

# Obstetric Patients and Healthcare Providers Perspectives to Inform Mobile App Design for Physical Activity and Weight Control During Pregnancy and Postpartum in a Rural Setting

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**Background:** Mobile health technology offers the opportunity for women to engage with physical activity promotion programs without many of the barriers commonly associated with exercise during and after pregnancy (eg, childcare concerns, rigid schedules, fear of doing harm to fetus or self, access to fitness facilities, uncomfortable with body in front of others) which may be particularly useful in under-resourced rural environments. We conducted the first known study on perspectives of pregnant women, postpartum women, and obstetric healthcare providers in a rural setting on needs related to the development of a mobile app designed to increase physical activity during pregnancy and postpartum.

**Methods:** Focus groups and in-depth face-to-face personal interviews were conducted with 14 pregnant women, 13 postpartum women, and 11 healthcare providers in a rural community. Semi-structured questions utilizing constructs of the Health Belief Model were used to identify barriers, facilitators, and other influences on physical activity during pregnancy and postpartum. Recordings of all in-depth interviews and focus groups were transcribed and standard content analyses for qualitative data were conducted.

**Results:** Rural women and healthcare providers expressed several key perspectives about and recommendations to promote physical activity during and after pregnancy. Broadly, these perspectives encapsulated two main themes: 1) physical activity as critical for weight control and 2) the need for evidence-based exercise information. Key desired features of this app identified include goal setting/progress tracking, evidence-based exercise guidance tailored to specific time points of pregnancy and postpartum, social support via community-based forum, symptom tracking, time-efficient workouts, and push notifications.

**Conclusion:** The perspectives identified by participants should be utilized when designing mobile health physical activity mobile apps for pregnant and postpartum women in rural areas.

**Keywords:** pregnancy, postpartum, exercise, mHealth, app, rural

## Background

Pregnancy and postpartum are two significant time periods in the lives of most women. During reproductive years (ie, pregnancy and postpartum), the development of obesity and/or diabetes is occurring at an unprecedented rate,<sup>1-4</sup> and both are even more prevalent among women living in rural communities.<sup>5</sup> Because of this, the maintenance of a healthy lifestyle during these phases is important, as excessive weight gain and retention are associated with adverse health outcomes.<sup>6</sup>

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Risks associated with excessive gestational weight gain during pregnancy include preeclampsia, gestational diabetes, macrosomia, congenital defects, low birthweight, preterm birth, and increased prevalence of obstetric intervention at delivery.<sup>7,8</sup> Postpartum weight retention is also an independent risk factor for long-term maternal health consequences including obesity, type II diabetes, cardiovascular disease, and postpartum depression.<sup>9,10</sup> Concerns for maternal weight retention are substantiated by the fact that at six months postpartum, approximately 50% of women retain  $\geq 10$  pounds, approximately 25% retain  $\geq 20$  pounds, and many of these women gain additional weight during the first postpartum year.<sup>11,12</sup> Therefore, there is an urgent need to develop effective intervention strategies to reduce weight gain during pregnancy and postpartum.

The need for effective intervention strategies is even more critical among women living in rural areas. Women in rural areas experience poorer obstetric outcomes and face impeded access to healthcare resources compared to their urban counterparts.<sup>5,13</sup> Additionally, compared with other locations, most rural areas (in the United States) have fewer women's healthcare providers.<sup>5</sup> In Kentucky specifically, 76 of the 120 counties have no obstetricians and most residents drive between 30 and 60 minutes for access to a maternity center.<sup>14</sup> This lack of access to obstetric services prevents women from receiving adequate prenatal care and professional guidance about weight status and physical activity during pregnancy and postpartum. This issue is exacerbated in rural areas where obstetric services are being eliminated (possibly due to the increased costs associated with providing labor and delivery services in these areas), leaving obstetricians overworked as they may be the sole healthcare provider serving a high volume of patients.<sup>15</sup>

Physical activity interventions (with and without dietary components) have been shown to reduce gestational weight gain and retention and improve maternal and infant health outcomes during and after pregnancy;<sup>16–21</sup> however, many of these interventions are not feasible or available to women in rural settings (eg, many involve access to a centralized fitness facility). Following delivery, the focus of medical attention shifts to the health of the infant, while maternal health status is often disregarded.<sup>22</sup> The American College of Obstetricians and Gynecologists (ACOG) suggests that ongoing medical care and resources need to be provided to women during the first year postpartum.<sup>23</sup> Specifically, ACOG recommends using technology (eg, email, texts, apps) to help engage women

during the first year after delivery.<sup>23</sup> While mobile apps have become popular during pregnancy,<sup>24</sup> few address physical activity, none appear to be evidence-based, and research does not support the use of current apps on the market for educational advice during pregnancy.<sup>25</sup> Equally important, other commercially available pregnancy apps only provide information for mothers while pregnant; thus, women are not provided with information or guidance during the critically important postpartum months.

Mobile health apps offer the promise of engaging in programs without the challenges of traveling long distances and navigating sparse or absent community programming, which is especially relevant to women living in rural communities.<sup>26</sup> While mobile health apps have been used extensively in urban populations,<sup>27</sup> few such programs have been developed for women in rural settings, and to our knowledge, none have been developed specifically for pregnant and postpartum women in rural communities. Therefore, the purpose of this study was to utilize focus groups and in-depth interviews to gain insight from pregnant women, postpartum women, and their healthcare providers regarding their needs and perspectives related to physical activity during and after pregnancy in a rural setting. Ultimately, these insights may provide important information that can inform the development of specific features for a mobile application designed to improve health outcomes in pregnant and postpartum women in rural communities.

Because education is necessary, but insufficient to elicit meaningful increases in physical activity during pregnancy,<sup>28</sup> it is important to utilize a theoretical model of behavior change when designing an intervention tool (in this case, a mobile app) that addresses more than just knowledge. Further, the majority of physical activity apps have minimal theoretical content despite the fact the apps based on theory tend to be better and more effective.<sup>29</sup>

Previous work has demonstrated an educational intervention utilizing the Health Belief Model did favorably influence health beliefs about physical activity during pregnancy.<sup>30</sup> For this study, we used the Health Belief Model (and its key constructs of perceived severity, perceived susceptibility, perceived barriers, perceived benefits, cues to action, and self-efficacy)<sup>31</sup> to not only design the questions for the data collection but also to support the rationale for the identified mobile app features. The results of the study will allow for the integration of participant desires with important mobile app features supported by

theoretical evidence linking them to changes in physical activity behaviors.

## Methods

This study was reviewed and approved by Western Kentucky University's Institutional Review Board (IRB: 19-413) and the study was conducted in accordance to the Declaration of Helsinki. To obtain perspectives on a mobile health app, focus groups and in-depth face-to-face personal interviews were conducted with pregnant and postpartum women and healthcare providers serving these women from Bowling Green, Kentucky and surrounding areas. A total of 38 (pregnant:  $n=14$ , postpartum:  $n=13$ , healthcare providers:  $n=11$ ) people participated in the study. All pregnant and postpartum participants were recruited through local advertising (ie, Facebook), word-of-mouth, and chain referral sampling.<sup>32</sup> Healthcare providers were recruited through the first author's professional connections with the Medical Center labor and delivery staff and local obstetric clinics. Inclusion criteria for pregnant and postpartum women were: 1) age 18–44 years (ie, childbearing age); 2) pregnancy: confirmed viable pregnancy (4–40 weeks gestation); postpartum: delivered a baby within the past seven months; and 3) English-speaking. Exclusion criteria included inability to provide voluntary informed consent. All healthcare providers who treat obstetric or postpartum patients were invited to participate (obstetricians, nurse midwives, nurses, women's health physical therapists).

Focus groups and interviews took place between October 2019 and February 2020. Before beginning the focus groups and interviews, all participants provided written consent to participate, be recorded, and have anonymized responses used for analyses and publication. At the start of each session (after written consent was obtained), all pregnant/postpartum participants completed a written form with demographic information including age, body mass index, gestation age/week postpartum, marital status, annual income, subjective assessment of income, race/ethnicity, educational attainment, health status, and parity. Healthcare providers completed a written form requesting information on their age, gender, race, educational attainment, job title, and physical activity level. IBM SPSS Statistics, Version 27 was used to determine means, standard deviations, and descriptive variables (number and percentages) for all demographic variables.

Semi-structured questions (eight questions, Table 1) were used to guide the focus groups and interviews.

Constructs from the Health Belief Model were used to guide the development of questions. The Health Belief Model has been shown to be useful to guide the development of culturally appropriate intervention strategies for weight management.<sup>31</sup> Through exploration of questions addressing these constructs (perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy),<sup>31</sup> the goal was to identify barriers, facilitators, and other influences on physical activity during pregnancy and postpartum. Such insights will help inform the researchers on ways to develop an app to address these factors. In addition, specific questions regarding desired mobile app features were administered and responses were aligned with the same constructs of the Health Belief Model.

Focus groups were held at Western Kentucky University's Health Sciences Complex. With participants' permission, all interview and focus group responses and subsequent discussions were audiotaped (Evistr Digital Voice Recorder, Evistr Technology, LTD). A moderator asked a series of questions (eg, facilitators and barriers to physical activity and weight status during pregnancy), as well as opinions regarding desired features in a mobile health app. Focus group sessions lasted between 45 and 70 minutes. In-depth (individual) interviews lasted between 10 and 25 minutes. Focus group sessions included the study principal investigator (PI), a nurse practitioner with experience in group care models, as well as one-to-two graduate students from Exercise Science and/or Public Health. In-depth interviews included the PI and the interviewee only.

Three focus groups were held, with six, five, and three pregnant women in each session. Only four and two postpartum women were able to attend focus groups due to challenges finding an agreeable location and time; thus, we elected to conduct face-to-face in-depth interviews instead. Seven one-on-one interviews were held. In-depth interviews were conducted with the women at their home or another location that was most convenient for them. The questions asked in the postpartum in-depth interviews were the same as those asked in the postpartum focus groups (Breakdown of focus groups and interviews for each group is depicted in Figure 1).

Most healthcare provider sessions were conducted as in-depth interviews. Six healthcare providers were interviewed one-on-one in the provider's office. One focus group was held for healthcare providers when researchers were invited to a standing meeting of obstetricians at The

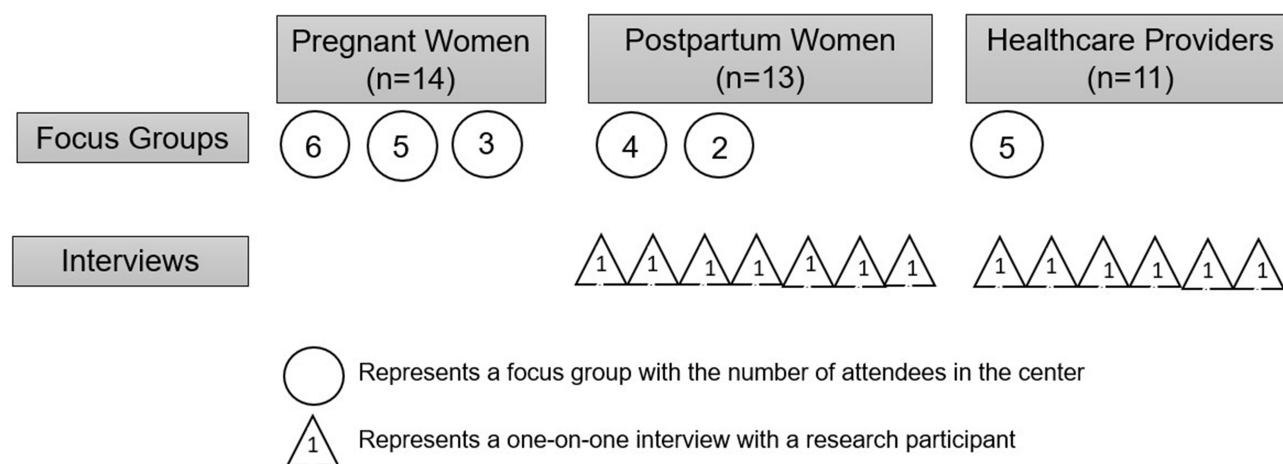
**Table 1** Focus Group and Interview Questions According to Domains of the Health Belief Model

Domain (HBM <sup>21</sup> )	Questions		
	Pregnant	Postpartum	Healthcare Provider
Perceived severity and susceptibility	Q1. What do you think are the risks of gaining a lot of weight or sitting too much during pregnancy? Do you worry about these things happening to you?	Q1. What do you think are the risks of gaining a lot of weight or sitting too much after pregnancy? Do you worry about these things happening to you?	Q1. Do many of your patients exceed guidelines for appropriate gestational weight gain? If so, is this something you are concerned about? Why? Q2. Are many of your patients physically inactive or mostly inactive during and after pregnancy? If so, is this something you are concerned about? Why?
Perceived barriers	Q2. Why it is hard to get exercise when you are pregnant? Q3. What would make it easier for you to get exercise during pregnancy?	Q2. Why it is hard to get exercise after having a baby? Q3. What would make it easier for you to get exercise after having a baby?	Q3. Do you use any strategies for helping women to stay within appropriate gestational weight gain guidelines during pregnancy? If so, what are these strategies? How successful have they been? What about after pregnancy? What strategies do not seem to work? Do you have any ideas about why they have or have not worked? Q4. What strategies have you found to be successful for helping women to become/stay active during pregnancy? What about after pregnancy? What strategies do not seem to work?
Perceived benefit	Q4. Some people have used a mobile app to help people control their weight and to help them be active. What do you think about this? Do you think this would work here? Why or why not?	Q4. Some people have used a mobile app to help people control their weight and to help them be active. What do you think about this? Do you think this would work here? Why or why not?	
Cue-to-action	Q5. What features would you like to see in an app that would help you with your weight control and/or physical activity levels?	Q5. What features would you like to see in an app that would help you with your weight control and/or physical activity levels?	Q6. What information would you like an app to contain to assist your patients with weight status and/or physical activity levels during pregnancy and postpartum?
Self-efficacy	Q6. Do you think you would be able to get more exercise and keep a healthy weight during pregnancy if you used an app?	Q6. Do you think you would be able to get more exercise and keep a healthy weight after having a baby if you used an app?	

Medical Center in Bowling Green, Kentucky. After consenting to participate and be recorded, healthcare providers were asked a series of questions regarding concerns for their patients and how a mobile app could best serve the women they treat. The same questions were used for healthcare provider in-depth interviews and the healthcare provider focus group.

Standard qualitative content analysis procedures for focus group and interview data were utilized.<sup>33</sup> Specifically, recordings of all in-depth interviews and

focus groups were transcribed first by Trint transcription services, then edited for clarity and accuracy by a member of the research team (CD). Content analysis was conducted using Erlingsson & Brysiewicz's guidelines for analyzing qualitative data.<sup>34</sup> Three researchers (RT, SB, CD) independently reviewed and coded the data into patterns or themes that emerged during discussions. Codes were created by identifying themes in the responses to each question, then summarizing each reoccurring theme under one unifying code. For example, a quote such as "I



**Figure 1** Breakdown of focus group and interviews among pregnant women, postpartum women, and healthcare providers.

don't know what I can and can't do" would be coded as "lack of guidance". The themes and codes were identified for every question asked in each subpopulation (pregnancy, postpartum, and healthcare provider). Each coder independently identified the most common codes, and all coders discussed the results to reach a consensus about the codes most frequently mentioned in response to each question. From the codes, key themes were determined.

Qualitative data and social science are critical to understanding key aspects of public health, medical interventions, and wellbeing.<sup>35,36</sup> Specifically, focus groups provide a crucial way to connect with people who are directly involved in health interventions.<sup>37</sup> In reporting the results from qualitative data collection methods, it is important to fully and adequately represent the words, thoughts and ideas of the participants who helped formulate the themes and results in this paper, which formed the basis for decisions on structuring the following results and discussion sections.

## Results/Findings

### Demographics

Demographic information for pregnant and postpartum women as well as healthcare providers can be found in Tables 2 and 3, respectively. The average age of pregnant women was 29.9 years, and the average BMI (during pregnancy) was 28.8 kg/m<sup>2</sup>, while the average age of postpartum women was 31.0 years, and the average BMI was 27.6 kg/m<sup>2</sup>. The majority of the pregnant women were Caucasian (n=13, 93%) with 7% (n=1) identifying as Latina. Eleven women in the postpartum group were Caucasian (85%), with one participant identifying as African American (8%) and one participant identifying as Latina (8%). Based on birth

records at The Medical Center in 2019, this sample is generally representative of the pregnant population in Bowling Green, KY (80% Caucasian, 10% African American, and 4% Asian). Healthcare professionals interviewed included obstetricians/MDs, certified midwives, postpartum nurses, and physical therapists. The average age of healthcare providers was 39 years and six of the 11 (55%) were female. All healthcare providers were Caucasian (n=11).

### Themes from Focus Groups and Interviews

Tables 4–6 contain concepts that emerged in response to each question, as well as representative quotes from participants, which were used to identify main themes. Quotes that contributed specifically to one of the two main themes or the development of a specific mobile app feature are designated as such within the tables (Table 4: Pregnancy Focus Group Responses, Table 5: Postpartum Focus Group and Interview Responses, Table 6: Healthcare Provider Focus Group and Interview Responses).

Rural women and healthcare providers expressed numerous perspectives about physical activity during and after pregnancy, allowing us to identify two overarching/key themes: 1) physical activity as critical for weight control, and 2) the need for evidence-based exercise information. Participant responses were also used to identify fundamental mobile app features to improve physical activity during and after pregnancy.

#### Theme 1: Physical Activity as Critical for Weight Control

All participants (pregnant women, postpartum women, and healthcare providers) expressed concern about weight gain

**Table 2** Pregnant and Postpartum Participant Characteristics

	Pregnant (n=14)	Postpartum (n=13)
Age (y)	29.86 ± 4.42	31.0 ± 2.92
BMI (kg/m <sup>2</sup> )	28.82 ± 4.34	27.59 ± 6.8
Gestation Week/Postpartum week	22.32±8.75	14.58 ± 7.37
Marital Status		
Married	12 (85.7%)	12 (92.3%)
Single	2 (14.3%)	1 (7.7%)
Annual Income		
<10,000	1 (7.1%)	1 (7.7%)
10,001–20,000	1 (7.1%)	0 (0.0%)
20,001–40,000	1 (7.1%)	0 (0.0%)
40,0001–60,000	0 (0.0%)	2 (15.4%)
60,001–80,000	3 (21.4%)	4 (30.8%)
>80,000	8 (57.1%)	6 (46.2%)
Subjective Assessment of Income		
Struggle to get by	2 (14.3%)	2 (15.4%)
Have enough to get by	11 (78.5%)	7 (53.9%)
Have more than enough	1 (7.1%)	3 (23.1%)
No response provided	0 (0.0%)	1 (7.7%)
Race/ethnicity		
Caucasian	13 (92.9%)	11 (84.6%)
African American	0 (0.0%)	1 (7.7%)
Latina	1 (7.1%)	1 (7.7%)
Highest Level of Education Completed		
High School/GED	2 (14.3%)	2 (15.4%)
Associate's Degree	2 (14.3%)	0 (0.0%)
Bachelor's Degree	6 (42.9%)	8 (61.5%)
Master's Degree	4 (28.6%)	2 (15.4%)
PhD or higher	0 (0.0%)	1 (7.7%)
Physical Activity Level*		
0 days	0 (0.0%)	2 (15.4%)
1–2 days	6 (42.9%)	3 (23.1%)
3 days	1 (7.1%)	5 (38.5%)
4–5 days	4 (28.6%)	3 (23.1%)
6–7 days	3 (21.4%)	0 (0.0%)
Self-reported Health Status		
Poor	0 (0.0%)	0 (0.0%)
Fair	0 (0.0%)	2 (15.4%)
Good	4 (28.6%)	3 (23.1%)
Very Good	7 (50.0%)	6 (46.2%)
Excellent	3 (21.4%)	2 (15.4%)
Parity (current or at most recent pregnancy)		
Nulliparous	7 (50.0%)	5 (38.5%)
Multiparous	7 (50.0%)	8 (61.5%)

**Notes:** \*The number of days per week a participant reported exercising. Data presented as Mean ± SD or # of people (%).



**Table 3** Healthcare Provider Characteristics

	Healthcare Providers (n=11)
Age (y)	39.11 ± 12.26
BMI (kg/m <sup>2</sup> )	26.5 ± 4.48
Sex	
Male	5 (45.5%)
Female	6 (54.5%)
Race	
Caucasian	11 (100%)
Highest Level of Education Completed	
Associates Degree	1 (9.1%)
Bachelor's Degree	0 (0.0%)
Master's Degree	1 (9.1%)
PhD, MD, or higher	9 (81.8%)
Job Title	
Obstetrician/MD	7 (63.6%)
Certified Midwife	2 (18.2%)
Postpartum Nurse	1 (9.1%)
Women's Health Physical Therapist	1 (9.1%)
Physical Activity Level	
0 days	1 (9.1%)
1–2 days	3 (27.3%)
3 days	2 (18.2%)
4–5 days	5 (45.5%)
6–7 days	0 (0.0%)

**Note:** Data presented as Mean ± SD or # of people (%).

and retention, highlighting the potential role of exercise in mitigating these concerns. Many pregnant women expressed that their primary concern is not necessarily the pregnancy weight gain itself, but the ability to lose what they gain after the baby is born. A woman pregnant with her first child said:

I actually had just started to lose weight when I found out I was pregnant. My best friend was getting married in July. February I started losing weight. And by April, I found out I was pregnant. My goal was 50 pounds [weight loss], I actually made it to like 46 before the wedding. But I do not wanna gain all of that back, and then, you know, have more trouble losing it again. That's a big worry for me, is that I would gain too much, and then be like, how am I ever gonna lose this back?

Postpartum women also expressed concern about weight gain and weight retention after birth, as well as the health implications associated with excessive weight

gain and/or retention. Postpartum participants described concerns about not only losing pregnancy-related weight gain but also continuing to gain weight after giving birth as a result of poor lifestyle choices, as one postpartum woman said:

It is harder to get active again. And if you do not find yourself like getting up and just doing little things, you find yourself gaining more weight because you have that tendency to like, continue to eat because that's what you are used to, because you are just carrying a child. So you do not think, oh, I am no longer pregnant, I probably should not be eating like this anymore.

Participants identified lifestyle habits, mental health challenges like depression, and childcare responsibilities as reasons they continued to gain weight after birth. An obstetrician who has been practicing in the community for over 30 years noted that the implications of weight gain during pregnancy extend beyond the current pregnancy, particularly considering multiparity with short intervals. Pointing to an example of a prenatal chart, he noted:

And their next pregnancy weight will be at the top there. And I have had women where I had three pregnancy flow sheets. This weight [end of pregnancy 1] was that weight [start of pregnancy 2]. Then this weight [end of pregnancy 2] was that weight [start of pregnancy 3].

This physician and others expressed concern about weight gain and the implications of weight retention over time and over multiple pregnancies. Healthcare providers also emphasized the complexity of working with pregnant women who are experiencing weight retention or obesity, as well as how commonly they are faced with providing care for these patients. One healthcare provider explained:

I mean, first of all, we have a lot of patients coming into pregnancy, you know, in the overweight or obese categories to start with. And of course, that we have a little bit different guidelines for ideal weight gain. So, yeah, that's a struggle. If I had to just, off the thumb, two thirds of our patients [are overweight or obese]. It's a struggle.

Another obstetrician described how it is easy to motivate pregnant women to be active, but motivation decreases during the postpartum period, suggesting an important opportunity to make an impact on lifestyles during this critical time period. He said:

I had one patient who was diabetic and was obese, she lost 50 pounds during the pregnancy just being on her diabetes

**Table 4** Pregnancy Focus Group Responses

Question	Theme	Examples
Do you worry about the risk of gaining too much weight or sitting too much during pregnancy?	Pregnancy-related health concerns	<p>"My job, I sit, like you cannot stand and see clients. I mean I have, but it's not- so I worry. I do worry about sitting too much and how it will eventually, as I grow, how it will cramp everything up and I slouch a lot more. So I am like, wondering if I am like suffocating the baby. But I know like some of the risks of like being sedentary are like, higher rates of cholesterol and higher blood pressure and higher, like higher weight gain. And I do not want to ... yeah."</p> <p>"I was really sick in my first trimester. Like, I could not get out of bed. I was sick all day, every day. And I did not exercise at all, like at all. I have just recently started walking every day trying to do like a mile or two, but I am going to ease in, try to do more eventually. But I was really worried about like laying in bed and sitting all day because, you know, I know that you are supposed to get exercise, but I was not doing any of it."</p>
	Issues with weight control	<p>"I actually had just started to lose weight when I found out I was pregnant. My best friend was getting married in July, February I started losing weight. And by April, I found out I was pregnant. My goal was 50 pounds, I actually made it to like 46 before the wedding. But I do not wanna gain all of that back, and then, you know, have more trouble losing it again. That's a big worry for me, is that I would gain too much, and then be like, how am I ever gonna lose this back?"</p> <p>"Well I just know, this time around I was less active than I was my first pregnancy, partly because I am chasing a toddler and a couple of years older and just work and all the demands. And I have noticed that I know- I have gained more weight this time, which I am not happy about." (Theme 1: Physical activity as critical for weight control)</p>
Why is it hard to get exercise after baby?	Pregnancy related symptoms/ physical limitations	<p>"And then I just feel like my lung capacity, like because of everything that's changing. I just feel like it's harder to breathe."</p> <p>"I couldn't- I'd walk outside and try to walk and I'd puke because I got hot."</p> <p>"Especially when your body, like when your belly changes and your center of [gravity]. Because I mean, I climb in and out of the ambulance and I have been doing it for 8 years. But I feel out of the ambulance the other day because- trying to get my leg up that high to climb in it."</p>
	Uncertainty about what to do	<p>"Do not know how hard to push it. Like I am really like- I will push it til I am, like, laying on the ground. It's like, okay, we need to step back a little bit, like we are not doing that right now. That's not the goal. And knowing that, like, okay I can do this weight but should I? Is it going to hurt the baby? Is it going to hurt me?" (Theme 2: Need for evidence-based exercise information)</p> <p>"I have stopped doing speed workouts because of like, I do not know how intense I can go. And I have stopped doing a lot of strength training because I do not know what moves I can do. And I Google things and like research things. And I found this YouTube video of a woman doing these Pilates exercises. And it was every- like once she started doing it, it was like everything I read that you should not do. So I was like, I just do not know." (Theme 2: Need for evidence-based exercise information)</p> <p>"Yeah, I'm on what to expect. They tell you like safe sleep positions, and sex, and non-stress, but they don't really tell you what you need, like what type of exercise would be most beneficial."</p> <p>"I think my concern is, like, it's similar to yours in that I do not really know what I can do. And I also do not trust an instructor- like if it's a group class to be able to tell me if it's appropriate for my body because I have had people tell me something that's appropriate and then it does not feel right. Or ... And the other thing is that I think like a lot of exercise programs are created for a biological, like a biologically male pelvis, and they are not necessarily created for a female pelvis. So why would they be OK for a pregnant woman either? So there's just like general concerns in terms of how somebody can actually instruct me." (Theme 2: Need for evidence-based exercise information)</p>

(Continued)



Table 4 (Continued).

Question	Theme	Examples
	Uncertainty about what your body is telling you	<p>"That piece of advice is totally discouraging because your body is doing something completely different than it has ever done before. So 'listen to your body' is like, I don't know what the hell my body is doing" (Theme 2: Need for evidence-based exercise information)</p> <p>"I know sometimes I cramp when I run. And I do not know if I am like constipated, because that's like constant too or if it's like the pressure of the baby, like this is the first. I am not- I am also not familiar with like what sensations are normal or not. Like nothing happens, I thankfully have not bled. But like when I, I ran a half marathon a few weekends ago and like the entire time I was like, I was a little crampy so I was like, am I killing- am I doing something really, really, wrong? Everyone tells me I can, but like, is this normal? Is this not normal?" (Theme 2: Need for evidence-based exercise information)</p>
	Logistical concerns/time/work/other children/lack of support	<p>"I have been very tired this pregnancy. Like I do not remember with the first pregnancy being so tired and I exercised a lot with him, did great with him. But now it's like, you cannot- I cannot wake up early to do it, I cannot stay up late. He's almost three and I am chasing him around and I am just tired."</p> <p>"But I have a 4-year-old at home, so I still have to be a mom at the same time. He goes to preschool 2 days a week, he's with me the rest of the time. So there's not a whole lot of sitting."</p> <p>"Because especially, you know, if it comes around- my second pregnancy, I'll have a child I'm chasing."</p>
	Fear of causing harm to the unborn baby or themselves	<p>"I was waiting tables when I first found out I was pregnant. And it was nothing for me to lift 5-gallon buckets of ice. And here I am, you know, 3 months pregnant. And they are like, what are you doing? And I am like uh- oh! You know. So I do not necessarily think about, right off the bat, oh, I should not be doing this. And then you think afterwards, of, did I do something to hurt the baby? So you have that fear of not knowing what level you should go to." (Theme 2: Need for evidence-based exercise information)</p>
	Lack of motivation	<p>"Well, the first trimester, it was really hard for me just to get the motivation to go, not, like once I got out I felt like I could do it but the motivation. The second I did really good, like I was running 5-6 miles. And then when I hit about 26 weeks, I was down to about 1-2 miles."</p> <p>"I'm very much, you know, like a goal person. Like, if you have something that says, OK, you need to walk a mile today, ok I'll walk a mile today. Or you know, something like that. But I've lost all motivation to get up and go." (Approaches for addressing concerns through key mobile app features)</p>
What things could make it easier?	Community/support system	<p>"Also, like if you had someone, like if your partner wanted to do it with you because it's always- for me, it's a lot easier to do stuff if I got someone doing it with me." (Approaches for addressing concerns through key mobile app features)</p> <p>"Maybe a way in the app you can link to other people in your area that even if it's not- even if you can't meet up, you can still be like, oh well I've walked today. Have you done what you're supposed to do?" (Approaches for addressing concerns through key mobile app features)</p>
	Knowledge about what do to and how to do it	<p>"The other thing I was thinking of in regards to like pregnancy movement is, what are some movements that you could do that would be specific to helping your body birth the baby? So like, you know, not just keeping yourself healthy, but like how can you strengthen your abdomen, your pelvic floor, to help?" (Theme 2: Need for evidence-based exercise information)</p>
	Convenient, time-efficient workouts	<p>"I think ways to do stuff around the house with like .... Because, I mean, I know, like, when we were in high school, like working out for softball and tennis and stuff like, they'd be like go get a kitchen chair and do this against each chair and stuff like that. Maybe stuff to, if you have this at your house, you can use this to do that."</p> <p>"But, like, 15 minutes is probably all that I'll have to myself."</p>

(Continued)

Table 4 (Continued).

Question	Theme	Examples
What features would you like to see?	Goal tracking and progress tracking for encouragement	<p>"I'm a very visual person too, I like that- like again, closing the rings. Like visualizing it. So like something with check marks or something, like each week you met your goal, 3 out of 3 workouts or whatever the goal is." (Approaches for addressing concerns through key mobile app features)</p> <p>"Kind of like a goal oriented thing. Like, because I have already been told that I am at risk for preeclampsia, I want to be able to work, like work to- I want to be able to track how I can improve, I guess, throughout the time and hopefully reduce the chances of anything bad happening."</p>
	Push notifications and reminders	<p>"I like them. They motivate me. They really do." (Approaches for addressing concerns through key mobile app features)</p> <p>"I like those, because if I'm like, oh you're almost there, to close all your rings, I'm like okay. I'll just get up and like walk around the house or something. Just like close my rings." (Approaches for addressing concerns through key mobile app features)</p>
	Community component for support and accountability	<p>"I do not like to exercise alone ... Support is a big thing. Like I have always had an exercise partner if I want to go exercise. So that's one thing, you know, my mom was always the person who went with me. She's still around, but she's not in great health either, so we cannot- we cannot do the same things anymore. And so that's, that's one thing that kind of makes me go, eh, I think I will just sit here instead." (Approaches for addressing concerns through key mobile app features)</p> <p>"So I go to those forums a lot, like what to expect when you are expecting and read about other moms and what they are going through. And if I were to see like, hey, I am a runner. I cannot run anymore, but here's some really beneficial workouts I am doing that might- we are both due in March. Maybe this would be good for you too. So you'd be able to talk to other moms about stuff they are doing. I do like that a lot." (Approaches for addressing concerns through key mobile app features)</p> <p>"Like if you had someone, like if your partner wanted to do it with you, because it's always- for me, it's a lot easier to do stuff if I got someone doing it with me. You know, like me and my mom have been walking together every day and she needs it for her reasons and I need to do it for my reasons but it does help a lot." (Approaches for addressing concerns through key mobile app features)</p> <p>A community-based social feature may also motivate some women through friendly competition, as one woman, pregnant with her first child and working full time as an elementary teacher, suggested, "Okay, I need to do it. [She] did something and she felt like crap today and she still worked out." (Approaches for addressing concerns through key mobile app features)</p>
	Individually tailored, time efficient workouts with video demonstrations	<p>"If you have the flexibility, you can account for how a pregnant woman is feeling in a day and that's forever going to be changing. So I think that the flexibility is nice, but I also like the structure of like knowing that you are getting a well-rounded workout." (Approaches for addressing concerns through key mobile app features)</p> <p>"You could have different, you know, someone could self-identify and say, well, I am a very active person, and maybe someone's more medium range and then a light range. And then if you classify yourself, whatever range, and then it could give you different ideas for different daily things. So you are not just doing the same thing every day because you are like well, I do not know what else to do. That it would give you some ideas tailored to your kind of activity level group." (Approaches for addressing concerns through key mobile app features)</p> <p>"I like videos for a workout because I am not good at picking stuff out for myself. Like I need someone to set something up for me to hold me accountable Cause I am not good at being like, oh yeah, that's good for my arms or my legs. Like I need someone to assign that stuff. I have never been good at planning it out myself." (Approaches for addressing concerns through key mobile app features)</p>

(Continued)

Table 4 (Continued).

Question	Theme	Examples
	Evidence-based information	<p>"I do use YouTube, but if I'm using YouTube then I'm scrolling and then wondering like well is that appropriate? Is this a trustworthy lady?" (Theme 2: Need for evidence-based exercise information)</p> <p>"Like getting expert feedback is very important to me. I've heard from the mommy groups and just all that, there's so much misinformation." (Theme 2: Need for evidence-based exercise information)</p>
	Education and exercise safety	<p>"And like I would like to know, and this is very detailed, of what, how long can I go at my max heart rate? Well, there is one study I read that said you were, they did, they did on female sheep that at 90% of their heart rate, the baby stopped getting oxygen ... I have been digging and digging and digging. Like what is, what is too much?" (Theme 2: Need for evidence-based exercise information)</p> <p>"Like how- how do you change the way you lift, like it's supposed to be hips a little more forward than back, you know, things like that. No one really instructs you on that." (Theme 2: Need for evidence-based exercise information)</p> <p>"We all have that concern as to where should I push myself to. To be like, okay I feel this way, but I feel like I could do more at the same time. Being able to have that interaction on the other end that knows what they're talking about." (Theme 2: Need for evidence-based exercise information)</p>
	Symptom tracking	<p>"I think you definitely need that because I am almost through my second trimester and I still have the days of oh my gosh, I am so nauseous. I am so tired. I have had a lot of dizzy spells, to where every time I stood up I would have to sit back down immediately. So, I mean, you know in that situation, I do not wanna get up and exercise, I am going to die. You know, I was waiting tables and I did not know to limit myself yet because here I am, you know, 8 weeks pregnant, why am I limiting myself? And I passed out in the middle of the restaurant." (Approaches for addressing concerns through key mobile app features)</p> <p>"I was the first person at that office the other week, and there were 3 people who came in and they were all there for an 8 am appointment with her. And I was like oh, so we are triple booking, which sounds terrible for her. So, like, I do not- I have waited for 45 minutes by the time she gets there. I know it's only gonna be a 5-minute appointment. So it'd be nice to have a note to say like, oh this is what I experienced when I was working out. Because by the time she gets there, I was like yeah, everything's great. Nothing really to report. And then I leave and I am like, oh shit, there's like 45 things I wanted to tell her." (Approaches for addressing concerns through key mobile app features)</p> <p>"And so maybe getting that feedback, being able to tell ... It's okay to feel sick right now. Don't feel like you have to do it if you feel bad." (Approaches for addressing concerns through key mobile app features)</p>

diet. But as soon as that baby was born, she went back to her old ways and gained all of that weight right back. And that's the key; trying to keep people motivated. And like I said, sometimes they will do things for the child that they would not do for themselves.

Taken together, participants among all groups expressed concerns about weight control during and after pregnancy, and all supported the idea that exercise could potentially mitigate these concerns. Taken in the context of the Health Belief Model, it appears that women view themselves as susceptible to the effects of sedentary behavior, and that these can have serious consequences

(ie, severity).<sup>31</sup> However, exercise must be prescribed carefully and properly to be effective for pregnant and postpartum women. As described below, this need for evidence-based information from a trusted source constitutes a key concern for participants.

### Theme 2: The Need for Evidence-Based Exercise Information

To increase exercise during pregnancy and postpartum, participants described a need for high-quality, evidence-based, trustworthy exercise information from qualified professionals. Pregnant and postpartum women indicated

**Table 5** Postpartum Focus Group and Interview Responses

Question	Theme	Examples
Do you worry about gaining too much weight or sitting too much after having a baby?	Weight retention and continued weight gain during postpartum	<p>"I do, because I do. I gained- obviously I gained weight when I was pregnant. And part of that was I had some back issues because of the weight gain during my pregnancy. So for me right now, the weight gain ... I do not worry about gaining weight after having him, but I do worry about like sitting here. I am not getting very many steps in during the day. I am not very active. So I am worried about like still that back hurting because you are not really losing weight. And then I also worry about just sitting here, you start becoming a little hunch, especially with breastfeeding. So, you know, I do worry about that." (Theme 1: Physical activity as critical for weight control)</p> <p>"It is harder to get active again. And if you, if you do not find yourself like getting up and just doing little things, you find yourself gaining more weight because you have that tendency to like, continue to eat because that's what you are used to, because you are just carrying a child. So you do not think, oh, I am no longer pregnant, I probably should not be eating like this anymore."</p>
	Biometric sickness	"Gaining too much weight obviously. High blood pressure, gestational diabetes, just long term, just not being able to get the weight off, obviously, which leads to long-term health problems. Sitting too much. I mean, really, I think it can like increase your chances of having things like hemorrhoids."
	Physical discomfort or issues	<p>"I do, I have worried about sitting too long, because I went back to work at two and a half weeks, so that was part time and it was flexible. But I had the responsibilities and I did have to sit and take care of stuff. And now my- her birth was very, I did not rip. I did not have any surgical things. It was very -I can bounce, my body bounced back. If you could call it that, healed very quickly. But I could still tell that sometimes I kind of like- my body almost hurt from having sit too long."</p> <p>"The combination of trying to eat enough to sustain life for your baby, plus finding energy throughout the day. I know the first month or so for me, I felt like I was a zombie and having enough time and energy to actually work out was really tough. But also at the same time making sure that you are not using that as an excuse to eat everything in sight. But at the same time, you are tired."</p>
	Mental health and PPD	<p>"I think that like, probably the biggest risk would just be even like your mental health with it. Like after I had [my baby], I would notice like, if I was just like- I always joked that I had my square on the couch and I just wanted to stay there, all the time. And I think you can get into kind of like a habit, almost like ... and like it can affect your mental health."</p> <p>"I definitely feel 100% better if I am working out. You know, postpartum. I mean a hundred percent like, you just feel better. Not even like weight wise, just your brain is stimulated and you feel energized. Yeah."</p>

(Continued)

Table 5 (Continued).

Question	Theme	Examples
Why is it hard to exercise after having a baby?	Logistical Concerns	<p>"Yeah, I mean, there's like a window. There's like smaller windows of time where your baby needs to eat or he's gonna be awake and needs your attention so then, there's like that little window where they nap. So, I mean, there's all kinds of excuses."</p> <p>"I think like you are so overwhelmed, like right after you have a baby. Not that you do not worry about it. But I can remember just thinking like one hour at a time, one hour rotation at a time. And like, I remember thinking like, I need to exercise, but like, I just do not have time. Like, I was like, I do not know, when on the three hour rotation I would even fit it in. And then when you first do ... When I was first postpartum like right after I was released from the doctor, like I would start walking and stuff in the mornings, and that always did make me feel better."</p> <p>"I think it's hard because you are. You do not think about. In my experience- you focus so much on, are the other kids adjusting well to the baby, is the baby doing well, is everything being taken care of. And then you kind of just worry about yourself in a minimal way, which is yeah, for me you'll be- am I sleeping enough, am I eating or drinking enough water because I am breastfeeding, my health directly affects her health. So. And then the exercise part. I mean, I am just worrying about sleeping enough hours. Like thinking the extra stuff is just harder."</p>
	Fatigue and other physical recovery issues	<p>"I can remember wanting to go exercise. And then as soon as I would, I would like push it too far and it would make me like exhausted or sore or whatever. Even just basic walks. Like I can remember, as crazy as it is, even going to the grocery sometimes and like, like getting sore from it."</p>
	Lack of guidance over what you can and cannot do	<p>"I feel like there's a lot of things that are like, exercises you should do when you're pregnant. But there's not a lot like right after, like postpartum because there's still things that are like healing and recovering." (Theme 2: Need for evidence-based exercise information)</p> <p>"Especially the ab exercises. I was like, am I gonna hurt myself doing that? Like, I did not really have anybody to go to, to be like, is this OK? I mean, I felt OK, but they always make such a big deal out of that. Just, that would be kind of cool to have you know, these are the exercises that you could do and these are the exercises that you should wait four months, or however long to do." (Theme 2: Need for evidence-based exercise information)</p> <p>"So, just knowing what I can do, what I can't do, and then the opinions of others, because sometimes they make you feel bad and you're like, I probably should go sit down. I don't want to have a setback or whatever, but that's probably, probably it." (Theme 2: Need for evidence-based exercise information)</p>
	Priorities	<p>"I'm just worried about sleeping enough, thinking about the extra stuff is just harder."</p> <p>"And I can remember some moments like when I feel really overwhelmed. I'm like, you know what, like for this first year, I just can't fit that in right now. You can only fit so much in and I felt like that's just something I have to take off my plate."</p>

(Continued)

Table 5 (Continued).

Question	Theme	Examples
What would make it easier for you to exercise after having a baby?	Guidance on what to do/how to exercise properly	<p>"Well it's kind of weird because you go to your 6-week appointment. She's like everything looks good, see you for your annual, and you kind of feel like you are just thrown to the wolves ... So that's it, like I just have to go on with my life and I am not going to see you?" (Theme 2: Need for evidence-based exercise information)</p> <p>"Especially modifications. Because with me, I have a lot of back problems anyways with my sciatica, and I also have lupus and fibromyalgia. And so any, just getting up and being active as hard as it is with these rugrats running around is pretty much my exercise." (Theme 2: Need for evidence-based exercise information)</p> <p>"And if somebody could, like, offer me something, it would be like, like what reps to do. Like I feel like at one point if I had a set like routine of 30 reps of ABCDE and F and do that every day, and it would at least help tone or maintain or something. I would have done it because what would happen is, I would get those things and then like I would not know what to do." (Theme 2: Need for evidence-based exercise information)</p>
	Time-efficient and convenient videos or workouts	<p>"Well, the hardest thing is just finding the time and the mental commitment to do it, I guess, because usually when you have a chance and the baby is napping and you feel like you have the opportunity to work out, you feel like you need to do all the other things, the dishes, all the laundry."</p> <p>"I do all my workouts in my living room at home ... because of my husband's work schedule and breastfeeding and all of the things, that's the only possible way I can workout."</p>
	Additional support from others	<p>"I think what would make it easier would be. Having the support of someone that could watch the child while I maybe took a walk around the block. If it was cold or raining, they could not come or just knowing that they are secure in their crib or in a swing. So I could do a 15 minute workout video, something on those lines."</p> <p>"So having the support, like having, like have friends coming together, say, hey, we're gonna do this together ... But I really feel like groups helping each other is the best. It's just easiest." (Approaches for addressing concerns through key mobile app features)</p>
What features would you like to see in a mobile app?	Structured plan with videos	<p>"If I don't follow a schedule and regimen and I try to skip around, I won't be successful." (Approaches for addressing concerns through key mobile app features)</p> <p>"It's so hard, because even with structure stuff, it's almost like you want accountability, so you want the structure, but you cannot, you cannot help all this stuff coming up happening. Because during this phase of your life, you have got so many dependents and so they get sick or this or that happens. So, you know, we had to cancel all my plans this week from Friday to Sunday because 2 of the kids got pinkeye on Thursday. So when I picked them up from their dad, that Friday was just taking care of them. Nothing, nothing got done." (Approaches for addressing concerns through key mobile app features)</p> <p>"But yeah, definitely videos because I worry a lot about when it comes to exercising. I like, I am normally very active. I like having fun and, like do cartwheels, all that kind of fun stuff and rock climbing. But when it comes to doing a set of exercises, maybe with the weights or like Pilates or something like that or yoga, I do worry about form. I feel like if you do it wrong, you are actually hurting yourself. So video does help." (Approaches for addressing concerns through key mobile app features)</p>

(Continued)



Table 5 (Continued).

Question	Theme	Examples
	Education for easing back into exercise, teaching them what they can and cannot do	<p>“Or like just as far as milk supply, like are saunas bad, like should you try not to, like sweat, is cardio worse than weight training. So that would be good because it's like, the one thing I do worry about exercising while nursing. And then just certain, like there's certain target areas after you have a baby.” (Theme 2: Need for evidence-based exercise information)</p> <p>“You know, for what's hard with postpartum women is your body has changed so much even from if it's your first child to your second or third child. I mean, my body's been different every single time. So I know a workout that I did four years ago before I was pregnant is probably not going to do the same as it was then to now ... Because my body is so different. So it'd be nice to have that education, that helpfulness. You do not hear a lot of people talk about pelvic floor, but that's important after you have a baby when you are postpartum.” (Theme 2: Need for evidence-based exercise information)</p>
	Progress tracking/goal tracking/workout tracking	<p>“My phone is very important. So something was giving me reminders and what not.” (Approaches for addressing concerns through key mobile app features)</p> <p>“I definitely would like to have something that kept obviously the history, where I started and where you I am now, almost like a progress tracker ... And again, for me, because my brain's so scattered, just really just that progress. What did I do the other day? I cannot even remember, let me look on my app and see what workout I did or, you know, some people probably would want like food or water intake. But for me, that's not the most important part of that.” (Approaches for addressing concerns through key mobile app features)</p>
	Push notifications/reminders/encouragement that they are doing well	<p>“You go to your phone and have like, a little encouraging message that encourages you to work out and be better for you and the baby.” (Approaches for addressing concerns through key mobile app features)</p> <p>“Exactly. With the amount of other things we're worrying about, that'd be nice to have a little reminder.” “I think postpartum people just need encouragement that they are doing a good job. Or even trying.” (Approaches for addressing concerns through key mobile app features)</p>
	Community support/forum	<p>“I think that postpartum women are too are always looking for people that are in their same boat.” (Approaches for addressing concerns through key mobile app features)</p> <p>“You have people to relate to. You know, like if you had a group that was like, all the babies born in August, all the babies born in September. I think I'd be more motivated if I had more people, like in my same boat.” (Approaches for addressing concerns through key mobile app features)</p> <p>“Yeah. Just to hear somebody be like ‘I didn't work out because I was overwhelmed that I wanted to cry’ like, OK. It's not just me.” (Approaches for addressing concerns through key mobile app features)</p>
	Symptom tracking and workouts based on how they feel	<p>“Like you are not feeling- yes, I think that'd be good. Especially like going back to like, it depends on how postpartum you are because like right now, obviously, I am in a whole different state than I was, you know at eight weeks or even six weeks. So yeah, that would be good.” (Approaches for addressing concerns through key mobile app features)</p>

(Continued)

**Table 5** (Continued).

Question	Theme	Examples
	Mental health checking	<p>"I would include something as far as mental, like the mental health component because. You are not alone. Sometimes it's like even if it's just something just encouraging you. I know this is tough, Mom, but you got it. You know, it does not have nothing where you have to sit here and read and you have a full reflection, but just a little pop up. You got this, you know, keep it going because, you know, it's work. It's hard. It's hard. And if you do not always have that support, you do not know how much an app just saying there is enough support to keep you going, you know." (Approaches for addressing concerns through key mobile app features)</p> <p>"I think that the emotional section, I think that would be really helpful. I think the tips would be nice. Notifications would probably be good. Even for the emotional stuff, I think that that would be nice, like maybe you are just crying in the shower for the third time in a day or something. You go to your phone and you have like, a little encouraging message and then encourages you to work out to be better for you and the baby. I think that, you know." (Approaches for addressing concerns through key mobile app features)</p> <p>"Is there anything [in the plans for the app] in there for like postpartum depression? I both suffered from it with him. When he was in the NICU obviously we felt our hands are tied. We cannot really do anything for him. We cannot hold him. We cannot- we cannot. We cannot really be his parents. We could not even change his diapers or anything. We could not touch him. No stimulation, period. He had a tube down his throat and everything. So it was rough .... But with him- it hit hard. Like I have never experienced depression ever, ever .... Or something [an app feature] to keep your mind off the negativity. Like to keep the negative thoughts out of your head." (Approaches for addressing concerns through key mobile app features)</p>

a desire to know explicitly what frequency, intensity, time, and type of exercises they should be doing at specific time points of pregnancy and postpartum. According to our participants, this information is not readily available to them currently. Many women stated that they often did not exercise because they were unsure of what to do, and this uncertainty contributed to a fear of causing harm to themselves or their child. Taken in the context of the Health Belief Model framework, women perceived a high level of risk and believed this risk may outweigh the perceived benefits; thus, likely limiting their decision to participate in physical activity. A woman pregnant with her first baby stated:

I think my concern is, like, it's similar to yours in that I do not really know what I can do. And I also do not trust an instructor- like if it's a group class to be able to tell me if it's appropriate for my body because I have had people tell me something that's appropriate and then it does not feel right. Or ... And the other thing is that I think like a lot of exercise programs are created for a biological, like a

biologically male pelvis, and they are not necessarily created for a female pelvis. So why would they be OK for a pregnant woman either? So there's just like general concerns in terms of how somebody can actually instruct me.

Women also reported that existing resources and information fail to clearly describe recommended levels of regular daily activities. For example, a restaurant server, who was three months pregnant with her first child, discussed her uncertainty of the safety of physical exertion:

I was waiting tables when I first found out I was pregnant. And it was nothing for me to lift 5-gallon buckets of ice. And here I am, you know, 3 months pregnant. And they are like, what are you doing? And I am like uh- oh! You know. So I do not necessarily think about, right off the bat, oh, I should not be doing this. And then you think afterwards, did I do something to hurt the baby? So you have that fear of not knowing what level you should go to.

**Table 6** Provider Focus Group and Interview Responses

Question	Theme	Examples
Are your patients inactive? Is this something you are concerned about?	Majority of providers expressed concern	"Yeah, I mean, that, that's the- I mean, first of all, we have a lot of patients coming into pregnancy, you know, in the overweight or obese categories to start with. And of course, that we have a little bit different guidelines for ideal weight gain. So, yeah, that's a struggle. If I had to just, off the thumb, two thirds of our patients. It's a struggle."
	Some are very active, some very inactive; there is a mixture of patients	"A lot of them are very much inactive." (Theme 1: Physical activity as critical for weight control)  "They are under the mindset that I am pregnant. I'm building the baby. So I don't really have to do anything after that." (Theme 1: Physical activity as critical for weight control)  "If they aren't doing it before pregnancy, they don't pick it up." (Theme 1: Physical activity as critical for weight control)  "There's a lot of variation. I mean, we do have some that are very health conscious that come into the pregnancy, really having a set exercise program. And you know, in those patients, I mean, with proper reassurance that they can safely do quite a bit, they continue on with that. Others, you know, just, just getting them to get from the chair to the exam table is as much as they are going to do." (Theme 1: Physical activity as critical for weight control)
	Cultural influences and misconceptions among patients	"Because, of course, almost all women are worried about weight gain. It's just ingrained in us. That's how it is. So women talk about weight gain a lot. And when they asked me about exercise, there is a lot of fear and worry. Like what- what can I do that's safe?" (Theme 1: Physical activity as critical for weight control)  "It's something hard because you know, every culture says you're eating for two, and pregnancy cravings aren't usually healthy." (Theme 2: Need for evidence-based exercise information)
	Bigger issues to deal with	"... just with all the things you have to cover, it's not a huge part of what we do"  "Well, with weight gain, I mean, my first thing is what have you been doing? I've got my basic talk for their OB visit. It's probably not as in-depth as maybe it should be, but it just kind of gets buried in all of the other education we have to do."
Do you have specific strategies to help your patients control their weight?	Focus more on diet	"I try to talk to them first about what they're eating and diet, because that has a lot to do with it."
	Routine weight checks	"I will say today your weight was this and you have gained one pound since you were here last time and you have gained 10 pounds since your very first visit with us. And I do that every visit. So that's just part of a routine of what I say. And they get used to hearing me address weight. And again, I do not care if their starting weight was 125 pounds or 300 pounds, I still address it with the exact same manner."  "I try not to overreact about weight gain. I just try to look at the big picture, look at other things they're doing that are healthy habits."

(Continued)

**Table 6** (Continued).

Question	Theme	Examples
Do you have specific strategies for encouraging physical activity?	Not really something covered	"It's probably not as in-depth as it should be, but it just kind of gets buried in all the other education we have to do."
	Continue to do what they are already going, if inactive, do not start doing something new	"Well, again, you know, starting what they are able to do and what they are doing currently. I mean, if they say I have got a gym membership, I have been going, ok, build on that. If they are really not doing anything, I mean, start with the basics. Everyone can walk." (Theme 1: Physical activity as critical for weight control)
	Integrate activity into daily life	"What I try to do is tell them that when you are going to your normal routine things incorporate the newer things into it. So like if you are going to shop at the mall, maybe instead of parking as close as you can, park as far away as you can, and little things, like or maybe take stairs instead of using the elevator. Sometimes during pregnancy, it's harder to get patients to do that because they do have that decreased volume of their lungs and so they get dyspnea upon exertion a little bit easier." (Theme 1: Physical activity as critical for weight control)
What features would be best for a mobile app?	Activity logging and goal tracking	"I think a diet log. Something that's easy to log what they're eating and when they're eating would be really helpful." (Approaches for addressing concerns through key mobile app features)
	Information about appropriate weight gain and patterns	"If there were something like in the app where they put in their pre pregnancy weight and height to calculate the BMI and then it gives the recommendation for total pregnancy weight gain based on their BMI, because it's different for each category, and then they know." (Theme 2: Need for evidence-based exercise information) "Well, and the realization that that weight gain is not linear." (Theme 2: Need for evidence-based exercise information)
	Education about safe exercises and what to avoid tailored to week of pregnancy/postpartum	"... suggestions for the exercises that are safe in pregnancy, or like the exercise of the day, like a yoga move that like would be helpful for like low back pain if they are, you know- like targeted to what week they are at. You know, if maybe they are at 33 weeks, the yoga move that would be more helpful than something at 10 weeks." (Theme 2: Need for evidence-based exercise information)
	Push notifications with reminders and encouragement	"So, you know that just those little reminders for those moms, cause there's all kind of negative things out there, so we just need some more positive things to combat all that." (Approaches for addressing concerns through key mobile app features)
	Symptom tracking with notes about when to contact the provider	"I don't know how to say like symptom tracker, but like if they're monitoring their diet, are there things that, they kind of pattern over time. Like oh, this usually doesn't make me nauseous, or, oh, I noticed that I've had heartburn these few nights." (Approaches for addressing concerns through key mobile app features)
	Simplicity for the patient to understand	"Our clinic is very diverse in a lot of different ways. You know, language and educational status. We got patients that are very simple. That, you know, they get their hands on a lot of stuff that the typical person may understand clearly that's right over their head." (Approaches for addressing concerns through key mobile app features)

(Continued)

**Table 6** (Continued).

Question	Theme	Examples
Should providers be able to view data from the app?	Majority say no, they already have so much information and data with limited time.	"It is really utilizing a finite amount of time, and deciding which is the best way to use that time. So again, if this is very awkward, if we have to sign into something and dig something up and we have to spend five minutes for a patient, it will not be utilized."

Women described the physical activity advice given by their healthcare providers as arbitrary and not particularly helpful, as described by a pregnant participant:

That piece of advice [to listen to your body] is totally discouraging because your body is doing something completely different than it has ever done before. So "listen to your body" is like, I do not know what the hell my body is doing.

Women reported similar perspectives after having a baby, as one postpartum woman stated:

Well it's kind of weird because you go to your 6-week appointment. She's like everything looks good, see you for your annual, and you kind of feel like you're just thrown to the wolves.

Consistent with their patients, healthcare providers admitted that they seldom provided exercise education during or after pregnancy as part of routine care. As one obstetrician said, "... just with all the things you have to cover, it's not a huge part of what we do", indicating that during prenatal care, obstetricians tend to focus on what they view as more critical issues, for example, smoking cessation. In addition, healthcare providers report feeling unable to discuss physical activity due to the demands of clinical productivity, which limit the amount of time they can spend with each patient, which is particularly relevant in rural areas where healthcare provider shortages exist. Another obstetrician admitted that he did not sufficiently discuss exercise with his patients:

Well, with weight gain, I mean, my first thing is what have you been doing? I have got my basic talk for their OB visit. It's probably not as in-depth as maybe it should be, but it just kind of gets buried in all of the other education we have to do.

As pregnant and postpartum women are provided with more evidence-based physical activity information, many common misconceptions about exercise during pregnancy

will be dispelled. Misconceptions about exercise during pregnancy came up in data collection with pregnant women, postpartum women, and healthcare providers. Healthcare providers expressed concern about how these misconceptions exacerbate certain unhealthy behaviors during and after pregnancy. For example, a pregnancy and postpartum nurse educator discussed how she addresses pregnancy parking spots with her patients, "You know. Here's another myth. You know, those parking spots that are there for you. Don't park in them. Park and walk." Many patients reinforced healthcare providers' concerns, harboring misperception that physical activity is potentially dangerous for pregnant women and their unborn children.

Healthcare providers also expressed concern that cultural and social misconceptions may be encouraging pregnant women to consume far too many calories while also not burning enough through physical activity. One obstetrician with 34 years of experience said, "They are under the mindset that 'I am pregnant. I'm building the baby. So I don't really have to do anything after that.'" Providers often mentioned additional problems with energy balance stemming from the misconception that pregnant women should be "eating for two." Healthcare providers acknowledged many challenges associated with overcoming cultural ideas and expectations, as these messages are widespread and embedded into everyday life through word of mouth and media.

Pregnant and postpartum women report receiving information suggesting they should limit movement after having a baby, and some women reported that friends or family members showed disapproval of exercise routines or encouraged them to rest. On the contrary, most healthcare providers suggest that moving early and often will facilitate an improved recovery after delivery. Healthcare providers discussed how communication can and should be adapted to better reflect the reality that moving after delivery can be helpful. One postpartum clinical nurse and nurse educator said:

I really think changing the mindset of all these moms is super beneficial and reminding them that they can do that [exercise] despite what was done 20 years ago ... I think that they need to know. First of all, it's OK to get up and move. You know that they need that little you know- this is why it's good to get up and move like that. This is how it helps your body. This is what it does for you. It helps your sleep. You know, like all those kind of things. So they need to know that they can do this .... It's like I tell our C-section moms, hey we need you to get up and walk the hallway, they are kind of like, I can do that? And we are like yes, it will help you. Yeah, it will help you, and so I think if we can get that message across, that could be really good.

Taken together, women and healthcare providers expressed that common misconceptions about physical activity during and after pregnancy may limit women's willingness to be physically active. The need for evidence-based exercise information that supports overall health and encourages weight control led to our final set of insights, developing mobile technology to improve physical activity levels among pregnant and postpartum women.

### Approaches for Addressing Concerns Through Key Mobile App Key Features

Participants identified a number of desired app features to increase physical activity during and after pregnancy, many of which address the concerns described above, and nearly all of which fall under proven theories for behavior change such as the Health Belief Model.<sup>38</sup> First, participants described the ways in which progress tracking and goal setting help women meet evidence-based fitness and weight control goals. One pregnant woman who already uses mobile technology to assist with her exercise levels stated that having an exercise goal to obtain motivates her. Regarding the notifications her watch gives her to move, she said,

[If the watch says] you're almost there, to close all your rings, I'm like okay, I'll just get up and like walk around the house or something. Just like close my rings.

This perspective demonstrates how an individualized progress-tracker may push women to reach their fitness benchmarks.

Similar to tracking physical activity progression, participants described progress tracking for nutrition and weight management. Although the goal of the study was to inquire about physical activity during and after

pregnancy, participants frequently mentioned weight gain and nutrition during data collection. Pregnant and postpartum women and healthcare providers expressed interest in an app feature providing tracking information on appropriate weight gain tailored to each woman's needs (ie, pre-pregnancy BMI, exercise level, age), and the inclusion of physical activities that could improve or mitigate inappropriate weight gain.

To enhance trustworthiness of exercise information and overcome exercise misconceptions, which were important topics of conversation during data collection, women and healthcare providers suggested that the app contain safe, evidence-based physical activity guidance. For example, a postpartum woman with a four-month old baby said:

And if somebody could, like, offer me something, it would be like, like what reps to do. Like I feel like at one point if I had a set like routine of 30 reps of ABCDE and F and do that every day, and it would at least help tone or maintain or something. I would have done it because what would happen is, I would get those things and then like I would not know what to do.

Participants also indicated that workouts included in the app should be tailored specifically to the time point of pregnancy or postpartum, because existing resources do not provide this type of tailored guidance, and pregnant and postpartum bodies are constantly changing. One pregnant participant described her ideas for how the app could communicate with her based on gestation week:

You have hit the, whatever, 13 week mark. You should be fine to like run or maybe start walking. And then maybe when it gets closer to the ninth month, like hey, let us slow down a little this week, just some walking.

This representative quote suggests that women would like a mobile app to tailor the physical activity information to the specific week of pregnancy. They want clear guidance regarding safe and recommended activities for specific time points of pregnancy (and postpartum). Obstetric healthcare providers also suggested tailoring exercise information to the specific time point of pregnancy. As an example, one obstetrician stated:

Suggestions for the exercises that are safe in pregnancy, or like the exercise of the day, like a yoga move that like would be helpful for like low back pain if they are, you know- like targeted to what week they are at. You know, if maybe they are at 33 weeks, the yoga move that would be more helpful than something at 10 weeks.



Participants also proposed a community forum as an important app feature to increase social support, stay or become active, and positively impact mental health. For example, a stay-at-home mom who was 35 weeks pregnant with her third baby stated:

So I go to those forums a lot, like what to expect when you are expecting and read about other moms and what they are going through. And if I were to see like, hey, I am a runner. I cannot run anymore, but here's some really beneficial workouts I am doing that might- we are both due in March. Maybe this would be good for you too. So you'd be able to talk to other moms about stuff they are doing. I do like that a lot.

Similarly, when asked about what would help facilitate exercise during postpartum, a woman with a six-month-old baby said, "I think postpartum people just need encouragement that they're doing a good job. Or even trying". Another postpartum woman stated, "So I think a forum style thing, where people can talk to each other and ask questions. Just ask, kind of like the group." A community forum of other new or expectant mothers going through these exciting but challenging time periods together could provide the sense of social support and community that these women clearly desire. In turn, the added social support can assist them with reaching clinically important physical activity goals.

Postpartum women expressed concern for mental health after having a baby, noting that a community forum in a mobile app may provide necessary assistance with physical activity and social support, both of which can favorably impact mental health. When asked about the risks of sitting too much after having a baby, a mother of three with a 4-month old who was back to work as a teacher said:

I think that like, probably the biggest risk would just be even like your mental health with it. Like after I had [my baby] I would notice like, if I was just like- I always joked that I had my square on the couch and I just wanted to stay there, all the time. And I think you can get into kind of like a habit ... and like it can affect your mental health.

A mother of three whose youngest spent several weeks in the neonatal intensive care unit also expressed concern for mental health, and inquired about ways a mobile app could potentially assist with mental health after delivery. She asked:

Is there anything [in the plans for the app] in there for like postpartum depression? We both suffered from it with him ... So it was rough .... But with him- it hit hard. Like I have never experienced depression ever, ever .... Or something [an app feature] to keep your mind off the negativity. Like to keep the negative thoughts out of your head.

All participant groups expressed a desire for push notifications to remind them to move. For example, a postpartum woman said, "You go to your phone and have like, a little encouraging message that encourages you to work out and be better for you and the baby." Healthcare providers agreed that push notifications could serve as an important potential app feature. For example, one obstetrician stated,

Or maybe there's just something in that app that kind of reminds them, did you go for a 10-minute walk today? Or did you watch what you ate for lunch? I think those are keys.

Participants suggested several additional mobile app features, including links to time-efficient workouts and symptom-tracking. Generally, women report feeling like they do not have a lot of free time (ie, "I remember thinking, I need to exercise, but like, I just don't have the time"); thus, workouts should be designed to complete in a short window of time. Regarding symptom tracking, participants also mentioned wanting to be able to keep track of how they are feeling, specifically whether a workout is advisable based on symptoms, and customize workouts accordingly. One pregnant participant stated:

I think you definitely need that [symptom tracking] because I am almost through my second trimester and I still have the days of oh my gosh, I am so nauseous. I am so tired. I have had a lot of dizzy spells, to where every time I stood up I would have to sit back down immediately. So, I mean, you know in that situation, I do not wanna get up and exercise, I am going to die. You know, I was waiting tables and I did not know to limit myself yet because here I am, you know, 8 weeks pregnant, why am I limiting myself? And I passed out in the middle of the restaurant.

As an additional safety feature, healthcare providers suggested symptom tracking with flagging for when to contact the provider. Healthcare providers indicated that they often feel like their patients do not know what is normal or what is not normal and what would warrant

contact with the provider. A women's health specialist/physical therapist said:

I could have helped better and possibly kept them moving longer, kept them off pain meds, and things like kept them off bed rest or limited activity. I mean, there's all of these things that had we gotten to them sooner, we could have prevented. Red flags for you have got to get to the doctor.

Pregnant and postpartum women differed on the desired app features and structure. Pregnant women generally desired flexibility in the workouts and the schedule of the workout program. As one pregnant woman stated, "If you have the flexibility, you can account for how a pregnant woman is feeling in a day and that's forever going to be changing." On the contrary, postpartum women desired structure to help ensure their success using the mobile health app to be physically active. A postpartum woman said, "If I don't follow a schedule and regimen and I try to skip around, I won't be successful."

## Discussion

This study gained novel perspectives from pregnant women, postpartum women, and obstetric healthcare providers on their concerns and their patients' needs and desires for assistance related to physical activity during pregnancy and postpartum. Broadly, these perspectives encapsulated two main themes: 1) physical activity as critical for weight control and 2) the need for evidence-based exercise information. In addition to aforementioned themes, participants identified specific features and approaches for future integration into a mobile app to positively influence physical activity behaviors during and after pregnancy.

All participant groups identified the importance of utilizing physical activity for weight control. Our findings are similar to previous work which demonstrates that both patients and healthcare providers are concerned about gestational weight gain, yet patient-provider information exchanges about gestational weight gain lack sufficient depth to facilitate uptake of healthy lifestyle behaviors.<sup>39</sup> Our findings suggest that pregnant women intend to lose weight after giving birth; however, postpartum women have found weight loss (and even preventing additional weight gain) after pregnancy to be challenging. There exists an urgent need for both pregnant and postpartum women to implement successful strategies to assist with

both weight gain during pregnancy and weight retention afterwards.

Future intervention strategies should focus on providing women with evidence-based exercise information, which is another important theme identified by study participants. Misconceptions and misinformation surrounding physical activity during pregnancy and postpartum<sup>40,41</sup> combined with a lack of evidence-based information regarding exercise during and after pregnancy contribute to women not knowing how to safely and effectively exercise. Some women may avoid exercise during pregnancy and postpartum because they are nervous to cause harm to their unborn child<sup>42</sup> or to themselves, and both of these could possibly be attributed, at least partially, to a lack of consistent information and guidance.<sup>42,43</sup> Our data are consistent with a previous study by Saligheh et al who found that postpartum participants mentioned a lack of high-quality exercise programs as a major barrier to exercise after having a baby.<sup>43</sup> An opportunity exists to update traditional practices and services<sup>44</sup> by providing pregnant and postpartum women with technology and evidence-based exercise advice. Utilizing this contemporary platform is advantageous in that it can be tailored to the individual, contains personal health tracking, utilizes real-world settings, improves efficiency and frequency of communication between patients and healthcare providers, respects the considerable time demands of mothers, and may be more accessible to low-income women in rural areas.<sup>45,46</sup> Further, previous research demonstrates that postpartum women, who are often unable to leave the home due to childcare needs or safety concerns, strongly value online support and resources.<sup>47</sup>

Pregnant and postpartum women also report a lack of guidance from healthcare providers on this topic. There exists a potential missed opportunity for healthcare providers to focus on utilizing physical activity as a means to positively influence body weight (and other important health outcomes) during and after pregnancy. Our data are consistent with previous studies suggesting that both patients and healthcare providers view discussions of physical activity favorably; however, oftentimes the counseling is limited and not fully consistent with guidelines.<sup>48</sup> Women in the present study reported that the advice from their healthcare providers was often arbitrary and not specific or particularly helpful during and after pregnancy. Previous research shows similar barriers perceived by pregnant and postpartum women;<sup>42,49,50</sup> it seems common

that healthcare provider advice regarding physical activity is often insufficient and inconsistent.

Another important consideration as to why physical activity information is not being adequately provided to pregnant and postpartum women is that most obstetric healthcare providers do not have specific training in exercise physiology, as most medical schools do not have exercise education in their curriculum.<sup>51</sup> With this in mind, giving detailed exercise information may not be something they feel qualified to provide. One solution to this could be to involve an exercise expert (ie, physical therapist or exercise physiologist) on the obstetric healthcare team;<sup>8</sup> however, this option poses logistical and financial challenges as currently no structure exists for direct referral to an exercise expert, and there is no insurance coverage for the patient to receive services from an exercise expert at low or no cost to them. An additional problem with adding exercise experts to the obstetric care team is that similar to obstetricians, a shortage in physical therapists and fitness professionals also exists in rural areas, which furthers the potential for technology to assist with interventions and activity assistance.<sup>52</sup>

Healthcare providers also recognized the lack of knowledge and uncertainty that pregnant and postpartum women experience pertaining to their body and exercise. Healthcare providers brought up that these misunderstandings exacerbate unhealthy lifestyles during and after pregnancy. Many misconceptions about activity during pregnancy exist, which is logical given that ACOG has amended its recommendations for physical activity during pregnancy five times since 1985,<sup>53</sup> and overarching recommendations have changed drastically over the past 35 years with the arrival of high-quality evidence of the safety and efficacy of exercise during pregnancy. The normalization and expectation of substantial weight gain and “taking it easy” during pregnancy are culturally embedded as social norms. It is well-established that people conform their lifestyle behaviors to social norms set by others, and pregnant women are even more susceptible to the influences of social norms.<sup>54</sup> Cultural messages which encourage less activity during pregnancy are reinforced as social norms, and therefore healthcare providers recommended that a future mobile app have reminders or tips about the lack of validity of such messages.

Given the fact that rural women are disproportionality impacted by more serious health issues such as obesity and smoking,<sup>55,56</sup> healthcare providers may also not prioritize physical activity guidance. However, physical activity may

potentially be used as part of therapy for weight loss and/or smoking cessation,<sup>19,57</sup> thus, making an important case for facilitating communication between patients and healthcare providers about physical activity during and after pregnancy. In addition to higher rates of smoking and obesity, which have potential negative impacts on the health of the mother and baby, healthcare providers also explained that many of their patients experience low socioeconomic status and therefore encounter substantial stress facing everyday obstacles (ie, “And then we just have such a huge segment of the population who, just honestly, they’re just trying to survive day to day.”). While physical activity could be an effective way to mitigate this stress, it is important to recognize that exercise may not be a priority for women who are struggling financially. Future efforts should focus on the widespread benefits of physical activity during and after pregnancy, including stress relief,<sup>58</sup> mental health,<sup>59,60</sup> and smoking cessation.<sup>61</sup> In addition, future intervention strategies that do not involve added expenses (eg, gym memberships, exercise equipment) should be considered for use among rural women.

The present study also revealed that women desire social support to encourage them to be active and positively influence their mental health during pregnancy and postpartum. Our findings regarding women’s desire for social support are consistent with research which demonstrates that postpartum women desire social support from peer groups.<sup>47</sup> Social support is an important facet of future app development, as social support is useful for encouraging appropriate prenatal care and healthy behaviors during pregnancy<sup>62</sup> as well as exercise during postpartum.<sup>43</sup> Previous work demonstrates that social support, especially after birth, is important for mothers of all ages to reduce the risk of developing postpartum depression in addition to encouraging healthier behaviors.<sup>63–65</sup> Concerns for mental health were evident among our study participants, as many women described challenges associated with mental health after having a baby and desired mobile app features that could assist with managing postpartum depressive symptoms. Mental health concerns are substantiated by the fact that up to 84% of the women experience some form of a depressive disorder after pregnancy, and postpartum depressive disorders can have serious health implications for both mother and baby.<sup>66</sup> For instance, postpartum depression contributes to the high maternal morbidity and mortality rates in the United States.<sup>67,68</sup> Further, mental health disorders may be

worse for women residing in rural settings where there is less access to mental health resources/services and fewer opportunities for social interaction.<sup>64,69,70</sup>

While mental health concerns are prevalent during and after pregnancy, physical activity holds the potential to improve depressive symptoms during and after pregnancy.<sup>66,71</sup> In fact, physical activity is an essential factor for preventing postpartum depressive disorders.<sup>66</sup> Therefore, a mobile app has the potential to serve pregnant and postpartum women by providing support, a community of women, and exercise guidance, all of which could potentially help with depressive symptoms and other physical activity-related outcomes. Taken together, there is an opportunity for a mobile app, specifically designed and operated by exercise experts, to provide evidence-based exercise information and social support to pregnant and postpartum women. This allows the desired information to assist and support women without placing an additional burden on healthcare providers.

While the mobile app features were identified by participants themselves and not selected based on behavior

change theories, we feel confident these features will positively influence physical activity behaviors during pregnancy as nearly all of the identified features are linked to behavior change theory constructs. Strong evidence suggest that interventions designed with behavior change theories are effective at influencing behavior at the personal, community, and population levels.<sup>38</sup> Among physical activity mobile apps specifically, apps developed with cognizance of theoretical concepts of health behavior are more effective (and subsequently more expensive).<sup>29</sup> During pregnancy, addressing constructs of the Health Belief Model in the form of education has been successful in influencing physical activity beliefs during pregnancy.<sup>30</sup> The key identified app features fall directly in line with many of the constructs of the Health Belief Model (See Table 7), and thus, we believe the present study provides a sound framework, based on theory, that will allow for the development of a mobile app that can improve physical activity behaviors during pregnancy.

For example, nearly all behavioral theories, including the Health Belief Model, suggest self-efficacy as an

**Table 7** Participant Identified App Features and Their Application to the Health Belief Model

App Feature Identified	Application to Health Belief Model (Theory of Behavior Change) <sup>31</sup>
Progress tracking	Increase self-efficacy: Progress tracking allows participants to self-monitor and track progress towards a goal <sup>76</sup> Online self-monitoring shown to positively influence exercise behavior during and after pregnancy <sup>77</sup>
Safe and evidence-based/ trustworthy content	Increase self-efficacy: Education which may positively influence self-efficacy <sup>74</sup> Reduce perceived barriers: <sup>79</sup> Increase perceived safety which enhances exercise interventions during and after pregnancy <sup>77</sup> Increase perceived susceptibility and severity: educational components will help pregnant and postpartum understand the negative implications of being inactive
Clear guidance on what can/ cannot do	Self-efficacy: Education which may positively influence self-efficacy <sup>74</sup> Reduce perceived barriers: a common barrier to physical activity during pregnancy is a lack of information about what to do; <sup>42</sup> clear information would overcome this barrier Reduce perceived barriers: A common barrier is fear of harm to unborn baby; <sup>42</sup> clear evidence based guidance would assist with overcoming this barrier. Also, guidance will increase perceived safety which enhances exercise interventions during and after pregnancy <sup>77</sup>
Community forum (social support)	Cue-to-action: Communication or posts that positively influence pregnant and postpartum women to engage in healthy behaviors
Reminders/Push notifications	Cue-to-action: reminders that trigger a pregnant or postpartum woman to action (eg a reminder to workout).
Time-efficient workouts	Reduced perceived barriers: Overcome the commonly cited barrier of lack-of-time <sup>79</sup> Increase self-efficacy: Allow busy pregnant and postpartum women feel confident in their ability to complete workouts given time constraints
Symptom tracking	Increase self-efficacy and reduce barriers: Provide education about safety and allow them to feel confident that their symptoms are normal and that they can still pursue physical activity (fear of harming unborn child is often a barrier to exercise during pregnancy <sup>42</sup> ) and increase perceived safety which enhances exercise interventions during and after pregnancy <sup>77</sup>

important determinant of health behaviors and eliciting health behavior changes.<sup>30,72</sup> In the present study, the majority of the features identified are likely to positively influence self-efficacy towards exercise behaviors. In fact, many of the concerns identified by participants (ie, I do not know what to do?) are ultimately going to contribute to low levels of self-efficacy for exercise during pregnancy, which may play a role in the small percentage of pregnant women achieving recommended physical activity guidelines.<sup>73</sup> Specific and evidence-based information about physical activity during pregnancy will not only increase self-efficacy but will also overcome a common barrier to exercise for many pregnant and postpartum women.<sup>42</sup>

Further, previous work suggests that a broad array of interventions, including those with educational brochures/information, positively influenced self-efficacy towards exercise during pregnancy<sup>74</sup> and exercise levels during pregnancy,<sup>30</sup> which is especially relevant given women in rural areas of America are likely to lack self-efficacy and education about the benefits and safety for exercise during pregnancy.<sup>75</sup> In addition, many of the features identified will help overcome common barriers to exercise during and after pregnancy.<sup>42</sup> Another example that can positively influence self-efficacy is self-monitoring/progress tracking, which has been identified as the most important behavioral strategy in lifestyle interventions and<sup>76</sup> and consistent online self-monitoring has been successful in changing exercise behavior pregnant women and early postpartum women.<sup>77</sup> Further, if a goal has been set for a behavior such as reaching physical activity guidelines, self-monitoring allows for the tracking of progress towards that goal, which can be very beneficial towards reaching a goal.<sup>76</sup> Additional examples can be found in Table 7. Taken together, we believe the app features identified by participants in the present study hold potential to positively influence physical activity-related health behaviors as evidenced by previous work with online interventions among pregnant and postpartum women.<sup>77</sup>

## Limitations

One limitation of the present study is that most of the pregnant and postpartum participants had relatively high educational attainment and income levels. To elaborate, over three-fourths of our study participants reported an income level at least \$15,000 above the average income reported for the region. Also, all of the healthcare providers were Caucasian. Therefore, it is possible that the

characteristics of our study participants limit the generalizability of our results. Further, all women who participated were able to attend and to transport themselves to the location of the focus groups. There is likely a subset of pregnant/postpartum women residing in rural places that could not access the focus groups (due to lack of transportation, childcare concerns, work schedules, or other reasons); once again, findings cannot be generalized to these women. Although the focus groups and interviews were carefully facilitated to encourage honest answers and everyone to participate, it is also possible that some women may not have wanted to publicly share their views. A final limitation is that all emerging ideas were organized into two broad themes in order to streamline results, as is customary in qualitative work; however, it is possible some ideas did not fit well into either key concept and were not discussed in detail. A final limitation is that our in-depth interviews were shorter in duration than what would be considered ideal; however, the other qualities essential to in-depth interviewing are relevant and present (eg, semi-structured format, flexibility, a personal relationship); thus, we decided to still classify these as in-depth interviews.<sup>78</sup> Despite the limitations, we feel our study presents novel data that will allow for the design and development of an app that currently does not exist and meets a critical need - a physical activity app for pregnant and postpartum women in rural communities. Further, we feel strongly that using direct feedback and opinions from the population we intend to serve (pregnant women, postpartum women, and healthcare providers in a rural setting) to inform the selection of features was a critically important (and oftentimes overlooked) step towards successfully developing this mobile app.

## Conclusion

Our results are the first to identify the perspectives of three key groups of individuals in a rural community (pregnant women, postpartum women, and obstetric healthcare providers) regarding physical activity during and after pregnancy, and how a mobile app could be developed to best serve the community. Perspectives gained from the present study contribute to enhanced understanding of the concerns of the population as well as the identification of desired app features that should be thoughtfully considered in future mobile health interventions among rural women. Given the challenges faced by pregnant and postpartum women, the development of a mobile app tailored to



women in a rural setting has strong potential to overcome these challenges and improve clinical outcomes.

## Abbreviations

ACOG, American College of Obstetricians and Gynecologists; BMI, Body Mass Index; HBM, Health Belief Model.

## Data Sharing Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

## Ethics Approval

This study was reviewed and approved by Western Kentucky University's Institutional Review Board (IRB: 19-413).

## Consent to Participate

All participants read and signed an informed consent document before study participation began.

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## Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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