

Unpacking the Lived Experience of Collaborative Pregnancy Tracking

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ABSTRACT

Pregnancy brings physical, emotional, and economic challenges for expectant parent(s), close relatives, and friends. Existing technology support, including tracking technology, largely targets pregnant people and ignores other stakeholders. We therefore lack an understanding of how to approach designing collaborative pregnancy tracking technology. To understand how people collaborate around pregnancy tracking and wish to do so, we interviewed 13 pregnant people and 11 non-pregnant stakeholders in the U.S., including partners, friends, and grandparents-to-be. We find that people collaborate for goals like social bonding and jointly managing various pregnancy data. Stakeholders collaborated by either dividing up data types or collectively monitoring the same information. We also identify tensions and challenges, such as pregnant people's privacy concerns and stakeholders' varied levels of interest in tracking. In light of socio-cultural norms and stakeholders' distinctive roles around pregnancy, we point to opportunities for designing collaborative technology that aligns with as well as challenges socio-cultural practices around pregnancy tracking.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; Empirical studies in HCI.

KEYWORDS

Pregnancy tracking; Personal informatics; Self-tracking; Social tracking; Women's health

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1 INTRODUCTION

Pregnancy marks a major life change for many people, and often brings physical, emotional, and economic challenges to anyone who is involved in a pregnancy journey [8, 50, 85]. Prior work suggests that pregnancy requires collaborative effort between pregnant people and non-pregnant stakeholders (e.g., partners, family members, and close friends) to obtain a healthy outcome (e.g., the absence of pregnancy-relevant complications and the death of the fetus or the pregnant people) [51, 110] and prepare for a harmonious family dynamic [16, 91, 111]. When facing pregnancy's complexity and difficulty, many pregnant people often rely on pregnancy tracking technology to help them monitor various important aspects of pregnancy (e.g., maternal health, fetal growth, lifestyle factors, and doctor appointments), seek crucial information, and socialize with like-minded people [20, 47]. Since pregnant people frequently rely on non-pregnant stakeholders to achieve a satisfying pregnancy outcome [91, 111], pregnancy technology would benefit from considering non-pregnant stakeholders' roles and needs and supporting interaction among different parties involved.

However, research has surfaced that pregnancy tracking technology primarily targets pregnant people and ignores non-pregnant stakeholders' involvement, following the medical paradigm where pregnancy-related technology and services usually center around pregnant people and/or the fetus(es) [50, 87]. A plethora of works have focused on understanding pregnant people's experiences with and needs for technology, and treated non-pregnant stakeholders as passive bystanders whose main role is to be informed by pregnant people about how the pregnancy is progressing [8, 13, 57]. While a few works have started to emphasize the need to consider non-pregnant stakeholders' involvement [70, 85–87], less is known about how to approach designing pregnancy tracking technology to support multiple stakeholders in collaboration.

This study therefore aims to unpack the lived experience of how people try to collaboratively track pregnancies, with the intent of informing how technology could be better designed to support collaborative pregnancy tracking practices. In this paper, we define *pregnancy tracking* as people's monitoring behaviors encompassing any data or aspects relevant to pregnancy, such as pregnant people's weight, blood pressure, symptoms, food, physical activity, mood, fetal growth data, and doctor appointments. Our definition is grounded in the wide range of data encountered by participants in their pregnancy journey, aligning with functionalities supported by

existing pregnancy tracking apps [19, 92, 93, 106]. Doing so offers insights into how technology could support various stakeholders' needs and mitigate their concerns and tensions among their needs. We answer the research questions:

- RQ1: Why do pregnant people and non-pregnant stakeholders (e.g., partners, family members, friends, colleagues) collaborate for tracking and managing pregnancy in everyday situations?
- RQ2: How do pregnant people and non-pregnant stakeholders collaborate for tracking and managing pregnancy in everyday situations?
- RQ3: What challenges and tensions do pregnant people and non-pregnant stakeholders face in the collaborative pregnancy tracking process?

To answer these questions, we conducted semi-structured interviews with 24 U.S.-based participants in total, 13 pregnant people and 11 non-pregnant stakeholders respectively. Pregnant people and non-pregnant stakeholders collaborate to bond with each other, provide and seek social support, jointly manage pregnancy data, and promote a healthy pregnancy together. We identify various tracking approaches in a pregnancy journey: self-tracking, social sharing, and collaborative tracking. While self-tracking and social sharing of pregnancy-relevant data largely resemble existing tracking practices [23, 36, 66], we find that stakeholders shared and varied in the responsibility of collecting, integrating, and making sense of data. This approach largely differs from depictions of collaborative tracking described in prior work, which either highlight people's equal participation in tracking or rely on one person to collect or make sense of data [72, 79, 117]. We further surface that stakeholders often face tensions and challenges in collaborative tracking including privacy concerns, managing stakeholders' opinions and feelings, and stakeholders' varied interests in tracking. Considering these tensions and challenges and their associated socio-cultural practices, we suggest opportunities for collaborative tracking technology to both align with and challenge these practices. Aligning collaborative pregnancy technology with societal norms suggests providing configurability around what data to track, how to track, and how often to track as well as helping different stakeholders negotiate around their preferences. To challenge societal norms, designs could encourage or mandate the involvement of non-pregnant stakeholders, such as making the inequity in pregnancy management visible in what and how people track.

We contribute:

- An empirical understanding of the lived experiences of how pregnant people and non-pregnant stakeholders collaborate for tracking and managing pregnancy. We find people collaborate in two ways: dividing tracking responsibilities along different types of data, and jointly tracking the same type of data. Stakeholders divided tracking responsibilities based on their respective tracking capabilities and interests. When facing data that was difficult to collect, remember, or interpret, they jointly track by splitting tasks around that data.
- An empirical understanding of the tensions and challenges that people face when collaboratively tracking pregnancy. For example, pregnant participants often have to manage the opinions that others might have about pregnancy data, and sometimes lack

trust in other stakeholders to track effectively. Both pregnant and non-pregnant stakeholders occasionally desire moments to disengage from pregnancy and tracking to get some distance from the process, but this can place burdens on the other stakeholders.

- Recommendations for designing collaborative tracking technology which recognizes that people collaborate by dividing labor. We discuss socio-cultural factors which shape people's perceptions and experiences in collaborative pregnancy tracking, as well as challenges balancing bodily autonomy with the benefit of involvement of others. We suggest values in providing flexibility and visibility in collaborative tracking, aiming to address concerns around protecting pregnant people's bodily autonomy and encouraging non-pregnant stakeholders' involvement.

2 RELATED WORK

2.1 Cultural Context Surrounding Pregnancy in the United States

While the United States, where this study was conducted, is one of the most developed countries globally and spends over \$60 million on maternal health care each year [113], its maternal mortality rate (MMR) has been on the rise, with the highest MMR among the developed countries [105, 113]. Several reasons may contribute to this concerning trend. The U.S. is the only developed country without a national-level guaranteed paid parental leave [52, 104]. In comparison, other developed countries such as Canada and the UK typically provide around 16 to 18 weeks of government-paid maternity or parental leave [52]. Additionally, the fragmented healthcare system in the U.S. results in people having radically different experiences surrounding formal pregnancy support. For instance, pregnant people covered by Medicaid, a public health insurance plan for people with limited income and resources, often experience more incomplete postpartum care (e.g., no support for a postpartum medical visit and less practical support at home) compared with those with private medical insurance [27]. There are pronounced racial and ethnic disparities in receiving maternal healthcare in the U.S. The MMR of black women is 2 and 3 times higher than their white counterparts [10, 27, 101]. While studies suggest that paternal involvement is positively associated with positive pregnancy outcomes, socio-cultural norms and fragmented policies in the U.S. can discourage fathers-to-be from actively participating in pregnancy since pregnant people are perceived to be the sole focal point during pregnancy [3].

In some non-Western settings, researchers point to greater levels of stigma surrounding non-pregnant male stakeholders' involvement with pregnancy than in the U.S., inhibiting pregnant people from getting the desired support. For example, in some African regions, male partners who offer care for their pregnant partners are often stigmatized as "*weak men*", and pregnant people are proud of giving birth without support from their spouses [1, 68]. In some Asian countries, such as India, pregnant people may overwhelmingly rely on their mothers for informational and emotional support rather than spouses [12, 95]. While we focus on the lived experiences of collaborative pregnancy tracking in the U.S. context, we expect many of the tensions we unpack carry over and are perhaps exacerbated by other cultural norms.

2.2 Women's Health in HCI

In recent years, HCI has repeatedly argued for the importance of studying and designing technology to support and empower women's physical, mental, and reproductive health [6, 61], since their health & wellness needs have been historically overlooked due to systemic discrimination around women's access to health and education [5, 37]. Mirroring academia's interest in supporting women's health, the FemTech (female-oriented technologies [7]) industry is similarly experiencing remarkable growth, and is predicted to be a \$50 billion industry by 2025 [37, 53, 116]. Numerous studies and technologies have begun to explore and support various aspects of women's health, such as pregnancy [50, 85], new motherhood [31, 91], menstruation [35, 107], menopause [63], fertility [43], and intimate care [114]. Existing works have highlighted multiple benefits of technology in supporting women's health, such as helping make sense of data, raising health awareness, and signaling potential risks [35, 44].

Despite technology's advantages, research has also surfaced various tensions, drawbacks, and potential risks associated with technology for women's health. For example, prior works have highlighted a need for collaboration as many aspects of women's health need social support, such as fertility and pregnancy, while existing technology is primarily designed to support solo experiences [42, 87, 114, 115]. A core challenge in designing social or collaborative experiences to support women's health pertains to privacy, as women's health data is often viewed as highly sensitive that could disclose intimate and detailed information about their everyday lives [76]. However, current studies that examine privacy concerns related to technology for women's health mainly focus on app practices around sharing data with third parties without users' consent or the potential to share data with governments or other authorities for legal needs [11, 30, 75]. Less is known about people's concerns when supporting women's health in their in-person or social settings such as disclosure concerns among friends, families, or other peers. Some prior work suggests that most users do not have privacy concerns or knowledge about how their data related to women's health is being collected and used by technology [18, 37, 98]. However, political issues around women's bodily autonomy, such as the overturning of Roe versus Wade, have led to greater concern around how women's sensitive health data could be abused [30, 75]. Besides concerns around privacy and bodily autonomy, research also surfaces that women's health is often stigmatized and regarded as taboo, resulting in women being judged or feeling ashamed when talking about their health issues or using relevant technology in public [4, 25, 115, 116].

Prior works' examining people's experiences with technology for women's health as well as its benefits and drawbacks are mainly situated in a broad societal context, such as workplaces, politics, and culture [30, 63, 103, 114, 116]. This work expands on this understanding by exploring concerns and tensions when pregnant people collaborate with their close social networks around tracking and managing pregnancy.

2.3 Pregnancy-Support Technology in HCI

The HCI and CSCW community have delved into multiple facets of how technology can support pregnancy. For example, fertility

apps aim to help people get pregnant by predicting ovulation and providing insights about people's fertility status [42, 43]. Social media and online communities provide a way for pregnant people to receive social support, such as getting emotional support to help cope with negative outcomes like pregnancy complications and loss, and learning from others' experiences [9, 50, 94]. Online search engines help pregnant people find useful information about how to manage pregnancy [46, 62].

Pregnancy tracking technology aims to support pregnant people in achieving healthy pregnancy outcomes by enabling them to monitor data on their health and wellbeing (e.g., maternal health, mood, diet, and physical activity) and identify patterns and gain insights [29, 41, 84]. Some also provide detailed information about fetal development, such as fetal size or changes in fetal capability (e.g., new senses like hearing, behaviors like kicking) [47]. Existing technology support rarely considers non-pregnant stakeholders' needs and roles during pregnancy [70], even though they also play a pivotal part [26, 40, 64]. For example, a few studies examine the user experience of pregnancy tracking apps, but mostly concentrate on understanding how existing technology aids or hinders pregnant people [8, 13, 87]. In terms of social interactions during pregnancy, the existing design space primarily focuses on supporting pregnant people in getting support from healthcare providers, peers, and local communities [20, 50, 87, 118]. The understanding of how pregnant people and their close social networks, such as family members and close friends, mutually support each other is much more limited. This work extends the current literature by understanding how pregnant people and non-pregnant stakeholders collaborate around tracking pregnancy in everyday lives.

2.4 Social and Collaborative Practices in Personal Informatics

The field of Personal Informatics (PI) stems from people's increasing use of self-monitoring technology in everyday lives [36, 66, 97]. While the concept of PI centers around people seeking self-understanding on their own, studies find people's self-tracking behaviors are heavily intertwined with social interactions [23, 73, 97]. Social practices in PI can be mainly categorized into three forms: socially sharing one's data [23, 67, 69], personal data being tracked by others [45, 59, 117], and co-tracking behaviors [79, 82, 90].

Prior work suggests that people socially share their personal data via tracking tools' internal social features (e.g., built-in social platforms, rankings, and leaderboards) or external social platforms (e.g., Twitter, Facebook, Instagram) to get emotional support, celebrate achievements, seek information, compete with others, and to be held accountable [23, 49, 69]. Social sharing behaviors also frequently happen in clinical and personal health settings, where patients self-monitor complex health conditions and share data with clinicians for them to view and make medical decisions [24, 56, 99]. While trackers can socially share their data with diverse groups of people including like-minded strangers, close social networks, or medical professionals, these people usually are passive data recipients who are not actively involved in the tracking experience [23, 24, 33]. They may react to the data by giving advice on what or how to track, or may help people further make sense of their data

[23, 33]. However, they typically do not participate in the person's process of tracking data.

In other circumstances, people may have others track data about them on their behalf. This largely happens when people are often preoccupied, such as dealing with a serious health condition, and they therefore turn to caregivers to offload the responsibility of tracking and understanding necessary data [59, 78, 117]. Studies also show that when caregivers directly track patients' data, it helps enhance their understanding of and fosters empathy toward the patient's behaviors and health conditions [59, 117]. In family settings, parents sometimes track on behalf of their children when they cannot track on their own [59, 100].

Mishra et al. coin "collaborative tracking" to refer to when multiple people track an individual's health and care throughout all stages, meaning they participate in preparing to track, collecting the data, through reflecting and acting on that data [79]. The practice of collaborative tracking has largely been studied in family or clinical settings, involving patients, caregivers, and clinicians. Perspectives around family informatics, or tracking in families, exhibit similar practices wherein family members collaborate around all stages of tracking [90, 102]. A frequent recommendation for supporting collaborative tracking is to offer all stakeholders equal data access and control, such as granting access to a patient portal or enabling everyone involved in the collaboration to contribute data [38, 79, 90, 100]. This approach allows each stakeholder to contribute their perspectives toward a tracking event, since they might experience it differently (e.g., a patient and a caregiver may have different interpretations of tracked data) [14, 79, 82]. It also helps reduce the burden of data work on a single individual, such as the patient [82] or a particular parent [72, 90]. Some also suggest treating caregivers as proxies (e.g., taking over the role of collecting and making sense of data) rather than supporting actors, empowering their agency to meet care recipients' health needs better [14, 45].

Across forms of social practice, tensions often arise when self-tracking behaviors are extended to interpersonal practices. For example, trackers frequently have impression management concerns, such as worrying what they are sharing is not of interest to others [23, 34, 69]. When multiple people participate in tracking, they may have conflicting views about how to interpret data or what actions to take [79, 102]. Research frequently points to concerns around the disclosure of private information, particularly when more detailed data about a person's lifestyle is shared and disclosed [32, 82, 89]. When others are monitoring a person's data or making decisions on their behalf, people sometimes feel that their bodily autonomy is violated [21, 82, 102].

This work examines social practices of PI in the case of pregnancy since its social dynamics diverge from the ones examined in the common social tracking settings. In these conventional collaborative tracking scenarios, the need for collaboration usually arises because whoever needs to be tracked is either incapable of tracking or it would be difficult or burdensome to do so, such as in cases of younger children or people with serious health conditions [78, 82, 90, 117]. However, in pregnancy, pregnant people typically have full capacity to track, and prior discussions on the topic primarily perceive non-pregnant stakeholders as passive data recipients [85–87]. Examining how people practically collaborate around pregnancy in their everyday situations can shed light on

how people approach collaboration when multiple stakeholders are capable contributors, but where societal and technological norms suggest differing levels of participation.

3 METHODS

This study examines the lived experience of pregnant people and non-pregnant stakeholders collaborating on tracking pregnancy. We held semi-structured interviews with 24 participants, with 13 people who had pregnancy experience in the past two years and 11 non-pregnant stakeholders who had been a big part of someone's pregnancy and offered support. This study was approved by our institution's Institutional Review Board (IRB).

3.1 Participants

We recruited two sets of participants for this study: pregnant people and non-pregnant stakeholders. For potential pregnant participants, we asked them to verify that they were either currently pregnant or have had a pregnancy within the past two years. This choice was to ensure that the pregnancy was recent enough that they could recall details about their collaborative management and tracking practices. Also, we opted for a two-year range rather than a one-year or shorter was to minimize participation demands on people taking care of a recent newborn. We similarly required non-pregnant stakeholders to verify that they were either currently supporting someone close to them through pregnancy or had done so in the past two years. We did not restrict the nature of the relationship that non-pregnant stakeholders had with the pregnant person beyond being a close tie. All participants were also required to be 18 or older and currently reside in the U.S.

While we were interested in obtaining perspectives from multiple stakeholders surrounding a pregnancy, we opted to not require pregnant people and non-pregnant stakeholders to jointly participate. We expected that many potential participants would now be sharing in the responsibility of coordinating pregnancy-related logistics, or in the case of people who were recently pregnant, of managing new childcare tasks. We therefore sought to minimize the time burden we placed on any dyad. For instance, requiring both parents to attend the interview might create challenges in coordinating schedules and care for the newborn. We did ask every pregnant person at the end of the interview and in follow-up emails whether people who supported their pregnancy might be able to participate, as well as asked supporters whether the pregnant person they supported would be able to participate. Although all the participants showed a willingness to help with recruitment, we did not receive any additional sign-ups from this method.

We mainly recruited our participants through ResearchMatch, a nonprofit program sponsored by the National Institutes of Health (NIH) which helps connect volunteers with researchers across the U.S. [96]. ResearchMatch enables researchers to search for targeted volunteers by setting up demographic and health condition criteria. We described our study as one that primarily focuses on parenting or pregnancy, enabling us to reach out to broad pregnancy-relevant stakeholders. We further set up filters for specific pregnancy and parenting statuses to find potential pregnant participants, using

filters provided by ResearchMatch such as pregnant, pregnant-planned, or parenting caregiver status. We contacted potential volunteers who fit our criteria with a general recruitment message, providing a link to our demographic survey on Qualtrics to collect the demographic information and further screen for eligibility. We also posted our recruitment message on other online platforms and social media, such as Reddit, parenting Discord servers, Twitter, and public Facebook groups.

Table 1 describes the pregnant participants' demographics with certain information aggregated to protect participant anonymity. Pregnant participants' ages ranged from 28 to 38 (mean=33, sd=3.19). While we did not have gender criteria for pregnant participants, all of the pregnant participants were Female. About half (N=6) of the participants had been pregnant once, the other half had twice or more (max=5). Most (N=10) of our pregnant participants had at least one pregnancy-relevant health complication, with anxiety or depression (N=7) being the most common one. Most of our pregnant participants identified themselves as White, with one as Hispanic or Latino and one as Asian. Two participants self-identified as bisexual while the others were heterosexual. All the participants were either married or in a domestic relationship. Our participants were generally highly educated (all had a bachelor's degree, and eight had a graduate degree) and affluent, with the median annual household income being \$100,000 or more.

As for participants who supported a pregnant person (Table 2), Six were non-pregnant partners, two were siblings, two were mothers of pregnant people, and one was a close friend. Their ages ranged from 23 to 75 (mean=42.82, sd= 17.93). Most of these participants frequently interacted with the pregnant person, with nine reporting talking with the pregnant person about the pregnancy more than three times per week. Most of our participants were Male, with three Female and one Non-binary. More than half reported themselves as White, with two as Black or African-American, one as Asian, and two as Multiracial. One participant self-identified as bisexual and one as gay or lesbian, and the remainder were heterosexual. Participants who were non-pregnant stakeholders also were generally highly educated, with 10 having a bachelor's degree, and six having a graduate degree. The median annual household income of these participants fell between \$60,000 to \$79,999.

3.2 Interview Process

Our interviews sought to understand how stakeholders approached tracking pregnancy, with a particular focus on their collaborative practices and any tensions or challenges which may have resulted from jointly tracking. All interviews were semi-structured in nature, following up with participants as they described their collaborative tracking practices and challenges. We asked different interview questions with pregnant people and non-pregnant stakeholders. During interviews, we explicitly asked participants about whether and/or how other stakeholders were involved in their pregnancy, probing into what others did and their perspectives about others' involvement. This approach aimed to help develop a comprehensive understanding from multiple stakeholders' perspectives.

Interviews with pregnant people contained three parts, seeking to understand how they benefited from and experienced challenges with collaborative tracking. We first sought to understand how the

pregnancy was supported by their close social network in general, asking questions like *"How has anyone, such as your partner, family members, close friends, and even colleagues, been involved in your pregnancy?"* We then examined their experiences with self-tracking, asking questions like *"Did you use any tool or method, such as paper journals, digital notebook, excel, software, mobile apps, or even just your memory, to memorize, journal, record, track, or manage any pregnancy-relevant data?"* Finally, we dove into how pregnant people's close social relationships participated in pregnancy tracking by asking questions like *"How had anyone, such as your partner, family member, close friends, and even colleagues, been involved in your journaling or tracking toward pregnancy?"*, *"Do you wish that the other people were more involved or less involved in your tracking around pregnancy? Why?"*, and *"What are the benefits and challenges of involving other people in your tracking toward pregnancy?"*

Interviews with non-pregnant stakeholders had two major sections related to their experiences with collaborative pregnancy tracking. We first asked the participants to reflect on how they supported their pregnant person's pregnancy in general, asking questions such as *"How have you been involved in [pregnant person]'s pregnancy?"* and *"Do you wish you could be more involved or less involved in [pregnant person]'s pregnancy? Why?"* We then explored how the participant was involved in tracking around the pregnancy by asking questions like *"Do you know if [pregnant person] is using any tool or method, such as paper journals, digital notebook, excel, software, mobile apps, or even just the memory, to memorize, journal, record, track, or manage any pregnancy-relevant data?"*, *"What has it been like to be involved in any forms in [pregnant person]'s tracking toward pregnancy?"*, *"Do you wish you could be more involved or less involved in [pregnant person]'s tracking toward pregnancy?"*, and *"What are the benefits and challenges of being involved in [pregnant person]'s tracking toward pregnancy?"* We also inquired about how or whether other non-pregnant stakeholders were involved with the pregnancy. For example, we asked N5, a non-pregnant partner and the father of two children, about how the elder child was involved in and responded to his wife's second pregnancy.

We conducted all the interviews via Zoom and video recorded all the sessions. The first author transcribed all the interviews. The interviews were about one hour on average, with little difference between the stakeholder groups. We compensated our participants each with \$25.

3.3 Data Analysis

Our qualitative approach drew influence from an inductive approach to thematic analysis [17]. The first and second authors familiarized themselves with the first ten transcripts and open-coded them to identify interesting takeaways relative to our research questions. They regularly compared insights and discussed findings with the rest of the research team, resulting in some preliminary insights. We found that participants had different methods and forms of collaborating around pregnancy, and faced various challenges in doing so. We decided to focus on more deeply understanding these collaborative tracking practices. Drawing from these insights, the first author built a codebook centering around different tracking formats and the associated benefits and tensions. The first and second authors used the preliminary codebook to go

Table 1: The self-reported demographic information of 13 participants who had pregnancy experience.

ID	Age	Gender	Occupation	# Times Pregnant	Pregnancy Complications	Pregnancy Progress
P1	33	Female	IRB Staff	2	No	Birth 1-2 Years Ago
P2	32	Female	Social Worker	4	Diabetes	In the Third Trimester
P3	33	Female	Engineer	2	Anemia, Anxiety or Depression	Birth 1-2 Years Ago
P4	28	Female	Resident Assistant, Stay At Home Mom	3	No	In the Second Trimester
P5	35	Female	Consultant	2	No	In the Second Trimester
P6	37	Female	Stay At Home Mom, previously RN	4	Anxiety or Depression, Diabetes, Young or Old Maternal Age	Birth 1-2 Years Ago
P7	38	Female	Not Disclosed	1	Anxiety or Depression, High Blood Pressure, Young or Old Maternal Age	Birth 1-2 Years Ago
P8	34	Female	Homemaker	1	Anxiety or Depression	Birth 1-2 Years Ago
P9	28	Female	Postdoctoral Researcher	1	High Blood Pressure	Birth 1-2 Years Ago
P10	33	Female	Homemaker	1	Anxiety or Depression	Birth Less than 1 Month Ago
P11	29	Female	Not Disclosed	1	Anxiety or Depression	Birth 1-2 Years Ago
P12	36	Female	Social Worker	5	Young or Old Maternal Age	In the Second Trimester
P13	33	Female	Mental Health Counselor	1	Anxiety or Depression	Birth Less than 1 Month Ago

Race: White (10), Hispanic or Latino (1), Asian (1), Asian and White (1)
Sexual Orientation: Heterosexual (11), Bisexual (2)
Marital Status: Married or in a Domestic Partnership (13)
Partner's Gender: Male (13)
Education: Bachelor's Degree (4), in Graduate School (1), Graduate degree (8)
Annual Household: \$20,000 to \$39,000 (2), \$80,000 to \$99,999 (1), \$100,000 or more (10)

Table 2: The self-reported demographic information of 11 participants who supported a pregnant person.

ID	Age	Gender	Occupation	Relationship	Pregnancy Progress Supported by the Participant
N1	23	Male	Law Student	Fiance	In the Third Trimester
N2	25	Male	Information Technician	Sibling	Birth 1-2 Years Ago
N3	33	Male	Software Developer	Partner	In the Second Trimester
N4	35	Male	BI Data Analyst	Partner	Birth 1-2 Years Ago
N5	47	Male	Business Manager	Partner	Birth 1-2 Years Ago
N6	28	Female	Therapist	Close Friend	Birth Less than 1 year ago
N7	31	Male	Research/Teaching Assistant	Sibling	In the Third Trimester
N8	69	Female	Economic Development Coordinator	Mother	Birth 1-2 Years Ago
N9	58	Female	Public Adjuster	Mother	Birth Less than 1 Month Ago
N10	75	Male	International Finance	Partner	Birth 1-2 Years Ago
N11	47	Non-binary	Homemaker	Partner	Birth 1-2 Years Ago

Race: White (6), Black or African-American (2), Asian (1), Two or More (2)
Sexual Orientation: Heterosexual (9), Bisexual (1), Gay or Lesbian (1)
Marital Status: Married or in a Domestic Partnership (8), Single (2), Divorced (1)
Education: Some College (1), Bachelor's Degree (3), in Graduate School (1), Graduate Degree (6)
Annual Household: 0 to \$39,999 (2), \$40,000 to \$59,999 (3), \$60,000 to \$79,999 (2), \$100,000 or More (4)
Average Frequency of Interaction with Pregnant Person: Once per Week (1), 2 to 3 Times per Week (1), More than 3 Times per Week (9)
Pregnant Person's Gender: Female (11)

through the first ten transcripts again, adding or re-organizing the codebook as necessary. Following a comparison of the two authors' codebooks and discussion involving all authors, the first author then generated a formal codebook with three parent codes (*tracking goals*, *tracking practices*, *collaboration factors*) and 11 child codes

(*goals*, *self-tracking*, *social share*, *co-track*, *temporality*, *privacy*, *pregnancy contexts*, *interaction concerns*, *data control/bodily autonomy*, *individual background*, *other factors*). The first author then coded all the interviews by using the formal codebook. Based on these codes, we surfaced three themes articulating why people collaboratively

track (RQ1), how they do so (RQ2), and the challenges and tensions they face (RQ3).

We refer to participants with pregnancy experience as PXX and participants who supported a pregnant person with NXX.

3.4 Positionality Statement

Reflecting on researchers' roles and experiences in the pregnancy journey, three of the four authors had past experience either being pregnant or being a non-pregnant partner. One author had been pregnant within the past year, and another a non-pregnant partner, and had both actively participated in collaborative tracking and management of pregnancy. Their past experiences provided some awareness into how existing technology both succeeds and falls short of supporting stakeholders' roles and needs around tracking pregnancy as a collective practice. Past experience likely shaped how the researchers interpreted the collaboration practices described by participants, comparing and contrasting collaboration strategies and tensions against their own experiences.

The fourth author, who had never experienced pregnancy as a pregnant person or a partner, has been a supporter of multiple pregnant people as a family member and a close friend. In their supporter role, they were exposed to some pregnancy-relevant data (e.g., fetal growth and pregnant people's symptoms) shared by pregnant people. The author's personal experience of being a non-pregnant stakeholder likely influenced how they framed follow-up questions during the interviews, such as introducing the types of support that they personally provided in the past.

All authors have a background in studying or designing technology to support women's health, equipping them with knowledge of how technology can both reflect and reinforce stereotyped socio-cultural norms, such as gender roles and body image issues, that may marginalize specific groups. Consequently, our entry into this study was guided by the expectation that collaborative pregnancy tracking might reinforce societal and gender norms in similar ways. Our background inevitably shaped how we reported participants' experiences and understandings of how technology should facilitate collaborative pregnancy tracking.

3.5 Limitations

Our participants were all involved in tracking different pregnancies, which had the benefit of increasing the range of experiences we were able to draw insight from. We designed our interviews to enable participants to provide insightful descriptions of how they collaborated with others to monitor pregnancy, and we utilized follow-up questions to delve into the intricacies of their collaboration. However, by not recruiting stakeholders who were involved in tracking the same pregnancy, we missed out on some nuanced dynamics between and among stakeholders. For example, when a participant surfaced a tension surrounding tracking pregnancy collaboratively, we were unable to follow up on how that tension was experienced by other stakeholders. We were also reliant on each individual's description of their involvement in collaboratively tracking. We posit that the difficulties with recruiting participants as pairs may speak to the challenging nature of collaboratively tracking pregnancy. We take it as a signal of how pregnancy has

profound impacts on people's everyday lives and social configurations, underscoring the necessity for researchers and designers to contemplate technology's potential role in addressing and mitigating collaboration challenges. While we used follow-up questions to prompt participants' experiences around pregnancy, people whose experiences were tied to a pregnancy within the past two years might still have some difficulties in accurately recalling details than those currently pregnant or recently gave birth. In addition, our non-stakeholder participants only included one LGBTQ+ partner (N11). This demographic may interact differently with the gender norms around pregnancy responsibilities that might influence collaborative tracking practices. Overall, we see opportunities for follow-up research to more deeply examine collaborative pregnancy tracking in specific stakeholder relationships to better understand their technology needs.

Participants generally described having healthy and supportive relationships with the social contacts they discussed. Questions around sharing tracked information and collaborative tracking become more challenging when relationships are more contentious. Future work might be worth exploring the collaborative tracking experience (or lack thereof) in the face of more complex social dynamics such as for single expectant mothers, those who lack family support, or have specific strained relationships they need to navigate when deciding how to track and share.

Our participants generally had a high education level and a relatively high income level, which limits the generalizability of our findings. While we aimed for our participants to cover more of the socioeconomic spectrum, ResearchMatch's focus on health-related studies may have influenced the demographic composition. For example, researchers or healthcare professionals often registered themselves as volunteers, which may lead to participants skewed toward individuals with higher education, affluence, or enhanced technological proficiency. Challenges and tensions around collaborative tracking might be different when examining people with relatively low socioeconomic status, since lived constraints (e.g., the labor required to collaboratively track) might interfere with people's ability to participate in collaborative tracking. It is therefore worth studying how people with low socioeconomic status (e.g., people with a relatively low education and income level) collaborate around pregnancy tracking, exploring how socioeconomic factors influence collaborative tracking. About two-thirds of our participants were White, suggesting a need for future studies to focus on racial minorities since they often encounter socioeconomic and educational disparities and experience challenges in pregnancy care support from the U.S. healthcare system. In addition, our pregnant participants' ages ranged from 28 to 38, with an average age of approximately 33 years old. As of 2019, the U.S. Census Bureau reports that the median age of U.S. women giving birth is 30 [81], suggesting that our participants were approximately the same age as the typical for the country. However, we acknowledge an absence of younger participants (e.g., 18 to 27 and teen pregnancies) or older participants (e.g., 40+), which may also impact the study findings as these groups may exhibit radically different social interactions and needs surrounding pregnancy. For instance, a teenage expectant mother might have limited support from peers who do not have experience with pregnancy, therefore having to mostly rely on their parents or family members [65]. On the other hand, the older group

might have more nuanced tracking needs, potentially necessitating support from non-pregnant stakeholders, as pregnancy-related complications are more common in this demographic [71].

At last, this study was conducted in the U.S., and we see opportunities to explore collaborative tracking practice in non-Western settings. There is a heightened level of stigma around women's health in some more patriarchal cultures [12, 15, 108], which might potentially influence pregnant people's willingness to disclose pregnancy details and involve non-pregnant stakeholders. Further, in some developing and indigenous regions, women with low socioeconomic status often face barriers to technology use and access to healthcare systems [109]. This may result in a need for non-technology approaches to support collaborative pregnancy, such as with local community health workers or other offline support).

4 RESULTS

Overall, we found pregnant people and non-pregnant stakeholders collaborate to bond with each other and seek/provide social support, jointly manage pregnancy data, and promote a healthy pregnancy together (RQ1). Stakeholders approached collaboration around pregnancy by dividing tracking responsibilities to monitor different types of data and collectively tracking the same piece of information (RQ2). We further identify tensions and challenges which stakeholders faced around collaboratively tracking: privacy concerns, managing stakeholders' opinions and feelings, level of trust in different stakeholders, varied interests in tracking, and desire to disengage occasionally (RQ3).

We now dive into why different stakeholders collaborate, how they jointly track pregnancy (Table 3), and the tensions and challenges in this collaboration.

4.1 Why Stakeholders Collaborate

Findings revealed three primary reasons why pregnant people and non-pregnant stakeholders collaboratively tracked pregnancy: bonding with each other and seeking social support, managing pregnancy data jointly, and promoting a healthy pregnancy together.

4.1.1 To bond with each other and seek social support. Interacting with pregnancy-relevant data became a way to form and sustain relationships between pregnant people and non-pregnant stakeholders. For example, P9 built a Google album to share baby's photos with a couple of people who were either close social ties or proactively expressed interests: *"We initially just added the grandparents. And then I added my brother and his wife, and [the] same with my husband's sister."* Pregnant people often exchanged experiences with people who were either pregnant or faced similar health risks to establish a sense of community. P2 developed gestational diabetes during her pregnancy, and felt her relationship with her father was enhanced by tracking each others' diabetes status: *"My dad is type 1 [diabetic]. He's pretty invested on the diabetic side of my pregnancy. He'll check in and ask me how I'm doing and validate how I'm feeling. [...] we can talk about the diet pieces that help in terms of carb counting."*

Expectant parents sometimes encountered data that triggered concerns, and they therefore turned to other stakeholders to seek support and get reassurance. For example, despite the happiness of seeing the fetus in ultrasound photos, participants often got

confused or anxious about what they showed. P11 turned to her family members who had relevant medical expertise to interpret a concerning ultrasound photo: *"I had a picture of the ultrasound and couldn't see the baby. I really didn't understand it. She [My sister-in-law] understood ultrasounds, so she was able to point out where his face was, and all the different parts of the baby."*

While participants' experiences with pregnancy tracking usually centered around the data of pregnant people and the fetus(es), results showed that collaborative tracking also served as a way to support non-pregnant stakeholders by enabling pregnant people to better understand how they were experiencing the pregnancy. For example, P9 felt her pregnancy could impact her partner's lifestyle and feelings, so being more aware could facilitate communication and take appropriate actions: *"We track sleep and stress levels to some extent on our [own]. So even just comparing sleep, like I was waking up a lot more during the night, and whether that was also waking him up during the night, and how his sleep was going. And same with stress levels as we were getting close because my stress was translating to him."*

4.1.2 To manage pregnancy data jointly. Participants described tracking a wide variety of data types during pregnancy. They mostly engaged with five types (Table 3): maternal health data (e.g., weight, blood pressure, blood glucose level, symptoms, and medications); mental health data; lifestyle data (e.g., physical activity, diet, and sleep); fetal growth data; and pregnancy and labor logistics, such as doctor appointments, notes during doctor appointments, and checklists. For example, P10 utilized various tools to track and manage the different types of data: *"So I tracked my blood sugar on a paper sheet [...] I would also keep track of things that I ate especially in the beginning when I was trying to figure out what I would react the most to [...] I use paper and notes to track notes from my doctor's appointments [...] I use What to Expect app to track the weekly development of the fetus and updates for my body."*

When pregnant participants tracked independently, they mentioned that managing the complex and diverse nature of pregnancy data was burdensome: *"It's frustrating that the burden does fall to women to track those things [...] I mean it takes time to track all those things. (P13)"* Pregnant people therefore often worked with non-pregnant stakeholders to jointly manage data and gain a more comprehensive understanding of aspects of their pregnancies. N5 was glad how that he was able to relieve some of his partner's tracking burden: *"I could find areas where I could help and that was important. I could also take the burden off of her in terms of any sort of tracking that she might want to do herself. Pregnancy is very psychologically demanding and distracting. So having another brain focused on it as well is useful."* Involving non-pregnant stakeholders, mostly partners, in managing pregnancy data also enabled both parties to jointly make informed health decisions when they all could access available information. P3 and her husband collectively decided when it was time to go to the hospital by looking through data on a contraction timer together: *"When I was trying to have contractions, I shared that data on the app [contraction timer] with my husband to help make the decision about when to go to the hospital."* Pregnant participants described sometimes overlooking some symptoms due to pregnancy's uncertainty, and insights from others provided them with greater confidence in their interpretation. P10

Table 3: A summary of pregnancy tracking data and their associated tracking tools.

Types of Pregnancy Data	Technology or Tools
Maternal health data (e.g., weight, blood pressure, symptoms, and medications)	Pregnancy tracking apps, weight scales, blood pressure monitors, electronic health records (e.g., MyChart and Kaiser Permanente), digital technologies (e.g., Google Doc, Excel Sheet, and Word), notes on the phone, paper reports, and paper journals
Mental health data	Mood journaling apps, pregnancy tracking apps, and paper journals
Lifestyle data (e.g., physical activity, diet, and sleep)	Food journaling apps, wearable devices (e.g., Apple Watch), and paper journals
Fetal growth data (e.g., ultrasound photos, fetal size comparison, and fetal kicks)	Pregnancy tracking apps, ultrasound photos, and paper report during doctor appointments
Pregnancy and labor logistics (e.g., doctor appointments, notes, and checklists)	Calendar, digital technologies (e.g., Google Doc, Excel Sheet, and Word), and notes on the phone

wanted to have a second eye to check her data since: *“I felt like I was having a hard time and wanted someone to be able to look at those types of things and then see if I was missing something.”*

4.1.3 To promote a healthy pregnancy together. Medical research regularly asserts that maintaining a healthy lifestyle during pregnancy, including diet and exercise, leads to better health outcomes for the fetus and the pregnant people [22, 80]. To support this goal, pregnant people and non-pregnant stakeholders cooperated around monitoring or sometimes competing in aspects of pregnant people’s wellbeing. N10 paid attention to his partner’s diet, shared patterns he observed, and made some suggestions: *“You know you’ve exceeded your calories [that] you can take for today. And it’s because you had too many cookies or too much Italian sausage.”* P4 competed with her family members around physical activity to ensure she stay active during pregnancy: *“I track on the Fitbit to keep me stay healthy during pregnancy. My husband’s also wearing a Fitbit. My dad uses it. My sister uses it. So sometimes we would do competitions there, seeing the step counts, and then we do a competition of who can get the most steps this week or whatever you can reach”*. N11 paid attention to her pregnant partner’s glucose level and made sure she prepared foods that could keep her gestational diabetes under control: *“I cared about the blood glucose level and wanted to make sure that it was not spiking in one way or the other. And the way I did was making sure that she had appropriate [food]”*

4.2 How Stakeholders Collaborate

Participants’ strategies for sharing their pregnancy-related data with others for support largely resembled social sharing practices discussed in prior works [23, 69]. Pregnant people often took charge of tracking, sharing pregnancy-relevant data with non-pregnant stakeholders to bond with others or seek advice. For example, N7’s pregnant sister was the first to get pregnant in their family, and she frequently shared her pregnancy progress in the family’s group chat: *“She shares [pregnancy] information with us often, like when we found out the gender of the baby. Like her doctor appointments, when she’s having one, she’ll say I’ll have the doctor’s appointment tomorrow. Then we’ll ask afterward: ‘How’s everything going with you and the baby?’”* We did not observe any instances where pregnant

participants largely had others tracking their pregnancy on their behalf, which has been observed in other domains [14, 117].

We primarily focus on describing participants’ experiences collaborating around pregnancy tracking. Our interviews surfaced two ways in which pregnant people and non-pregnant stakeholders collaboratively managed pregnancy tracking: dividing tracking responsibilities within a pregnancy to be in charge of different types of data, and jointly tracking around the same type of information.

4.2.1 Dividing tracking responsibilities within a pregnancy. Pregnant people and non-pregnant stakeholders, usually partners, often collaborated by allocating responsibilities for monitoring different data types based on their respective tracking capabilities and interests.

First, pregnant people and non-pregnant stakeholders often assigned tracking based on whoever was more well-suited to collect that information. Pregnant participants usually believed that they were more adept at monitoring data about the pregnancy which was unobservable or hard to observe, but that they physically experienced. For example, P9 felt only she could accurately count the fetal kicks since *“There’s a lot of kicks that only you feel, and it’s not visible or be able to be felt by somebody else, especially depending on baby’s position”* P2 felt her husband would not be able to notice her sleep pattern while he was asleep, especially when it was impacted by needing to go to the bathroom frequently: *“He [the non-pregnant partner] really has no idea what’s going on with my sleep because he does not wake up. I’m up multiple times a night to go to the bathroom.”* Participants felt co-located stakeholders, particularly partners, were often better equipped to collect measurable or observable types of pregnancy data since they were often well-attuned to the wellbeing and needs of the pregnant people and would take on the role of tracking those aspects of the pregnancy. For example, N1, as a non-pregnant partner, was *“around my fiancée all the time”* and took on the responsibility of mentally collecting and retaining his pregnant fiancée’s lifestyle data to help prevent developing pregnancy complications: *“I’ve mostly been keeping track of her lifestyle data, just the actual doing of making sure she’s eating regularly, sleeping, drinking, etc. [I am] Kind of keeping track of that mentally and through some notes on my phone to make sure that she hasn’t developed diabetes or anything like that.”* Beyond lifestyle

data, non-pregnant stakeholders were also able to notice and track pregnant people's mental health. P8 appreciated her husband for paying attention to her emotions and adding extra insights when they communicated with doctors: "[my] husband is noticing that: 'she's more irritable, or whatever it might be.' Prompts a conversation between me and my husband and my doctor."

Second, stakeholders also divided on who was responsible for tracking what data based on their level of interest in having that particular data tracked. Taking fetal growth as an example, most of our pregnant participants tended to leverage pregnancy tracking apps' size comparisons and virtual fetal models to track fetal growth. For example, P12 described, "In my first pregnancy, there was a really cool app. I had a 3D rendering of what the baby looked like every week, growing from an embryo to a fetus to more of a baby-looking thing." In contrast, non-pregnant stakeholders mainly relied on attending doctor's appointments to see and collect ultrasound photos, such as N3: "We're waiting till the next appointment in a few weeks to do the checkup of the baby's health and make sure all the fingers and toes are there." N5 specifically expressed that he did not enjoy how pregnancy tracking apps tracked size comparison "your baby is the size of a blueberry or other things. She found that entertaining, and I found it condescending. It seemed very elementary to compare the size of the baby to a Hot Wheels car.", but he enjoyed collecting ultrasound photos instead: "I was a fan of the ultrasound photos. We had printouts of them, and we scanned them for baby books. As a first-time father, on every single image that you could get, you know you wanted to keep."

4.2.2 Jointly tracking the same type of data. Pregnant people and non-pregnant stakeholders often collaborated around tracking a single piece of pregnancy data to jointly manage the difficulty of collecting that data, remembering all facets of it, or interpreting it. Some types of data were easier to collect if multiple parties were involved, such as photos of a baby bump: "He [P7's husband] did take some photos on his phone like our own maternity photo shoot. (P7)" Tracking doctor appointments often needed expectant parents to share their schedules to coordinate a convenient time for both to attend and stay informed about upcoming appointments: "We have a shared Google calendar. He would also be around when I would make the appointments at the doctor's office's front desk, and so he could say: 'Oh, I can't do that one. I have a meeting at that time'. (P13)" Participants also often leveraged their collective memory to share in the tasks of tracking questions they had for doctor's visits and remembering the insights they gained from appointments. N4 and his pregnant partner leveraged a Google doc to record notes from each of their perspectives after doctor's appointments: "We use in Google and a variety of different word documents where we would take notes. So every single time we come out of a doctor's appointment, we would usually have 2 or 3 paragraphs worth of things, and we would scan anything we were given so that we could both read it."

Non-pregnant stakeholders often assisted pregnant people in tracking by sharing the tasks of manual collection and integration. For example, P6 had to regularly journal her blood glucose level manually to manage her gestational diabetes "I had a journal that was handwritten for those data entries that the doctor's office had given to me. [And] I submitted it electronically to them at the end of every week or twice a week". Her partner participated in her process

of documenting and sharing data: "He remembers data until I can get it written down, or just helping me get things sent to the doctor's office." P4 wanted her husband to handle the manual tracking of her blood glucose level, such as poking her and recording the results, while she focused on the data interpretation work: "He could do the poking. I would be interested in actually seeing the results, just not doing the process to get the result."

Since much of the tracked data was initially manually recorded and not in digital format, often, one stakeholder would do the initial non-digital tracking, and another would digitize it to facilitate data organization and analysis. N2, as a brother of a pregnant person, transcribed his sister's data to Excel in order to find patterns: "She had a notebook that was specifically for her pregnancy-related data. But later I opted to use a spreadsheet, an Excel sheet, because it would be used to calculate, maybe the gradual increase."

4.3 Challenges and Tensions within a Collaborative Pregnancy Tracking Practice

While pregnant people and non-pregnant stakeholders were often able to collaborate around tracking and making sense of pregnancy-related data, they faced some difficulties in doing so effectively. We identified several challenges and tensions that shaped people's collaborative pregnancy tracking practices: privacy concerns, managing stakeholders' opinions and feelings, level of trust in different stakeholders' tracking capabilities, varied interests in tracking, and desire to occasionally disengage.

4.3.1 Privacy concerns. Pregnant people often expressed privacy concerns due to the sensitivity of some kinds of pregnancy data, mainly collaborating with their closest social ties around tracking pregnancy. For example, P2 was monitoring bleeding at the early stage of her pregnancy, but she did not let her family members know: "anything related to [maternal] health, whether it's tracking bleeding or sexual health. I don't think I would go beyond my husband or healthcare providers. And if any of that bleeding were related to sexual health or sex, that would be pretty personal and kind of embarrassing. There is also this level of taboo or shame when it comes to women's sexual health in general." Expectant parents sometimes preferred to withhold uncertain and abnormal maternal health data that they were tracking to avoid others worrying for them. For example, both pregnant and non-pregnant participants usually did not have collaboration concerns around fetal growth data, including P4: "Some of the general stuff like your baby's size is not really hugely sensitive to me. I'm happy with people: 'Oh, babies! A pumpkin!'" However, they also acknowledged that some pregnant people might not want others to know some abnormal fetal growth data: "there might be a complication or the baby is just not growing like it maybe should, or baby's growing faster than expected, or whatever it might be. So that might be a little more on the sensitive side." In light of potential legal repercussions following the overturn of *Roe v. Wade*, a few participants expressed concerns about multiple people having access to sensitive pregnancy-relevant data: "You see these horror stories right now after *Roe v. Wade*. I would think there'd be quite a few [people] who were really concerned about putting things out there, just in case there is a miscarriage, or even worse. And now they got to worry about being arrested." (N8)

It was worth noting that pregnant people's privacy concerns were often mediated by their relationships with non-pregnant stakeholders and their experience with pregnancy. All the pregnant participants had no concerns with involving their partners since it was important for partners to be able to support decision-making and provide timely support. P9 allowed her partner to access her patient health portal: *"My partner had access where he could log on himself for anything where I wanted him to look at it"*, a common practice among participants. However, pregnant people were often willing to involve non-pregnant stakeholders around some sensitive and uncertain maternal health data when they had pregnancy-relevant expertise and experiences. For example, P5 relied on her father, a doctor, to interpret her blood glucose level around controlling gestational diabetes: *"My father is a doctor, and so I would talk to him about it [gestational diabetes]. I was pretty upset when I got the diagnosis [for gestational diabetes] because I eat really healthy, and I have a very active lifestyle. I never expected to get a diagnosis like that. And my dad just helped me feel like I didn't have a problem, because he would look at the numbers and kind of interpret it for me and say: 'You're fine. There's really nothing to worry about'."*

4.3.2 Managing stakeholder's opinions and feelings around pregnancy-related data. When pregnant participants collaborated around tracking, they sometimes faced challenges managing non-pregnant stakeholders who had strong opinions about whether certain data was abnormal or not and how a pregnancy should go. For example, pregnant participants sometimes had tensions with their mothers around the data they collected, stemming from their close relationships and the mothers' strong beliefs of being more experienced in pregnancy. P3's mother overreacted to her blood pressure data on one occasion, interpreting it as a potential risk and suggesting P3 have an unwanted delivery immediately: *"At one point my blood pressure measured a little bit high, and she [my mom] became very worried, and she thought I should get an emergency C-section and have the baby right then. And then my blood pressure turned out to be fine at the next appointment."* N9, a mother of a pregnant person, felt disappointed that her daughter did not pay as much attention to her symptoms as she did: *"I was always concerned about scoliosis. I was impacted by [that] in the pregnancy, and I never really got any data or information about that. She had problems with sciatica as well. [...] I don't think she took it as seriously as I would."*

To avoid such tensions, pregnant participants sometimes had to limit certain people's access to their data: *"It's not good to give my mom too much information because she worries about and obsesses over every little thing. So I control what information I share with my mom. (P7)"* Some pregnant participants were also less inclined to involve others in tracking pregnancy collaboratively, feeling that they were capable and could manage the data work independently. For example, P1 felt that tracking empowered her into feeling like she could control her pregnancy, preferring to share her data with family members rather than letting them directly track: *"There are so many things going on during pregnancy that you just have no control over. So being able to track things on your own, does definitely feel like you have some control. It felt nicer to be able to share with family and then keep that distance from them."*

4.3.3 Level of trust in stakeholders' tracking capabilities. Pregnant people sometimes questioned non-pregnant stakeholders' reliability in tracking data about pregnancy or the quality of the data they tracked, feeling they might not value the practice as much. This sometimes led to a reluctance to rely on non-pregnant stakeholders to track. Pregnant participants often wondered if others, particularly their partners, would value the tracking as much as they do. For example, P7 managed her family's health appointments, and did not trust her husband to help with tracking: *"That would be great [if my husband could help track pregnancy], except that in my family I'm the one who tracks all the health appointments. My husband would not get his annual physical unless I told him to. My husband does not pay attention to health appointments. I have to tell him to go. It would be unrealistic for him to track health appointments."* Pregnant participants were also concerned that their partners might lapse in tracking: *"If he were going to be tracking, he'd maybe do it for like a day or two, and then just like other stuff again in the way, and he'd forget to log it. (P3)"* P11 felt she would find it more stressful to trust her partner to track rather than taking on the burden herself: *"He [husband] might forget, or might do something wrong, and the anxiety over that is greater than the burden to track it myself."*

Pregnant participants sometimes also wondered if non-pregnant stakeholders would be as attentive to the details that they found important to track. P10 doubted others could be as careful as she was around tracking her diet and blood sugar since *"It was very important to me that my sugars be controlled. I did some very careful experimenting. I was trying to control it pretty closely and carefully. And I tested my sugars a lot more than necessary, because I wanted to see how I reacted to different things. He [husband] definitely was aware and wanted to know how my sugar and stuff. But nobody interacted with the actual data like me."* Non-pregnant stakeholders, particularly men, also occasionally doubted that they could fully grasp aspects of pregnancy: *"I'm a guy, and I don't understand some things about the ladies and pregnancy. Sometimes she [sister] would share with me something that I wasn't conversant with."* (N2)

4.3.4 Varied interest in supporting tracking goals. Beyond interests in collecting data, pregnant participants sometimes questioned the interest level of non-pregnant stakeholders toward using that data to participate in goals like decision-making. P13 invited her husband to collaboratively use a spreadsheet to track her pregnancy, but he rarely used it: *"I love spreadsheets. It helps me to organize and visualize data, especially as a first-time parent. [...] I sent it to him [my husband] as a collaborator. He didn't really do anything with it. He would look at it on occasion. I think I was more the one who's into tracking."* Pregnant people's such concerns often resulted in hesitance to involve non-pregnant stakeholders around certain data types: *"Most of [maternal health data] is kind of sensitive. I like to keep it mostly between me and my midwife, and maybe my husband when I want to. I'm very open with him, but I don't know if he really cares about some of the data. (P4)"* Non-pregnant stakeholders often expressed concerns about overstepping their bounds and being more involved than the pregnant person wanted. For example, N7, as a brother of a pregnant person, worried his involvement would bother his sister: *"She [sister] had a lot of things going on in her life already that she's trying to balance. So any more involvement might have overburdened her."*

4.3.5 Desire to occasionally disengage. While pregnant people collected more and more useful data by involving others in tracking, they sometimes desired to disengage from tracking or having conversations around tracking with non-pregnant stakeholders. Pregnant people sometimes found pregnancy all-encompassing, and desired to have a break from the topic. For example, P11 said: *“I don’t want to interact with anybody today. And I just don’t tell anyone else anything.”* N3, a non-pregnant partner, similarly perceived that pregnant people might sometimes find tracking together fatiguing: *“There might be times where she might not want her friends or family, or myself to be as involved at the time. Maybe she just wants to be left alone. Everybody has an off day.”*

While non-pregnant stakeholders wanted to be supportive or helpful, they also sometimes wished for moments of disengagement from the pregnancy. N6 frequently offered her pregnant friend support around her mental health data, but had moments where she struggled to maintain the level of support: *“I love her, and I want to help her. But there might be days my husband would come in for the weekend [...] There were days where I was like I cannot do this right now. I am just too mentally strained. I’m exhausted.”* She therefore appreciated having another friend take up her care work: *“You know my friend could tap in, and I could tap out for a little bit.”*

5 DISCUSSION

We surface three major motivations for pregnant people and non-pregnant stakeholders’ collaborative tracking in their everyday lives: social bonding and seeking social support, shared data management, and promoting a healthy pregnancy together. We find that stakeholders tend to share the tracking responsibility of data collection, integration, and reflection, extending prior works about social practices in personal informatics which either assign tracking responsibility to one group of stakeholders or compare different stakeholders’ personal data [72, 89, 117]. In addition, literature has largely focused on how technology can support the needs of pregnant people and ignored other stakeholders [87]. However, our findings show that non-pregnant stakeholders often also have tracking capabilities and interests, and aim to share in the data work involved in managing pregnancy with pregnant people. We further identify tensions between pregnant people and non-pregnant stakeholders, such as pregnant people’s privacy concerns, managing stakeholders’ opinions and feelings, trust issues, varied interests in tracking, and the desire to disengage occasionally.

We now reflect on how our findings in the pregnancy space shape our understanding of how people approach collaborative self-tracking and how technology could support it. We point out the influence of socio-cultural factors on people’s experiences and perceptions of pregnancy, as well as the design of technology. Additionally, we surface that people’s collaborative practices around pregnancy tracking put bodily autonomy in tension with the involvement of non-pregnant stakeholders. We further offer design recommendations for designing a collaborative pregnancy tracking technology when considering the inequalities between pregnant people and non-pregnant stakeholders resulting from factors like stakeholders’ varied tracking capabilities and biased socio-cultural norms that root in people’s behaviors.

5.1 Collaborative Pregnancy Tracking in Light of Socio-Cultural Norms

When prior work has introduced and advocated for collaborative tracking in health domains, it has largely suggested treating stakeholders involved as a collective unit, with equal opportunity and unrestricted access to collect data and review it [38, 77, 79, 90], or as proxies for patients [14, 45]. These approaches can be practical in some circumstances, such as managing serious diseases or complex health conditions, as restricting personal tracking to whomever the data is about can make it more challenging for other stakeholders to assist or share in decision-making. While our findings continue to suggest that tracking benefits from being joint, it also requires more careful consideration of the downsides surrounding the expectation that everyone will and wants to participate in all tracking stages, especially in the context of socio-cultural norms around gender norms and parenting roles during pregnancy. Several tensions surfaced in this study, such as stakeholders’ varied tracking interests and a lack of trust in non-pregnant stakeholders’ tracking capabilities, might be rooted in gendered norms and expectations of family roles that narrowly assign pregnancy-relevant responsibility and capability to pregnant people [28, 39, 43, 54, 112]. For example, in our study, some pregnant participants had to self-monitor specific data types due to non-pregnant male stakeholders showing little interest in pregnancy management, resulting in pregnant participants’ co-tracking needs being unmet. Technology that encourages equal pregnancy participation, without considering gender norms and parenting roles’ potential influences on stakeholders’ responsibilities and interests, might not be effective at facilitating and sustaining different stakeholders’ distinctive involvement. Designing collaborative technology aligning with traditional gendered norms would risk perpetuating stereotyped and even misogynistic designs, placing a disproportionate burden of data tracking and management on pregnant people. However, a challenge in designing technology that avoids reinforcing stereotypes is how it might be used in light of national policies around pregnancy. For example, some countries offer extended parental leave for mothers as part of family bonding, often starting before birth [58]. These policies might impact who has more time to manage pregnancy, which might complicate efforts to design collaborative pregnancy tracking technology with equal parenting roles in mind.

Further, it is crucial to consider how the design of collaborative pregnancy tracking technology might vary across cultural settings, since culture greatly shapes people’s perceptions and experiences of pregnancy. In more patriarchal cultural contexts, male partners or elder family members tend to make health decisions and have control over information disclosure [15, 83, 109]. Pregnant people in these settings may therefore have limited agency in deciding which data to involve others and who gets access to collaborative tracking. In cultures where female family members (e.g. pregnant people’s mothers and mother-in-law) predominantly provide support and wield great influence [12, 48, 95], there may be expectations for them to be more heavily involved in collaborative tracking than non-pregnant partners, potentially putting pressure on pregnant people to grant them full access to sensitive pregnancy data. Furthermore, a collaborative tracking technology might face greater challenges in facilitating desired support for pregnant people in cultures where

pregnant people's needs are prioritized after those of their husbands or partners [12, 48] and where partners often face stigma around being involved in pregnancy [1, 68].

5.2 Tension between Bodily Autonomy and Stakeholder Involvement

Prior research has suggested that women can face challenges with protecting their bodily autonomy when using health technology [4, 7, 116]. Our work shows that trying to collaborate around pregnancy tracking can sometimes put pregnant people's bodily autonomy in tension with the opportunity for others to support them in tracking pregnancy. While our results indicate that non-pregnant participants are willing to help with various aspects of tracking pregnancy, their participation sometimes conflicts with pregnant people's control over tracking and interpreting their pregnancy data. For example, involving others when interpreting pregnancy data collaboratively might result in getting unsolicited suggestions from those with strong opinions about pregnancy. This aligns with prior works' concerns about the potential for women's sensitive data to be used to restrict decision-making [2, 7, 74]. In addition, some pregnant participants express that tracking independently sometimes empowers them to manage and make decisions about pregnancy, leading to their tendencies to share pregnancy progress with non-pregnant stakeholders rather than co-tracking with them. Therefore by preserving autonomy, pregnant people accept that they may take on more of the responsibility and labor of monitoring the pregnancy, which may result in greater tracking burdens and prevent them from getting desired support around pregnancy.

To protect pregnant people's bodily autonomy, all participants we talked to felt that pregnant people should have data control within a collaborative tracking practice, such as the authority to decide who they want to involve and what data others could access. However, considering some pregnant people's desire to track independently, providing full control over data control and tracking preferences might lead them to refuse non-pregnant stakeholders' involvement which might negatively influence their relationships with other stakeholders. This is particularly noteworthy in that pregnancy is often perceived as a "crisis" that reconfigures stakeholders' social relationships, and tensions around tracking of pregnancy could further drive a wedge between stakeholders [26, 40, 64]. This may further impact their ability to get support, or create obstacles around ensuring the health of the pregnant people and the fetus(es).

Moreover, women's health is often stigmatized and regarded as taboo, leading people to feel hesitance or shame when interacting with others regarding aspects of their health [25, 115, 116]. To mitigate stigma and support women in getting desired support, a few works explore opportunities for technology to promote collaboration around women's health [55, 103, 114]. A potential concern is that in pregnancy, rejecting non-pregnant stakeholders' participation may exacerbate pregnant people's experienced or perceived stigmas associated with pregnancy and their bodies.

Supporting collaborative pregnancy tracking therefore requires balancing between protecting pregnant people's bodily autonomy, such as ensuring their data control, and supporting non-pregnant

stakeholders' sharing in the responsibility of collecting and making sense of pregnancy-relevant data. We also see value in offering flexibility in tracking approaches, allowing pregnant people to choose among self-tracking, social sharing, and collaborative tracking. Meanwhile, designs would benefit from helping stakeholders better communicate and negotiate their expectations around involvement with pregnancy tracking.

In addition, aligned with concerns around the potential of incriminating women by mining their sensitive health data around abortion in the Post-Roe v. Wade U.S. [30, 60, 75], some participants shared worries about the legal implications of collaborative tracking technology when it could produce a heightened visibility around sensitive data potentially associated with an abortion. Since anyone aware of an illegal abortion can report it, the involvement of more people in a pregnancy enabled by collaborative tracking technology increases the likelihood of government awareness, without pregnant people's intent. Further, without careful design around bodily autonomy, collaborative pregnancy tracking technology has the potential to exacerbate existing racial/ethnic disparities in maternity healthcare. Collaborative technology could be used as evidence to disproportionately prosecute women of color, who are often in greater need of support services surrounding pregnancy and constitute the majority of abortion cases [10]. To support collaborative tracking in light of these concerns, designs could consider ways of supporting anonymity. For example, the period tracker Flo released a mode that removes the association between user health data and any identifiable information, which could be expanded to other pregnancy-related apps [88]. It may also be helpful to enhance the privacy awareness of other stakeholders, such as educating non-pregnant stakeholders about potential risks associated with (un)intentionally tracking and sharing pregnant people's health data without their consent.

5.3 Tension between Supporting and Challenging Inequalities around Collaborative Tracking

The tensions and challenges that participants faced around collaborative pregnancy tracking largely stem from differences in tracking needs, level of interest and tracking, and capabilities for tracking. For instance, pregnant people occasionally expressed concern about the tracking reliability and data quality of non-pregnant stakeholders, primarily male partners, suspecting they might not value pregnancy tracking to the same extent as pregnant people. These differences are influenced both by people's distinctive roles in pregnancy (e.g., bodily experience around pregnancy like fetal kicks) and relevant socio-cultural contexts (e.g., culture-specific gender norms and family dynamics). Our results suggest that supporting some people's desired practices around collaborative pregnancy tracking would require deliberately supporting unequal tracking practices, such as creating tracking technology that allows stakeholders to configure what data they each wish to contribute.

But, in line with more feminist design perspectives, our results also point to opportunities for designs to challenge the socio-cultural norms around involvement, moving pregnancy tracking closer to other domains which are more wholly collaborative. In the context of pregnancy, existing pregnancy tracking technology

usually assigns the data monitoring and management responsibility to the pregnant person [70, 85, 87]. Gendered norms lead to many male stakeholders perceiving a passive involvement in pregnancy [112]. Therefore, simply endorsing this unequal involvement without recognizing how biased norms permeate people's behaviors and technology design would reinforce these norms, similarly imposing the data tracking and management burden on the pregnant person. We now highlight design recommendations for both aligning with and challenging socio-cultural practices around pregnancy tracking, and acknowledge the tension that designers face in deciding how to approach technology design in this space.

If a design's goal is to support inequality arising from people's distinctive roles (e.g., varied tracking capabilities and relationships with pregnant people) in collaborative pregnancy tracking, a strategy could be to support tracking customization and configuration around individuals' preferences regarding what data to track, how to track, and how often to track. For example, pregnant people sometimes questioned non-pregnant stakeholders' capabilities in tracking some data types which can be hard to observe or measure, such as fetal kicks and pregnancy symptoms. Simultaneously, they often expressed a need for support in collecting other data, such as blood glucose levels and emotions. Some non-pregnant stakeholders, particularly pregnant people's mothers, were interested in knowing every aspect of pregnancy but also introduced tensions by giving unwanted opinions on certain data. Therefore, supporting certain levels of configurability could help guarantee that pregnant people maintain control over who has access to specific data while getting desired support. Although this approach aligns with cultural norms that position people at the center of pregnancy experiences, it could help ensure pregnant people's bodily autonomy.

Noted, supporting unequal tracking poses questions around who is involved in tracking pregnancy, what data to involve non-pregnant stakeholders with, and what collaboration responsibilities non-pregnant stakeholders undertake. Should these approaches be implemented, there is a need for designs to help stakeholders make informed choices around these topics. For example, early in pregnancy, tracking technology could help surface typical data that people often track and guide them through deciding who will be responsible for entry. Configurable profiles, such as from more distant stakeholders, could help indicate what data they are interested in being aware of. Even if pregnant people choose more restrictive settings around intimate data, surfacing interests could lead the stakeholders to have conversations about what they feel comfortable disclosing.

If a design's goal is to challenge inequality originating from socio-cultural norms around pregnancy, a goal would be to encourage or even require non-pregnant stakeholders' involvement. One technique could be to surface the inequity in pregnancy management, which can often be measured in tracking technology. Technology could directly surface the amount of time each stakeholder has put into collecting data or reviewing that data, in the hopes of facilitating a richer conversation about the division of labor. Another approach could be for interfaces to highlight the importance of the supporting roles in pregnancy. For instance, technology could highlight the benefit of the participation of non-pregnant stakeholders, especially male partners, toward the health and wellbeing of both the pregnant person and the baby.

While technology can play a role in mitigating stereotyped socio-cultural norms around pregnancy, it is worth considering how to design such features in light of deeply ingrained cultural perceptions in more patriarchal or sensitive cultural settings. For example, our suggestions to emphasize the benefit of non-pregnant partners' participation may not work effectively in cultures that stigmatize "caring" non-pregnant partners or prioritize the needs of partners over those of pregnant people. Further work is needed in conjunction with policymakers, local community health workers, and educators to examine how technology can be leveraged to raise people's awareness about some biased norms around pregnancy, mitigating cultural barriers that neglect pregnant people's bodily autonomy and fostering a supportive environment for pregnant people. We see the design of culturally relevant collaborative pregnancy tracking technology as potentially indicative of the underlying norms, but unlikely to singlehandedly reshape those norms.

6 CONCLUSION

Through examining the lived experience of how pregnant people and non-pregnant stakeholders collaborate around tracking pregnancy, we find people aim to share in the difficulty of monitoring, integrating, and managing a variety of pregnancy data as well as providing a complete understanding of pregnancy. However, tensions and challenges such as privacy concerns and stakeholders' varied interest in tracking, often influenced by societal norms, sometimes prevent people from effectively collaborating around tracking pregnancy. Collaborative tracking research has often suggested the value of giving all stakeholders complete access to data, but our findings suggest that this may impact autonomy and not align with how people prefer to collaborate around tracking. We suggest opportunities for collaborative tracking to both align with and challenge socio-cultural norms surrounding pregnancy, including supporting flexibility in configuration to align with stakeholders' varied needs, or encouraging or mandating non-pregnant stakeholders' involvement by pointing out who is contributing to tracking.

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