“Every pregnancy is different”: Designing mHealth interventions for the pregnancy ecology

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ABSTRACT
This paper presents the results of an ongoing study into the potential role of mobile or wireless health applications for targeting the prevention of excessive gestational weight gain in pregnant lower-income American women. Informed by a qualitative study of pregnant women’s experiences, we develop a set of design requirements for designing mobile health (mHealth) interventions related to healthy pregnancies. We identify a disconnection between physical activity and food tracking application design paradigms, and the reality of pregnant women’s lives and capacities. We introduce the concept of an individualized pregnancy ecology, which provides an alternative paradigm for design of health and wellness management tools for lower-income pregnant women.

Author Keywords
mHealth; pregnancy; pregnancy ecology; qualitative research; requirements

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H.5.m.

INTRODUCTION
Obesity is increasingly viewed as a major health issue, triggered by complicated factors from individuals’ environments, habits, social influences, and genetics [10,17,27]. Obesity becomes an extra cause for concern during pregnancy. Many American women gain too much weight during pregnancy [14,19], posing health risks to both mother and child [9]. Additionally, there are strong indications that excessive gestational weight gain (GWG) may have lingering negative effects on a child’s long-term health [35,36,42]. To prevent excessive GWG, early stage health education and health behavior self-monitoring may be effective. However, the majority of women in the United States do not receive formal medical counseling on dietary and exercise needs until after the first trimester [36]. This structural gap in care presents a health risk in which the popular term “eating for two” may be taken literally, resulting in too much weight gain early in the pregnancy [36], and potentially causing increased risks for long-term obesity and other health issues for the child [19]. In this way, eating for two can literally create obesity risks for two individuals.

One approach to address the health and wellness issue of obesity prevention and treatment is the use of mobile phones and targeted applications that encourage healthier eating and exercise habits, through activity trackers and diet diaries. Some studies suggest that this approach is an effective education and intervention method for diet and exercise management [15]. However, pregnancy is a period of life where bodily changes may make it challenging to adhere to traditional activity tracking models, due to disruptions in daily habits and added health stressors. We set out to understand pregnant women’s health needs, in relation to their challenges and supporters, in order to design a targeted health management application which incorporates the realities of the pregnancy experience and which encourages a healthy diet.

In this paper, we present the results of our six month design-oriented qualitative study into practices, self-concepts, and information needs among lower-income pregnant women in Pennsylvania. We examined the feasibility and appropriateness of using mobile phone technology as a method for early-pregnancy health education and behavior self-monitoring. Based on our study data, we present a series of considerations unique to the nine-month period of pregnancy that need to be accounted for in mobile health design. Specifically, we:

1. identify challenges in the use of diet, weight, and activity tracking application design paradigms that are specific to the pregnancy experience;

2. introduce a structuring concept we call the pregnancy ecology, which accounts for the information, physical and emotional self-care, and social support needs of pregnant women. This concept allows for a paradigm
shift away from activity, diet, and weight tracking applications; and finally, we

(3) provide design considerations for mobile health applications geared toward the needs of pregnant women.

By identifying specific challenges between a health community, its constituents, their domestic environments, and technological developments, we provide best practice suggestions for future mHealth development for pregnancy. Our design insight aligns to World Health Organization (WHO) Millennium Goals recommendations [43], while simultaneously taking into account the unique needs of each woman’s pregnancy experience.

To understand our target population, we use a study approach informed by CSCW and information seeking concepts from Crabtree & Rodden [7,8] and Nardi & O’Day [26] Our core contribution is a detailed design-oriented understanding of an American user group in a specific life course period, with targeted health and wellness needs that require targeted and personalized interventions. We accomplish this contribution through the use of our pregnancy ecology concept, which details the specific experiences of women during pregnancy, making visible the challenges, influences and opportunities for health empowerment. We compare the ecology against the gaps participants identify for us of the technology solutions and health and wellness care for pregnant women. We therefore add to the growing literature about technology use by pregnant women and mothers, and the literature around technology for health and wellness.

BACKGROUND
Healthier pregnancies mean less risk of pregnancy-related health complications (e.g.: gestational diabetes, pregnancy-induced hypertension, post-partum obesity) and lower fetal and infant mortality rates [31,35]. Key to a healthier pregnancy is encouraging women to achieve a healthy weight while pregnant, because maternal obesity during pregnancy is associated with long-term health risks for the child [36]. Forty percent of regular weight women and sixty percent of overweight women in the United States gain more weight during pregnancy than is recommended [6]. This indicates a clear need for effective interventions that are able to have a defined impact, but which also fit the lifestyles of pregnant women.

Global literature suggests that obesity prevention during pregnancy may be a critical period of intervention, at a point when women are highly invested in their health and in the future health of their child [19,37]. Obesity prevention is especially important among lower-income women, as they represent a population whose health is often depressed prior to pregnancy, due to unequal access to healthcare [18,19]. Many pregnant women are willing to make significant behavioural health changes due to the potential risk to both mother and child’s health. It is also a period when women’s information seeking needs are high [23,40], particularly among lower-income populations [34,39]. During this period in the life course, women seek out information and apps that are specific for pregnancy, and they seek diet and exercise information that is suitable for the period of life that is pregnancy. Thus, pregnancy presents a crucial and effective “teachable moment” [29] for obesity prevention, specifically, and health and wellness interventions, generally, particularly among lower-income women.

Why focus on mobile health?
Reaching lower-income pregnant women with targeted pregnancy information and support, and encouraging women to adopt healthy behavior can be difficult through traditional print and medical channels [19,36]. Brochures may seem to be too general to fit the specificity of a woman’s individual experience of pregnancy. Print publications are easily lost, misplaced or discarded. Disparities in education and reading capabilities among lower-income women may also mean that general printed health literature about pregnancy is insufficient for their self-education capacities. Additionally, American prenatal medical care is often not initiated by providers until late in the first trimester, which may be due to appointment availability and/or the desire of obstetrical practices to delay the first visit until after the highest risk of spontaneous abortions has passed. Putting this medical gap together with the informational gap, the factors form what we call the structural gap in care for lower-income pregnant women. The structural gap opens up possibilities for a pregnant woman to seek out information and support elsewhere, through potentially unreliable channels.

mHealth approaches may present a solution for healthier pregnancy management. As a key part of the health promotion activities in the “continuum of care” of the modern clinic and community [41:1092], mHealth interventions can be beneficial in helping women track their diets and exercise, obtain accurate and targeted health information, and develop strategies for coping with physical and emotional stressors of pregnancy. While much of the sparse published literature to date around mHealth for gestational and maternal health has focused on developing countries [see Figure 1], the World Health Organization (WHO) acknowledges a critical role to be played by mHealth in promoting healthier life choices and healthier maternal weight for lower income women in developed countries [41].

STUDY DESIGN
We understand gestational weight gain to be one part of a larger health spectrum around pregnancy. Therefore, rather than focusing narrowly on gestational weight gain, we wanted to understand pregnancy as a major life experience, within which weight gain and health are important contributing components. Because of this, we had four goals for this study. First, we wanted to identify informational resources used by low-income American women for learning about pregnancy-related health issues. Second, we set out to disclose barriers that may prevent women from
getting accurate pregnancy-related information, or applying this information within their own lives. Third, we sought to understand the impact of social factors within the specific health environment and life experience of pregnancy in lower-income American women, in order to understand their receptiveness to using mobile applications for prenatal care. Lastly, drawing on our findings, we wanted to contribute a set of mHealth design guidelines for pregnancy management interventions.

Data collection
To address these goals within a health and wellness frame, we used a qualitative iterative data gathering approach consisting of focus groups, followed by semi-structured interviews. We conducted four 90-minute semi-structured focus groups in the spring of 2013. Each group consisted of four to six pregnant women, recruited through targeted advertisements at a federal Women, Infants, and Children (WIC) clinic serving low-income families in Pennsylvania. Participants ranged in age between 20-38 years old. Some were experiencing their first pregnancy, and others had experienced previous pregnancies. During each focus group, participants were asked to share their opinions on what it takes to have a healthy pregnancy. Participants also described how they obtained pregnancy information. They discussed their use of digital devices to interact with others about their pregnancy, and they spoke about the people, organizations, websites and applications that influenced their understandings of pregnancy. Finally, they shared their opinions of how medical guidelines for gestational weight gain [31] applied to them.

After the focus groups, we conducted six additional semi-structured interviews with women recruited from Pennsylvania, who were pregnant or had recently been pregnant (within six months), and who had not participated in a pregnancy research or education initiative. Interview participants ranged in age from 24 to 33. Three used iOS devices, and three used Android devices. Recruitment stopped when we reached thematic saturation. During 60-minute semi-structured interviews, participants were queried on their experiences in pregnancy, and discussed reactions to existing and speculative pregnancy and parenting mobile phone applications.

Data analysis
Both the focus groups and interviews were recorded and transcribed. Data was analyzed using an inductive constant comparative method [22], and transcripts were coded by the first author, using an iterative coding process. Potential codes were created through the first pass of the focus group data, around five core research themes: Exercise; Eating; Energy; Expectations; and Influencers. The five coded sets of data were discussed in project team meetings, and the questions and themes each dataset provided into pregnancy management practice and the potential for mHealth interventions suggested a further set of focused themes: best practice; challenges; information seeking habits; and social sharing habits and feelings. After a second coding pass, the combined results of data coding informed the shape and content of interviews. To analyze interview data, additional open coding was completed, with five new themes emerging: Emotions; Folklore; Concepts/Ideas; Time Management; HCI issues.

PREGNANCY ECOLOGY

Pregnancy as a bounded period in a woman’s life may be understood by pregnant women to be a highly individual experience, that is heavily influenced by a variety of social, cultural, behavioral and economic influences [4,14,19,29]. The WHO recommends that designers of mobile technology interventions for maternal-child health should be attuned to
the socio-demographic, socio-cultural and socio-economic factors that influence female health behaviours [43]. This influenced our analysis.

Our participants cared more about subjective feelings of wellness than about objective initiatives for obesity prevention. It is for this reason that we consider their feelings of pregnancy wellness more generally, though the project was influenced by a desire to influence women’s healthy gestational weight gain.

Our participants made it clear to us that the potential of achieving a healthy weight during pregnancy is influenced by a variety of factors outside of diet and exercise. Therefore, we adopted ecology as a concept for reporting our findings. Used in biology, in health and wellness research, and in HCI, ecology as a concept is a description of a changeable ecosystem. An ecological description makes visible the dependencies of interaction and influence between environment, actors or users, and information [3,8,26]. We use the ecology term to describe our conceptual understanding of pregnancy and health potential, based on a user population of lower-income pregnant women. Drawing on our research, we weave our findings into a concept of a pregnancy ecology. We arrived at the term during data analysis and in team conversations, followed by literature searching. The pregnancy ecology reflects lower-income women’s perceptions of their ability to manage their pregnancy health, of which weight is a large part. The concept provides a structure around which we can understand existing or potential uses of mobile health tools for pregnancy.

**Physical aspects**

We focused on understanding the ecological factors that influence pregnant women’s ideas about diet and exercise management during pregnancy, as well as on how much weight gain was appropriate. We were surprised that most participants did not know how much weight they should gain during pregnancy.

A healthy weight gain? 30 pounds? I think…hmm…I have no clue. (FG3)

Some participants did have knowledge of weight gain guidelines, but appeared to be unconcerned by the recommendations, suggesting their own pregnancy was different because of a variety of factors.

I always thought it wasn’t about how much weight you gained as long as the baby’s weight was gaining. (FG3)

For me, I’m hoping I don’t gain that much, but if I do, I do. (FG3)

Participants were largely unaware that it is normal to lose weight in the first trimester, and that the weight gain guidelines are based on a total weight gain by the end of the pregnancy [31].

I think it depends on your starting weight to begin with… I had lost 10 pounds in the 1st trimester, they said you’re underweight… but now I went in for my last checkup and he had a growth spurt, but there are other things factoring in like I had lost weight… so he went, ‘I’m a little concerned’, and I said, ‘You told me I needed to gain 40 pounds?!’ (FG2)

Participants also did not always show an awareness of the fact that weight gain guidelines depend on where a woman’s weight falls on the Body Mass Index (BMI) weight guidelines categories (underweight; normal; overweight; obese) [36].

Related to exercise, there were misconceptions around what constitutes appropriate activity levels for health improvements. Many of our participants conflated everyday life activities, such as standing on their feet for their job or tending to their toddler’s daily needs, as equivalent to the recommended daily sustained activity guidelines for weight management.

I get exercise every day. I work in a kitchen. I feed 400 kids in an elementary school. (FG2)

My exercise was at work and now it’s chasing my daughter and my dog around. ‘No don’t do that! No put that down’…yeah… (FG3)

There were also stories of food cravings and aversions. Alongside and within those stories were tales of pregnancy dietary restrictions, stress and energy levels, and the impact of other family members on a woman’s ability to eat for a healthy pregnancy.

America is like fast food capital … (so I ate) fast food, because I couldn’t cook at home, I couldn’t stand the smell.. I couldn’t go out to a restaurant. You go to fast food, you go the drive-thru, you don’t have the smells except for exactly what you want… so it’s either that or cold cereal. (FG1)

I don’t know if mine is really cravings. It’s more a matter of….what can I keep down? It’s like, and it’s random…like the other day, the first thing that pops in my head that I think I can eat… I grab it. It was sardines and mac and cheese. So gross. But it was like…SO GOOD!? Cause it was like…it was the only full plate that I could eat that day…so it was just, like, it’s been random, like one minute, it could be CHOCOLATE, and I had to go out and buy, like, four chocolate bars, and like, just have this chocolate fix…and like other days it could be soup? Or salad? I’m just all over the place right now with food. (FG1)

Overall, two themes emerged from discussions of dietary choices and activity participation in pregnancy. The first was a feeling of lacking control over the body, and the dominance of the embodied experience of pregnancy over medical guidelines and dictates. According to our participants, the pregnant body is something to which they listen and submit, rather than something they actively manage. Symptom management in particular was singled out as a dominant reason for ignoring dietary best practices. Participants spoke of listening to their body’s dictates, by succumbing to food cravings, avoiding other foods that triggered heartburn, nausea and vomiting, and generally managing what they did eat around what their body would apparently tolerate. Pregnant women’s bodies control them,
and the ‘best’ way through a pregnancy is to listen and succumb to whatever the body requires of the woman. Thus, immediate needs of the body—for instance, eating only hash browns to avoid nausea—overtook longer-term needs, such as eating a balanced diet.

It all depends on the cravings… on the body type. The first one I couldn’t eat anything healthy, I had to eat junk food or soda just to keep the normal food down. (FG2)

For me, I think it’s really hard not to eat, I get cravings. I think my body needs a type of vitamin or something (FG3)

The second theme was the widely-held belief that every pregnancy is unique, and therefore pregnancy guidelines, and particularly weight and exercise guidelines, do not necessarily apply. In each focus group and interview, the participants spoke about the uniqueness of each pregnancy:

Like…each pregnancy is different. It’s so funny, like, I would have something, like some healthy cravings? And I would eat healthy and everything would be fine. As soon as I crave junk, the junk will come right out. (FG4)

Women told a number of stories that presented justifications for their understandings either of appropriate weight gain, or of how their own weight gain was acceptable because of extenuating circumstances.

Besides, I heard from a lot of people that if you plan on breastfeeding, you lose a lot of the weight afterwards… (FG3)

I asked my doctor, ‘doesn’t height have a lot to do with it’? She said, ‘yeah, but you’re just way over’. I’m 5’8” so I’m thinking that might be why…(FG3)

The appearance of extenuating circumstances was often due to a misunderstanding of the correct progression of weight gain over an entire pregnancy period.

It’s hard because a girl I work with has only gained 10 pounds with every pregnancy, and all her kids are healthy… but some people gain 90 pounds… My friend’s sister gained 90 pounds but it was all fluid… she went into the hospital and she lost 40 pounds, all in fluid. (FG2)

**Emotional aspects**

An additional theme that exacerbated participants’ ability to participate in health-promoting dietary and physical activity behaviors was self-care of mind and body. Stories of fatigue, stories of stress, and of the constant changing needs of the woman’s body presented challenges.

You set a goal, like, ‘I’m going to work out for half an hour’… and then you go and you work out for five minutes and you’re just done. Tired. Very tired. (FG2)

Our participants reported experiencing variable energy levels, yet few of the women we talked with showed an awareness of the potential to improve energy levels or stress management through appropriate diet or exercise:

I go to the gym but it’s not the same. I feel more fatigued now. I see myself quitting, pretty quick. (FG2)

Along with fatigue and stress came emotional upheaval, both as a result of the woman’s changing status in the home, and also attributed frequently to ‘hormones’.

I often feel bad for my husband cause he doesn’t know what he’s coming into when he comes home from work, you know? Like, I could be happy, I could be off the wall, I could be psycho… he doesn’t know… he doesn’t know what you’ve dealt with all day. (FG4)

The energy, stress and emotional affordances within each woman’s unique experience of pregnancy were also cited as the reason for their indifference to the demands of many apps, whether for self-monitoring health behaviors or tracking other aspects of pregnancy. The requirement to digitally write down everything a woman eats and every exercise activity they do may seem simple, but in the daily juggling act of the pregnant woman, the suggestion that they should actively track and record their activities was met with incredulity, laughter and sometimes derision. It was likened to the activity of trying to maintain a baby book of the baby’s first days.

I do like to keep a baby book of their first year. I try to do at least that, so they know when they got their first tooth and they know when they took their first steps, that’s important. But the time needed?! It would be nice if I could find an app for that. Because finding time to pull the book out and write it in? No, it’s hard. (FG4)

**Information aspects**

As mentioned in the background section, there is often a prolonged period between when women find out they are expecting and when they first visit a medical professional, regardless of their socioeconomic status. In our study, women reported having to wait between 8-13 weeks before having their first appointment. Participants also stated that the lack of early care from medical providers meant that in lieu of answering specific questions, they received printed medical material, a largely non-preferred format:

Today they gave me a whole bag of pamphlets and flyers and… didn’t explain or go over them with me… and now I have to go home and try to go through them, while I have a kid running around… and when you’re a new mom that’s overwhelming. (FG1)

Overall, our participants wanted information immediately upon either suspecting they were pregnant, or confirming pregnancy status. According to our participants, the information they sought online during their first trimester usually started with searching for the indicators that they might be pregnant. Based on their search results, all of the participants reported purchasing and using one or multiple home pregnancy tests. As their pregnancy progressed, information searches in the first trimester related mainly to managing dietary concerns around what was acceptable to eat, and how to eat around food aversions. In many cases, Google came to replace clinician advice:

With new moms, they’ll have all types of questions… they’re getting sick… feeling miserable. So they can get helpful tips. Instead of getting all the info late… so women are going on
Google to get their own answers because their doctors won’t see them. (FG1)

I found myself using Dr. Google, because I couldn’t get an appointment until I was at 14 weeks. They just wouldn’t see me. (IP1)

In the second trimester, participants reported that they most often searched for unusual symptoms related to pregnancy, so as to investigate whether something was normal, or a reason to call the doctor. For first time mothers in particular, the bodily and emotional changes brought on by pregnancy triggered many questions. It is not surprising, then, that pregnant women resort to seeking informational support from non-clinical information sources, such as family members, friends, and Internet resources such as search engines and certain pregnancy-oriented websites (e.g. BabyCenter.com, mommy blogs).

I did a lot of Google searches and, um, Pinterest?...just looking at different things. Like, my … my doctor didn’t tell me about round ligament pain, until … gosh! Maybe four weeks ago... but I was having it from, like, 13 weeks on…so I was having this severe cramping, and like, there is something wrong!? What’s going on? I am freaking out...so between, you know, Google research, and my sister who just recently had a baby as well, and talking with her…then obviously talking to my doctor eventually…(FG1)

In the final trimester, searches were often related to the birth event (such as premature birth and epidurals), nursery preparation, and newborn and infant parenting questions. Although the searches were seen as helpful, women noted that the act of searching for information online in could yield more questions, confusion, and anxiety than answers.

Two weeks ago, I was having pain around my belly button then I started to spot. Well I Googled it... it asked if I was showing signs of ectopic pregnancy, and all that, so that’s where sometimes Googling is not a good thing. (FG2)

Consequently, instead of referring to the potentially scary online sources or the perceived impersonal clinic-provided information, women at times turned to their social circles for information and support. All of our participants mentioned a range of folklore knowledge as a core influence on their ideas of pregnancy management and health. This folklore knowledge was diffused through the strong influencing role of family members, friends and the vague but powerful “they say” as information providers and emotional supporters, but also as challengers against dominant ‘and medical discourses.

If I have a question, I will just call my mom and dad and say ‘this is what’s going on’…they can tell me what to do….other than that, I’m not…Like, nobody tell me…I do it!’… (FG1)

Social support aspects
To cope with the many changes that come with pregnancy, participants singled out specific people in their life as being a pregnancy savior or “sanity check”, such as a domestic partner or husband. A “good husband” was mentioned in most focus groups as one of the most important people in their lives when it came to being able to ‘make it’ through pregnancy:

Cause my husband, like, for example, he comes off work and...he goes off to do something with the kids and leaves me by myself. That helps me because if he didn’t do that, I will be sitting in the kitchen, eating … binging and just being so mad! I dunno, he just gives me time alone. That really helps me to just control myself. Emotionally. (FG4)

Key to that support appeared to be a spouse’s ability to ‘read’ the pregnant woman’s mood, ascertain their need and solve it, whether it be for foot rubs, food cravings, or in the case of the following example, purchasing a new pancake griddle:

I was trying to make pancakes, using a new recipe. And they weren’t turning out right. My pan was burning them…. And so I was getting mad and … the kids are getting yelled at, and all of a sudden my husband disappears…and then I ask…’Where is your dad?’… ‘He went out in the car’… ‘ohhh well lie’s really going to get it!’…But he comes in, with a brand new griddle! He went out and bought me a griddle! And I just started bawling! I plugged in the griddle and the pancakes are saved... like, he saw what the real issue was, was all my pancakes were burning, so he went out and took care of it... you just get in a really bad mood about stuff and that totally defused it. So that’s the best thing he could have done, when he bought me a griddle. (FG4)

Despite the importance of the spouse or domestic partner in pregnancy management, participants noted that most commercial pregnancy apps available for their smartphones or tablets were clearly geared at the pregnant woman only, containing pink color schemes, stereotypically feminine imagery, and advice and alerts about “my pregnancy.” However, women did at times collaboratively look at website or app content with their family. For instance, participants reported sharing app-provided photos and descriptions of fetal development with adult and child family members, as well as watching online videos about pregnancy with spouses or children:

I had little guys … that wanted to know what the fetus was looking and what things it could do. So I like that Baby Center thing too, and I REALLY like the little videos? When I would show the kids all the little video clips of the baby developing. Those are REALLY good videos. And I would show ‘em, cause they send you the picture every week of what your fetus looks like. (FG4)

Given the popularity of social networking tools, a surprising finding was that our participants were largely uninterested in sharing their pregnancy experiences online, or finding social support from people outside of their close social circles. They were careful not to ‘overshare’ on social networks, only providing basic information about their pregnancies, if anything. None of the women were interested in using online forums to connect to other pregnant women, or in joining an online pregnancy club. Such clubs typically group women with similar weekly progressions together in a chatroom or discussion forum, and all of our participants
said that they ignored those sorts of online venues for sharing and support.

DISCUSSION

Excessive gestational weight gain presents both short- and long-term risks to mother and child. Addressing this issue in clinical settings remains challenging, due to entrenched constraints in the American healthcare system. Given the widespread availability and usage of mobile phones, this study explored whether and how mobile phones could play a role in helping lower-income women have healthier pregnancies, in order to achieve an appropriate gestational weight gain.

Addressing ecological gaps

There are a number of websites and mobile applications that focus on information needs of pregnant women. Similarly, there are many web and mobile tools for diet, activity, and weight tracking available at low or no cost. However, these tools may not be appropriate for addressing the problem of excessive gestational weight gain. Using our concept of the pregnancy ecology, we reveal gaps in the existing landscape of tools for assisting with weight management concerns during pregnancy. In North America, existing pregnancy apps appear to frequently be tied to for-profit publishing websites (e.g.: Babycenter app tied to BabyCenter.com), rather than medical or healthcare sites. These resources predominantly focus on basic information about pregnancy.

Preliminary review of available pregnancy management apps for iOS, Android and Kindle Fire, coupled with our focus group and interview discussions with participants indicate that the information commonly seen in pregnancy-oriented apps includes: facts or photos about fetal development; a countdown to the delivery date; checklists for what to bring to a doctor appointment or to the hospital during delivery; or general guidelines on risks of certain food and behaviors in pregnancy. Participants could not find (nor could we independently find) any mobile applications providing specific and sustained guidance on weight management during pregnancy. Research-based and NGO-supported maternal mHealth efforts have focused almost exclusively on developing countries, often relying heavily on SMS messages pushed to women [28]. Yet there is a lot of interest in expanded mHealth for pregnancy support in North America, particular among lower-income women in inner city or rural environments.

When looking more broadly at the existing space of mobile applications for activity, diet, and weight tracking, they too have blind spots when it comes to the needs of pregnant women. Based on all of these factors described above, we suggest that there is a need for an alternate design paradigm for mHealth pregnancy interventions.

Contribution

We understand pregnancy to be a hybrid ecology, akin to Crabtree & Rodden’s use of the term [8]. We see pregnancy to be a life phase that is influenced by a woman’s lifestyle, health, medical access, and mobile and connected technologies. When measured against participants’ feelings of self-management health efficacy, the gaps in formal care are visible and troubling. Through participants’ reports, we have shaped our understanding of the pregnancy ecology of a group of lower-income American women. This forms our first contribution. The gaps we have described provide openings for technology-based interventions and education via mobile devices. The following section provides our second contribution: a set of design requirements derived from our pregnancy ecology understandings. Both the pregnancy ecologies of specific user sections and the design considerations we present are what we avow should be accounted for in pregnancy mHealth design.

Design Requirements for Pregnancy Applications

Based on our study, we propose the following design requirements for pregnancy-related mobile applications. They are as follows:

1. design for first-trimester self-guided information seeking (& first time moms);
2. use immediate concerns (e.g. nausea prevention) as a “hook” to address long term concerns;
3. incorporate some, but not all of the social circle; and
4. provide tailoring for a woman’s perceived uniqueness of her pregnancy experience.

First-trimester self-guided information seeking

As our data shows, there is both a support gap and an information gap in women’s pregnancy ecologies that needs to be filled. The gap exists between information need and provision, and between individualized support and medical practice. Pregnancy mHealth interventions should include support about first trimester body changes and symptoms, common misconceptions about pregnancy health, and dietary and exercise needs. Intervention, social support and information should be grounded in the variability of pregnancy experiences which contribute to the feelings of pregnancy individuality we heard from our participants.

In particular, we find that addressing the differences between medically correct information and “folk wisdom” is one area in which mHealth interventions could have a notable impact early in a woman’s pregnancy. As women reach out to their social circles to get information about pregnancy—or they receive unsolicited information—there is the risk of inaccurate information, particularly surrounding healthy weight gain, appropriate amounts of physical activity, and how one should eat during pregnancy. For instance, one popular piece of folk wisdom is the idea that pregnant woman should be ‘eating for two’, which implies the need to eat significantly more food than they did pre-pregnancy. This discourse persists despite the fact that recommendations for eating during pregnancy involve adding only an additional 300 calories per day during the last 6 months of pregnancy.

In what appears to be a clear mHealth intervention possibility, we advocate for the creation of plain, jargon-less advice for pregnancy management. This intervention should
acknowledge circulating discourses about pregnancy that are misguided or outright wrong, and offer evidence-based pregnancy management recommendations.

**Use immediate needs as a hook for long-term concerns**

Food cravings and aversions, energy management and other immediate needs could be used as “hooks” to draw women into addressing longer-term health needs. We discovered that food cravings or aversions are variable between women and within each pregnancy. Some women have no food challenges; other women have food concerns at different points in their pregnancy; while still others experience food issues throughout. One option could be a food preference feature, in which users rank aversions or cravings, in order to receive tailored dietary advice.

We also suggest keeping interfaces as lightweight as possible. For instance, our participants enjoyed taking and sharing pictures, but did not like having to fill out a lot of forms, flip through quizzes, or actively remember when it was time to input information into a tracking app. Rather than designing systems with lengthy, complicated interaction, overwhelming amounts of text, or extensive nested menus, we recommend the use of simple designs. These could be a small number of personalized tips/tricks for a given woman’s weekly pregnancy stage and concerns, text messages with reminders or activity prompts, and photographic journals, rather than textual journaling. Similarly, we advocate for lightweight data input techniques, such as yes/no questions, checkboxes, or taking photos rather than entering large amounts of text.

**Tailor to the uniqueness of each woman’s pregnancy**

Additionally, we urge attention to perceptions of uniqueness across pregnancy experiences. An app’s health recommendations need to avoid appearing too generic or impersonal so as to cater to the pregnant woman’s sense that her specific pregnancy experience is different from anyone else’s. When discussing potential designs for pregnancy activity tracking apps, one participant remarked:

> As long as it goes by your individual person… not a hundred other people of one group… (FG2)

This idea that every pregnancy is different is one we heard repeatedly. While this may not differ greatly from obesity interventions generally, the fact that our participants were pregnant adds a crucial difference: the aspect of concern by the mother about her own and her child’s morbidity and mortality. The need to think beyond one’s self and manage health for two is what we see as a positive health behavior effect of pregnancy, presenting an opportunity to use pregnancy as a teachable moment to inform health management generally, throughout the life course, in and beyond the pregnancy period.

From a design perspective, this suggests that pregnancy mHealth has to maintain a balance between providing individualized advice, support and information for subjective feelings of pregnancy wellness, while still attempting to encourage behaviors that are consonant with evidence-based medical guidelines for healthy weight gain and exercise throughout the life course.

Paying attention to others in a pregnant woman’s home life, as they place demands on her time or ease her path through pregnancy, suggests an important profiling step, upon setting up a mHealth app for the first time. Knowing who provides help or who challenges the pregnant woman, and applying these understandings to design, can provide a personalized app experience. Examples of personalization features may include: how to talk to an existing child about pregnancy challenges; overviews of fetal development in a specific week; or how to work around food cravings and aversions while also playing head cook for the family home. While existing apps and sites such as Babycenter were used by our participants, they noted that the sites focus on the baby’s development, and on future parenting, as opposed to the overall health of mother.

**Include some (but not all) of the social circle**

Each woman’s social circle includes people of varying degrees of intimacy, from her significant other and offspring, to her parents, grandparents and siblings, out to her friends and in-laws and further, to co-workers and other members of more far-flung relationships globally. Each woman has informational needs and emotional touch points that require support at a variety of levels of intensity and frequency. Yet, based on our participant reports, drawing on visual presentation and informational design, most pregnancy-related apps are geared only at the pregnant woman. Our participants spoke of being frustrated by the lack of support available to their spouses through the apps, and the sense of alienation felt by their partners as a result of the gendered design of apps, which was incongruous with the fact that many spouses were considered to be important influencers and supporters in women’s lives.

While there is the need for social inclusion and cohesion in app designs that understand and incorporate the individual pregnancy ecology, designers should not assume that social networking systems and tools can adequately address this crucial aspect of pregnancy. Our participants’ disinterest in and distrust of pregnancy discussion forums, social media venues, and chat rooms conflicts with prior HCI work [e.g.: 9]. This raises a question for future research: who goes to health forums willingly, who does not, and what accounts for these differences? Also, within the HCI and social media literature [1,12,25,32], there appears to be a widely held assumption that women are social sharers, who will want to share pregnancy and early parenting information widely over a diverse set of social networks. Yet, based on our work, this does not appear to be a popular practice. Most women in our study reported that, within the context of their pregnancy, they used Facebook very intermittently to share general pregnancy updates (sonograms and baby bump photos being most cited), but they did not have the time, energy or inclination to go beyond these limited sharing practices. We suggest that further research is needed to
determine the impact of social media and forums on pregnancy ecologies, as well as the impacts of socioeconomic position on social media sharing habits.

CONCLUSION
Existing mHealth research appears to mainly address the pregnancy needs of women in developing countries despite the World Health Organization’s recommendations to address reproductive health issues at a global level. As our work demonstrates, there is still a need to address pregnancy-related health needs in North America, particularly among lower-income women. We argue that designing appropriate mHealth apps for this gap requires research into the target population’s pregnancy ecology.

We set out to understand the ecology of pregnancy, through a sample of lower-income American women. We wanted to identify the ways in which participants’ pregnancy ecologies might impact technological design recommendations for mHealth. We wanted to understand who influences women’s ideas about what pregnancy is, how pregnancy should be managed and what should be done to improve women’s experiences of pregnancy.

We were guided by mHealth global best practice recommendations from the World Health Organization [43], and through design and health literature [e.g.: 1,5,7,10,13]. But it was through researching a variety of lower-income women’s particular pregnancy ecologies that we discovered that each woman believed her own pregnancy to be unique; a finding that has ramifications for mHealth interventions. A key design challenge appears to be deciding how to personalize pregnancy information within an app, and how to make it appear to be targeted at the pregnant woman, while still encouraging adherence to the health guidelines for weight and exercise. Additionally, the pregnancy ecology approach showcases the need for mHealth to go beyond only addressing the mother, by acknowledging that there are other important people in a pregnant woman’s life who can act as positive influences on her health and well-being during pregnancy.

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