborative pregnancy apps before presenting our full analysis.

As represented in Table 2, we found that the apps served to meet five categories of functionality, some incorporating multi-functions within one app:

- Reference encyclopedias about pregnancy health and fetal development;
- Guides tied to expected delivery data, containing weekly or daily information overviews ('info nuggets', 'Tips & Tricks'); also included food and exercise guides, an fetal development guides;
- Trackers and logs: Birth countdowns; Dietary intake logs; Exercise logs; Contraction and kick counters; Health indicator calculators; Progress trackers (weight gain, baby bump growth, etc.);
- Heads-up dashboard presented in an 'at a glance' progress display, providing a combined information view. Often consisting of weekly countdown, a weekly info nugget, a weight or health indicator stat drawn from trackers, and a reflections feature, usually a reminder to take a 'bumpie' or a belly bump photograph; and
- Journal capabilities, usually text and/or photo journals, often expressly meant to document the bumpie change.

**TABLE 2: ASSESSMENT OF INTERACTIVE CAPACITY**

Type	Components
Reference	Static information
Guides	Static information Leverages user profile data
Trackers & Logs	Shallow customization Leverages user profile data Light interactivity
Dashboards	Shallow integration Leverages user profile data Light interactivity Integrated or consolidated views facilitated by profile and user preference data
Journals	Solo user-input data storage <i>Either:</i> Within app only – no export <i>Or:</i> Exportable as PDF

In terms of interactivity, we found that the majority of data in apps was static, though most modules drew on lightweight profiles to provide shallow customization or integration, mainly pulling on the birth event due date [Table 2]. Features in guides, trackers and dashboards made the most use out of expected due data information. Overall, we found that the main purpose of non-collaborative pregnancy apps was the provision of medical content about fetal development, weekly changes in a woman’s pregnant body, and ways to manage or mitigate risks to maternal and child health during pregnancy. The informative purpose of the apps was slanted towards what we call change education, primarily corporeal changes and fetal development, as well as guiding a woman’s understanding of the impact of her diet, exercise and lifestyle choice on fetal development. A secondary purpose was change tracking, again tied primarily to fetal development and corporeal changes.

Surprisingly, very few apps turned out to have actual collaborative or social support features, which accounts for the reduction in the final dataset to a much smaller number (n=21). Of these 21 apps, 16 were targeted toward pregnant women while 5 were designed for expectant fathers. We present our main results of the assessed apps as emerging themes or weaknesses. While the AppStore does not provide metrics related to usage or number of downloads, it does provide a total number of reviews that can be used as a proxy for usage. On average, the 21 apps had <500 reviews, with some of the most popular apps having <9000 reviews.

#### 4.1 Lack of Support for Fathers

While some apps did make claims about being for both expectant parents, our analysis revealed that the apps frequently focused individualized attention on only expectant mothers, excluding fathers. The exclusion of fathers was either explicit, through offering no actual content relevant to dads, or tacitly discernable, via the interface design choices. The tacit exclusion was visible based on pronoun usage (i.e., “she” and “her” or “your” referring to the pregnant woman), activities tracked (e.g.,

fetal development), and gendered color choices – with pink being the single most prominent color. While a few apps had profile options to specify a role in pregnancy other than that of the mother, the choice changed nothing in the informational content, presentation, or app functionality

The apps that attempted to include fathers were either static eBooks or apps for a singular purpose, such as a listmaker of what to bring to the hospital when contractions start. The few apps that explicitly targeted expectant fathers were surprisingly gender stereotypical about the role of fathers as life partners. As one example, the app *mPregnancy – For Men with Pregnant Women* [61] was listed in the AppStore’s “Health & Fitness” category. In it, the baby’s growth was equated to the size of a cigarette, a can of beer, and a football. The app gave advice to the dad on how to gauge his partner or spouse’s moods, so that he knew when to initiate sex or leave the house to avoid her ‘hormones.’ The app *Mr. Dad on Pregnancy* [62] was promoted positively as being adapted from a popular book on becoming a father [8], but the app itself was just a trivia game tangentially related to pregnancy.

#### **4.2 Limited Transition and Change Support**

The timing of pregnancy includes a transitional process that adds a temporal aspect to app usage. We found that the support within apps was mostly informational support around a medicalized notion of pregnancy as a corporeal series of trimestral changes. This is underscored by frequent references made to discussing various aspects of pregnancy with a woman’s doctor. For example, in the app *iPregnant* [64], women are told in week 4 to “Discuss my exercise routine with my health care provider”, in week 17 to “Check whether my doctor has done the Rhblood test or not” and in week 19 to “Ask my health care provider about safe acne solutions.” In many apps, change information was also provided as a directed activity to entice expectant mothers to purchase a variety of consumer goods and services, often with links to major retailers’ baby registries. The gamut of suggestions in the apps ranged from personal care items (special pillows; body lotions; maternity clothes), home ‘babyproofing’ safety items (cupboard locks; baby gates), personal services (masseuses; nursery decorators; photographers) and additional health care practitioners (doulas; lactation consultants; chiropractors). When apps mentioned support, they frequently were referencing medical support, rather than interpersonal support. Timing-based social support options were lacking. Apps typically did not reflect the life experience of pregnancy beyond the medical framing.

#### **4.3 Superficial Social Support for Collaboration**

While we had expected social support to be the most interactive module, the most interactive modules embedded within these apps were discussion forums or varying manifestations of shared Reflections. In the few apps that did offer moms some limited capacity to share [Table 3], the functionality was comprised of short stock emails from a single screen in the interface. In the apps that purported to include Facebook or Twitter connectivity, our testing found that such connectivity was not functional. Otherwise, most collaborative functionality was unidirectional, where pregnant women could share their experience to social media or a forum of other pregnant women, but rarely did the app facilitate bidirectional levels of support from

known others or loved ones. Instead of being an avenue to facilitate social support, in the final dataset, 8 out of the 16 mom-directed apps acted as a progress guide that was intended to generate awareness for others of her place in the pregnancy. Three apps acted as pregnancy trackers, keeping a pregnant woman alerted temporally to where her pregnancy is and what is coming next, and encouraging her to log changes to her body.

**Table 1: Features that Facilitated Collaboration or Social Support**

<b>Support Feature</b>	<b>App Count and Names</b>
<b>Discussion Forms</b>	<b>5 Apps</b> – BabyBump Pregnancy Pro, Happy Pregnancy Ticker, I’m Expecting, iPregnant Pregnancy Tracker Deluxe, bloom
<b>Social Media Posts</b>	<b>5 Apps</b> – Asian Pregnancy, Essential Pregnancy, iPregnant Pregnancy Tracker Deluxe, Ovia Pregnancy Guide, Pregnancy Companion II; PinkPad
<b>Email Messaging</b>	<b>3 Apps</b> – Asian Pregnancy, Ovia Pregnancy Guide, Pregnancy Companion II
<b>Birthclubs</b>	<b>3 Apps</b> – BabyBump Pregnancy Pro, My Pregnancy Today-BabyCenter, The Bump Pregnancy
<b>Birth Announcements</b>	<b>2 Apps</b> – BabyBump Pregnancy Pro, ExpectingBaby by Enfamill (via SMS)
<b>Baby Gift Registry</b>	<b>1 App</b> – My Pregnancy Today-BabyCenter
<b>No Social Support Feature Found</b>	<b>4 Apps</b> –Mediclinic Baby – Pregnancy, Pregnancy ++, Pregnancy Smiles, The Pregnancy Journal

In the biggest ‘brand name’ apps of the dataset, the idea of sociality tended to appear as features labelled ‘community’. Investigating further, we found that the definition of ‘community’ was broad but shallow. Functionality ranged from the ability to give thumbs up to some content linked on a central pregnancy-related website, across to full discussion forums containing a multitude of threaded discussions. In many cases, the totality of threads appeared stale dated, or contained only a few posts. Also, as part of community, we discovered a few popular apps which provided options for ‘birth clubs’, discussion forum-based features which link expectant strangers together according to their expected delivery date

Another common social feature was social media integration, with Facebook the most common option appearing, though Twitter was described in apps in a few examples. Looking deeper into Facebook integration showed that frequently the Facebook options were used mainly to manage lightweight profiles. Occasionally, apps allowed for posting to Facebook or Twitter via the app, but our use testing found that much of this kind of functionality either did not actually function, and resulted in error messages or app crashes, or it posted a canned message. Canned message content was frequently tied to literal status messages – for example, clicking on the posting button would attempt to post a message to the user’s Facebook wall, containing a progress count for the pregnancy (i.e. “I’m at week 22!”). In another example, Pink Pad [63] integrated a feature that seems to support the makers’ claim that the app is a “social health network”. Testing out the feature, we discovered that it

was a combination of canned Facebook posting that did not function, and pre-defined community feedback polling.

## 5 DISCUSSION

The expected outcome of our scoping process was to document the sociotechnical design space of iOS pregnancy apps, in order to suggest improvements to the space as it relates to digital pregnancy collaboration and social support. The idea of supporting a daily, intimate, lived experience of pregnancy through a mobile app, using a collaborative social support approach includes the spouse or partner and family or close friends. Pregnancy is a shared experience and support for that sharing should be part of pregnancy apps.

Based on our analysis of the audience and purpose for apps shown in Table 3, we find that iOS pregnancy apps generally do not provide this functionality

### 5.1 A Critical Overview of the Pregnancy App Design Space

In our analysis of the iOS app marketplace for pregnancy, we found that apps focused mainly on the result of pregnancy (the birth event) and focused almost exclusively on the physical health of the pregnant woman, defined according to medical guidelines. This supports previous work which suggests that pregnancy care in the United States has become increasingly locked into a medical frame [52–54]. This means that the idea of engaging pregnant women in self-care and psycho-social peer support with their spouse or close domestic supporter was largely absent. The information and support paradigm trended towards a medicalized notion of a solo pregnant individual, mitigating risks leading to a birth event.

We also found that the app landscape for pregnancy is dominated by a design approach that focuses on a birth event planning paradigm, rather than a health and wellness management paradigm. A large majority of apps included calendars, event and activity trackers, educational tips, baby development educational content, baby bump photo management and list managers. Some of the analyzed apps did attempt to include information and options related to ‘in the moment’ activities that are loosely correlated to pregnancy management. These include things like meditation suggestions; tips to managing social outings (i.e. where to sit when at the movies); advice on sexual practices in pregnancy; and other items geared more at the mother’s general well-being than at the health event of the baby birth.

Looking deeper at the information areas within the apps, we found that most were a kind of ‘gloss’ on the larger app purpose of either educating for healthy birth or directing attention to advertisements for baby and pregnancy related products. Supporting findings of a recent Australian survey of pregnancy apps [40], we find that much of the information and functionality in the apps was targeted at risk avoidance or reduction, following a medical model of pregnancy management. Dietary management modules often focused on what foods or medications to avoid. Exercises were often framed not in terms of helping the pregnant woman feel better and stronger, but instead, about how to be sure not to harm the baby. Modules such as kick counters and weight measures were also often framed around making sure the

baby was healthy. As Lupton and Pedersen [40] discuss, this can contribute to a lack of critical engagement with the content of apps. Women tend to not evaluate the quality and validity of the provided information.

We also note that most pregnancy apps in the final dataset focused on baby development imagery (fetus pictures; baby bump measurements) and on countdowns, lists of what to bring or buy for the hospital visit or nursery, and on other tracking and countdown devices such as weight gained or number of contractions. Due to this, we find that understanding and preparing for the childbirth event appeared to be the dominant guiding model or ‘paradigm’ in pregnancy apps.

## 5.2 Providing More Meaningful Social Support for Pregnancy

Literature from non-governmental agencies (‘NGOs’) [42], medical informatics [37], and HCI [38,59] argues that the design space for pregnancy focuses near exclusively on the pregnant woman, with a secondary focus on the interactions between a woman and her doctor. Our findings also align to the findings in other information science and HCI work [2,49] and health work [7,38] around the neglected role of expectant fathers. We found that the vast majority of apps perceived the expectant mother to be the sole target user for pregnancy apps. This was obvious in the user interface design approaches in the apps, with their emphasis on the color pink, sparkling sprite graphics, baby bump imagery, and functionalities like kick counters. None addressed the collaborative aspect of pregnancy management between an expectant couple, and therefore none treated pregnancy as a collaborative life experience within a couple’s relationship. We see this as an opening in the design space for future development work.

Grounded in the theories around social ecologies of support, these findings highlight the potential need for more nuanced methods of collaboration and social support in apps, enabling pregnant women to selectively share key milestones and information about their pregnancy between themselves in the expectant couple, and with a small group of pre-identified family members and close friends. We found that most apps did not allow for any kind of information sharing with close ties, a need that was suggested by both our earlier work and other HCI studies, all of which noted that differences in socioeconomic status meant a differing level of comfort in sharing health and life information with strangers.

## 6 DESIGN CONSIDERATIONS

We recommend a consideration towards supporting the full social experience of pregnancy, beyond the medical and corporeal context. Similar to [23,24], we call for consideration on the ways in which pregnancy is an adjustment towards parenting for both mother and father. We suggest that there exists an opening in the design space to include parenting preparation information into content displayed as early as the second trimester. This also means incorporating more relevant people into the digital support ecology. This provides a recognition that pregnancy involves more than just the pregnant woman and her gestating child.

Additionally, we call for designers to respect the role of close social supporters in managing and supporting a pregnant woman, giving attention to the respectful inclusion of the expectant father, spouse, or life partner. What each pregnant woman might consider to be her social circle will include people of varying degrees of intimacy, drawn from across the variety of people in her life, and the variety of social contexts in which she interacts (e.g.: school, work, church, neighborhood). This extends from her spouse or significant other and offspring, to her parents, grandparents and siblings, out to her friends, in-laws, and kin, and out still further; to co-workers, church friends, and other members of more far-flung relationships globally. Each pregnant woman has informational needs and emotional touch points that can be facilitated an appropriate app at a variety of levels of intensity and frequency. The current design space lacks the ability to respect these intimate connections; an oversight that should be rectified. At minimum, the father should be empowered to be included as a partner in the pregnancy experience, thereby redressing the exclusion of fatherhood noted in both medical literature [7] and HCI literature [2,49]. Managing the synergies and disconnections between information and support offered and given by all supporters of a pregnancy couple can be a difficult task. Additionally, when pregnancy is understood to also be a period of preparation for parenting, this information collaboration skill is cast in a new light; as something critical to the success of being a fully functional adult in a technologically driven society [24,34,55]. Therefore, understanding pregnancy sufficiently to be able to design an appropriate app for the social and emotional support of a woman's pregnancy ecology means also understanding the role of pregnancy as part of a process of social adaptations to the demands of parenthood, as suggested by [21]. Taken as a package of ecological adaptation, we identify three opportunities for the design space of pregnancy as a collaborative and social ecology of support:

***Pregnancy in the larger context:*** The dominant American view of pregnancy as that of a female health event that guides the biological incubation of a fetus towards the birth event narrows the scope of pregnancy to that of a medical concern. The larger scope of pregnancy is thereby in danger of being ignored, silenced, or simply minimized. Designing appropriately for pregnancy suggests designing for the larger context of pregnancy. This means that in addition to providing sound medical advice around gestation and physical symptoms, technological aids should provide support for the social and collaborative aspects of pregnancy, as both an information concern and a social experience.

***Pregnancy as an interdependent set of collaborations:*** When pregnancy is viewed solely as a biological and physiological event, the focus is on the woman and her body. This ignores or threatens the important role of the expectant spouse or life partner in the process. In turn, this might lead to the partner feeling excluded from a life development process that also deeply affects him. This oversight also re-inscribes outdated gender norms of behavior relative to impending parenthood and the role of the man in a child's life. The design challenge here is to better understand how fathers are already incorporated into pregnancy care and process management, and to identify gaps in support and information provision that can be addressed in a mobile technology aid. While Ammari and Schoenebeck [2] do give attention to fathers, their excellent work is focused on the post-pregnancy experience. We argue for more attention towards the pregnancy collaborations between the mother and the father, and

to the larger social ecology that support the parents-in-training. The challenge, then, is how to incorporate the larger scope of pregnancy into an app that supports a wider range of collaborations beyond a strict medical and the female biological context.

***Pregnancy as a temporally-bounded transition process:*** Unlike other transition processes triggered by a health issue or event, pregnancy is confined to a 9-month temporal experience. There is an obvious beginning and conclusion to pregnancy processes. If pregnancy is understood as a process of the development of the fetus, as the emergence of an adult into the parenting role, and as part of the personal development growth of a socio-cultural circle of individuals, the intense temporality of the change process of pregnancy presents a challenge to technological interventions geared at support, information and education. These three challenges of larger context, interdependent collaborations and temporally-bound transition lay bare the need for a nuanced ecological understanding of pregnancy as context, process, and collaboration, within the design approaches to facilitating collaborative information seeking and social support via digital technologies.

## **6.1 Limitations and Future Directions**

A limitation of our work is that we analyzed pregnancy apps that were natively designed for English-speaking audiences. Thus, our results and discussion may not be generalizable to other cultures, who may have different app offerings, social ecologies, and pregnancy app needs. Another limitation is linked to the heteronormativity implied in our framing. We speak frequently of fathers and partners, understood as the biological partner who shared responsibility for creating the pregnancy. While we have not explicitly included het-gendered and cis-gendered individuals, we acknowledge that there are many configurations of partnerships for which social support features in pregnancy apps could be considered beneficial during a pregnancy. How might other relationship configurations be accommodated and supported within pregnancy apps? This question is worthy of further exploration.

## **6.2 Key Research Contributions**

We ascertain through our work that our adapted scoping approach is a viable method to guide scoping evaluations of a large section of software artifacts, where the goal is to potentially adapt and/or design a new application or system. The structured approach to data gathering and gap analysis that we have undertaken makes it clear that there needs to be a shift in the way pregnancy is understood for technological support, particularly within mobile apps. We call for a move beyond the pregnancy as incubation approach found in our dataset, and we suggest that the social support features in future apps take advantage of the actual ways in which individuals use their mobile devices to strengthen their social ties, particularly those within the committed dyad relationship around a child. Finally, reflecting on the scoping review approach, we found it to be an effective way of conducting a thorough investigation into the existing app landscape for pregnancy apps. We appreciated the degree of interpretive reflexivity it required to accurately assess and narrow a large field of apps in a specific domain down to a smaller set that could be analyzed in depth for features, modules, user interface paradigms and user management approaches. Alongside our findings for the need for better development of information, dyadic



collaboration and close ties social support, we submit that our adaptation of the scoping approach represents a novel contribution.

## **7 CONCLUSION**

Many apps treated pregnancy as something to be discussed either solely with the expectant woman's doctor, or with strangers in online groups and websites. None of the apps in the final dataset provided the ability to selectively solicit or information within a domestic couple relationship, or between a pregnant woman and her close peer network. Experience sharing was not facilitated in apps, because sharing was narrowly understood to be content pushing to people through Facebook or Twitter. None of the final dataset's 16 apps actively or respectfully involved the expectant father in the full experience of pregnancy management and support across all three trimesters. The interface design of apps usually tacitly supported these findings. Heavily gendered color choices, interface designs that favored medicalized imagery of baby growth, or pictures of objects like flowers on growing pregnant stomachs were all prevalent design choices. The overall impression of the state of pregnancy apps is that they are for women only, and they are primarily intended to manage or mitigate medical risks during pregnancy and ensure the health of the baby.

Because of this, we believe that opportunities exist to improve the social aspects of the pregnancy experience, alongside the collaborative and shared nature of pregnancy for a woman and her partner. We find that few apps appropriately addressed the social and collaborative components. We also find that there is an opening in the pregnancy design space for an app that addresses the collaborative and shared experience of pregnancy. There is also a gap to be filled in the space around the preparation towards parenthood for the expectant couple. We call for future developers working in this space to consider these aspects. We advocate for addressing the larger social-cultural collaborative potential to support women in their pregnancy journey towards parenthood, and to respectfully support the role of fathers in pregnancy.

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