Development and feasibility of a web-based gestational weight gain intervention for women with pre-pregnancy overweight or obesity

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Background: Excessive gestational weight gain is associated with negative maternal and infant health outcomes. Digital health approaches may help overcome barriers to participating in lifestyle interventions requiring in-person visits. The purpose of this study was to develop and examine the feasibility of a web-based gestational weight gain intervention.

Methods: Intervention development included feedback and input from pregnant women. We conducted a 12-week one-arm pilot study during which participants engaged in an online discussion board with coaches and other pregnant women, tracked their weight gain with an interactive graph, and accessed a list of online resources for pregnancy health. Feasibility outcomes were recruitment, retention, engagement and sustained participation, intervention acceptability, and website usability. Gestational weight gain was an exploratory outcome.

Results: Participants (n=12) were on average 16.8 [standard deviation (SD): 2.0] weeks gestation with average pre-pregnancy body mass index of 30.5 (SD: 4.8) kg/m^{2}. Participant retention was 92% (n=11). Participants logged into the website a median of 21 times [interquartile range (IQR), 8–37; range, 2–98] over 12 weeks, and 58% (n=7) logged into the website during the last week of the intervention. All participants said they would be very likely or likely to participate again, and 100% said they would be very likely or likely to recommend the intervention to a pregnant friend. In post-intervention interviews, 64% (n=7) explicitly said that the website was easy to use, but 100% (n=11) mentioned usability issues. When asked their preferred intervention platform, 18% (n=2) somewhat or strongly preferred a private website, 18% (n=2) had no preference, and 64% (n=7) somewhat or strongly preferred Facebook. Seventy percent (n=7) had excessive gestational weight gain, 10% (n=1) inadequate gestational weight gain, and 20% (n=2) gained within recommended ranges.

Conclusions: Additional development work is needed before moving to efficacy testing. Most notably, usability issues with the investigator-developed website and participant preference suggest a switch to a commercial social media platform.

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Introduction

The Institute of Medicine (IOM) provides guidelines for weight gain during pregnancy to promote maternal and child health during pregnancy and beyond (1). Gestational weight gain (GWG) in excess of these recommendations is associated with negative maternal and infant health outcomes such as gestational diabetes mellitus, hypertensive disorders of pregnancy, macrosomia, delivery challenges, post-partum weight retention, and elevated risk of obesity in mother and child (2-7). More than half of women in the United States with pre-pregnancy overweight and 6 in 10 with pre-pregnancy obesity gain more than recommended (8), highlighting the need for programs to support healthy weight gain during pregnancy.

Two recent meta-analyses of 55 and 117 intervention trials found that lifestyle interventions reduce GWG by about 1 kg and reduce risk of excessive GWG (9,10). However, the majority of interventions included were delivered entirely or partially via in-person visits (9), and in-person meetings can be challenging for many pregnant women, especially for those with young children at home (11-13). Digital health approaches may help overcome barriers to participation in lifestyle interventions, and studies have demonstrated interest among pregnant women in digital support for GWG (14,15). However, two recent meta-analyses of 6 and 11 digital GWG interventions (i.e., delivered via websites, texting, or mobile apps) concluded that these approaches did not significantly reduce GWG or the proportion of women with excessive GWG (16,17). Contemporary to the studies included in these reviews, we developed a web-based lifestyle intervention to prevent excessive GWG and conducted a one-arm pilot study with pregnant women with pre-pregnancy overweight or obesity to assess feasibility and acceptability. In this paper, we describe the results of this formative work and discuss implications for research developing the next generation of digital lifestyle interventions to prevent excessive GWG. We present the following article in accordance with the TREND reporting checklist (available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-22-49/rc).

Methods

We developed a web-based intervention to prevent excessive GWG and conducted a one-arm feasibility pilot study to assess feasibility and acceptability of the intervention. The development phases occurred in 2014 and 2015 and the pilot study was conducted in spring 2016, with deliveries through summer 2016. The studies were conducted in accordance with the Declaration of Helsinki (as revised in 2013). The University of Massachusetts Medical School Institutional Review Board approved all phases of this project (formative work: protocol No. H00001690; pilot study: protocol No. H00008907). All participants provided informed consent.

Intervention development

We developed a 12-week lifestyle intervention to prevent excessive GWG by adapting the Diabetes Prevention Program (DPP) lifestyle intervention (18) to be consistent with recommendations for weight gain, nutrition, and physical activity during pregnancy (1) and for delivery

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Highlight box

Key findings
- Delivering a gestational weight gain (GWG) intervention via a private website was feasible and acceptable, but usability issues hindered engagement.

What is known and what is new?
- Lifestyle interventions can reduce GWG, but in-person intervention meetings are challenging for many pregnant persons.
- Delivering a GWG intervention via a private website was feasible and acceptable.
- Usability issues hindered engagement, and many participants would prefer an intervention delivered via a commercial social media platform such as Facebook.

What is the implication, and what should change now?
- Development of digital GWG interventions should incorporate preferences of pregnant persons.

via an interactive website (19). The lifestyle intervention is informed by Social Cognitive Theory (20), and digital delivery by behavioral analytic theory which holds that more rapid feedback has a greater impact on behavior change (21). Pregnant women engaged in an online discussion board with other pregnant women and interventionists, and accessed an interactive weight gain tracker and list of online resources, through a password-access website. Weekly topics focused on nutrition, physical activity, and behavioral strategies for lifestyle changes (e.g., self-monitoring of food and activity, nutrition/healthy eating, strategies for increasing physical activity, problem-solving to overcome barriers, strategies for healthy eating in restaurants, restructuring food and activity cues at home, social support, stress management) (18). We scheduled daily intervention posts and an interventionist logged into the website at least twice daily to interact asynchronously with participants, and to provide support and help participants problem-solve challenges. Participants were advised to peruse the feed daily, post about their questions, successes, and challenges regularly, and reply to others' posts. Participants were encouraged to track their diet and activity using the free commercial website and mobile app MyFitnessPal. We created an interactive GWG tracker/graph in R and integrated it into the website using JSON (JavaScript Object Notation). Women were instructed to enter their weights weekly (or more often if desired) and the graph showed recorded weights by week of pregnancy, and provided reference lines of weight gain based on the IOM's pre-pregnancy body mass index (BMI)-specific GWG recommendations (1). We used a user-centered design approach (22,23) to intervention development, incorporating input from pregnant women with pre-pregnancy overweight or obesity via formative interviews and usability testing sessions in order to maximize perceived relevance and ease of use, factors critical to use of technology-delivered interventions according to the Technology Acceptance Model (TAM) (24-26).

Formative interviews

We recruited women who had participated in a previous cohort study of pregnant women (27), and via Craigslist to provide feedback on our proposed intervention. Eligibility criteria for participating in formative interviews were similar to eligibility criteria for participation in a study assessing the intervention so feedback would reflect the intervention target population (e.g., ≥18 years old, <36 weeks gestation, pre-pregnancy BMI ≥25 kg/m^2, no medical conditions or medications affecting weight). Participants received a $25 gift card

following the interview. Participants (n=15) were on average 30.9 (SD: 6.1) years old and 30.0 (SD: 5.9) weeks gestation with mean pre-pregnancy BMI of 30.3 (SD: 3.5) kg/m^2. Sixty prcent (n=9) were non-Hispanic white, 47% (n=7) had a Bachelor's degree or higher education, and 33% (n=5) were nulliparous.

During a 30-minute semi-structured phone interview, we asked participants about their experiences with weight gain during pregnancy and solicited their feedback on the content and delivery format of our intervention. Overall, participants thought the proposed program would be helpful and liked the idea of having a community of pregnant women with whom to share experiences and support. Some women were enthusiastic about having access to an interactive GWG tracker that would show their weight gain compared to recommendations, but others didn't think they would find a GWG tracker helpful, and a few were concerned that tracking or focusing on weight would lead to anxiety. In terms of a program name, the consensus was to focus on mom's health primarily but also baby's health, and that focusing on weight would defer participation. Based on participants' feedback, we named the intervention the "Healthy Moms, Healthy Babies" program.

Usability testing

Second, after constructing an initial version of the intervention website, we conducted 60-minute usability testing sessions with 8 pregnant women (2 rounds with n=4 women per round) to obtain feedback on the website interface. During in-person usability testing sessions, participants explored the prototype intervention website using an iPad. For each round of testing, staff populated the website with sample intervention posts from a coach account and responses from fictional sample participants. Usability testing sessions were conducted using a "Think Aloud" protocol (28); as participants interacted with the website, they were asked to vocalize thoughts, feelings, and opinions, which allows us to understand how the user approached the interface and what considerations they have in mind when utilizing the interface. We asked participants to elaborate on their thoughts and experiences as they interacted with the website using prepared questions. Following the usability testing, participants completed the System Usability Scale (SUS), a 10-item 5-point Likert scale measure assessing human-computer interaction (29,30). A SUS score above 58 is regarded as above average, and a SUS score above 80 is regarded as high and a score at which participants are likely to recommend the product to friends (29,30). Participants

received a $40 gift card.

We recruited participants from the obstetric clinics at UMass Memorial Health, the UMass Medical School internal announcement board, and Worcester area Craigslist. Eligibility criteria were the same as for the formative interviews except eligible women were <40 weeks gestation. Participants (n=8) were on average 28.4 (SD: 5.8) years old and 26.4 (SD: 8.7) weeks gestation with mean pre-pregnancy BMI of 36.3 (SD: 5.5) kg/m^2. Twenty-five percent (n=2) were non-Hispanic white, 38% (n=3) had a Bachelor's degree or higher education, and 38% (n=3) were nulliparous. In round 1, usability scores were 82.5, 85, 87.5, and 92.5, and in round 2, usability scores were 80, 90, 90, and 95, indicating that participants found the prototype website to be highly usable. Participants overall reported that the website was easy to navigate, and provided feedback on how to make various sections of the website easier to use or clearer (e.g., add legend to GWG tracker, remove "report to moderator" button in Forum), more attractive (e.g., add images to Resources page), or more informative (e.g., sort recipes by topic, add links to general pregnancy information like common symptoms). We revised the intervention website to address participant feedback from these usability sessions.

The intervention website had five sections: Home, Forum, Meet the Coaches, Track, and Resources. The Home page showed the latest Forum posts, a personalized greeting (e.g., "Hello, Molly!"), and a tip of the day. In addition to standard greetings (e.g., "Hello", "Welcome, "Hi there"), greetings varied by day of the week (e.g., "Happy Monday", "TGIF") and included holidays (e.g., "Happy Valentine's Day"). We developed a list of diet and physical activity tips based on USDA ChooseMyPlate "Ten Tips" series (now available as the MyPlate Tip Sheets) and physical activity tips and suggestions based on the DPP materials. The Forum landing page showed a list of conversation threads ordered by most recently updated. Participants could click to view each conversation thread and reply to the interventionist and other participants. Participants had the option of reacting to each post or reply with a "thumbs up" or "thumbs down". The Meet the Coaches page showed photos of the three interventionists with brief bios outlining their professional credentials and a few personal notes (e.g., number of children, favorite type of exercise). The Track page showed the interactive weight gain graph/tracker. Participants could enter a new weight and date weighed. The weight graph showed their GWG by date and week of pregnancy, and included green lines showing the ranges of GWG recommended by the IOM (1). A legend also displayed the participant's pre-pregnancy weight, recommended range of total GWG, and recommended weekly gain in her second and third trimesters (1). Below the graph was a table showing dates, weights, and GWG for each weight entered. The Resources page included links to existing online resources (e.g., healthy recipes, prenatal yoga videos, general pregnancy information, instructions on how to use MyFitnessPal features such as barcode scanning). The physical therapist on the study team reviewed all physical activity online resources prior to their inclusion.

Feasibility pilot study

Recruitment and eligibility

Participants were recruited from the obstetric practices at UMass Memorial Medical Center (UMMMC) and from the Worcester-area community. Eligible participants had to be ≥18 years, pregnant with singleton gestation <20 weeks at the start of the intervention, pre-pregnancy BMI ≥25 and <45 kg/m^2 based on pre-pregnancy weight and height self-reported at screening, posted and/or commented on Facebook at least once in the past 7 days, comfortable speaking, reading, and writing in English, plan to deliver at UMMMC, and have medical clearance from their obstetric provider. We required participants to be active Facebook users because in our previous digital lifestyle interventions, we observed that participants who did not use social media regularly engaged minimally even when provided instructions for use (31). Exclusion criteria included chronic medical conditions which could influence body weight, current use of medication known to affect weight or to treat opioid dependence, previous weight loss surgery, or current participation in a weight loss program.

Study assessments

At a 60-minute baseline assessment at UMMMC, participants provided written informed consent, had weight and height measured, completed self-report measures, and were oriented to the study website by research staff. Research staff obtained medical clearance from participants' prenatal care providers. Following the intervention, participants completed a 60-minute follow-up assessment at UMMMC that included measurement of weight, a survey, and a semi-structured interview. During these interviews, participants answered open-ended questions about their overall experience in the intervention, website

usability, what influenced whether they responded to the coach's post, and whether they found the GWG graph helpful. Participants were also asked to offer suggestions for improving the intervention. Participants received a $50 gift card after completing the follow-up assessment. Following delivery, research staff reviewed participants' obstetric medical records and abstracted GWG, gravidity/parity, gestational age at delivery, mode of delivery, birth weight, infant sex, and pregnancy complications (e.g., gestational diabetes mellitus, pregnancy-induced hypertension, preeclampsia).

Intervention

The 12-week intervention is described above. The goal for the intervention was weight gain within IOM recommendations (based on pre-pregnancy BMI) (1). We provided women with total and weekly GWG goals (15–25 lbs total and 0.5–0.7 lbs/week for women who were overweight pre-pregnancy and 11–20 lbs total and 0.4–0.6 lbs/week for women who had obesity pre-pregnancy) (1). We calculated individualized daily calorie goals for each participant using the USDA's interactive dietary reference intake calculator (32) which takes into account height, pre-pregnancy weight, activity level, and trimester of pregnancy (33). The physical activity goal was 30 minutes or more of moderate-intensity activity on most or all days of the week, as recommended by the American College of Obstetricians and Gynecologists (ACOG) for women without medical or obstetric complications (34); we encouraged women who were inactive to gradually increase their physical activity to this level. Participants were encouraged to track their diet and activity using the free tool MyFitnessPal, and to track their GWG using the interactive weight tracker built into the intervention website.

The primary interventionist was a post-doctoral fellow with a master's degree in clinical psychology who had previously served as an interventionist for a digital lifestyle intervention based on the DPP. She was supervised by a licensed clinical psychologist with extensive experience delivering the DPP both in-person and online. Every morning, staff posted from the primary interventionist's user account, and then she logged in at least twice a day to reply to participants. Two additional interventionists— a physical therapist with clinical experience with pregnant women and an obstetrician/gynecologist with clinical and research experience with GWG—replied to participants' posts and answered questions specifically related to their respective areas of clinical expertise as needed. On Monday, research staff updated the Resources page with additional links to existing online resources related to the topic of the week (e.g., prenatal exercise videos for a week focusing on physical activity, healthy recipes for a week focusing on diet). Each Friday, staff downloaded engagement data from the website and emailed participants who had not engaged that week encouraging her to post and interact with the coaches and other participants. The second and third weeks of no engagement, the primary interventionist called the participant to check in and encourage her to engage.

Measures

The primary feasibility and acceptability outcomes were recruitment, retention, engagement and sustained participation, intervention acceptability, and website usability. We described GWG as an exploratory outcome. Data were collected from participant tracking systems, participant surveys, measurement of weight, engagement data collected by the website, and GWG abstracted from obstetric records following delivery.

Recruitment
We tracked recruitment efforts and documented reasons for ineligibility.

Retention
Retention was defined as completion of the follow-up assessment.

Engagement and sustained participation
Following the intervention, we downloaded objective engagement data from the website and calculated number of logins, number of posts or replies to the Forum, and number of weights logged. We calculated sustained participation as the date of the latest post to the Forum and secondarily, as the date of the latest login to the intervention website and date of last weight tracked (35).

Intervention acceptability
As part of the follow-up survey, participants rated on 5-point Likert scales how likely they would be to recommend the program to a pregnant friend and whether they would participate again during a subsequent pregnancy. In post-intervention interviews, we asked participants what they thought of the Healthy Moms, Healthy Babies program, what they found most helpful, and how we could make the program better.

Website usability
At follow-up, participants completed the 10-item SUS (29) to rate how usable they found the intervention website. During the post-intervention interview, we asked participants what challenges, if any, they had used the website, how easy

or not easy they found navigating the website, and what improvements or changes they would suggest to the website. Participants also provided feedback on website usability in response to the question about what they thought about the Healthy Moms, Healthy Babies program overall. Based on our experiences with technological glitches during the intervention, and our concurrent ongoing work developing and testing lifestyle interventions delivered via commercial social media platforms (31,36,37), we also asked participants what they thought about offering the Healthy Moms, Healthy Babies program through a private website (like the current study) versus via a secret (private) Facebook group, including what would be appealing about each modality and what concerns they had about each modality, and which they would prefer (strongly prefer private website, somewhat prefer private website, no preference, somewhat prefer secret Facebook group, strongly prefer secret Facebook group), along with and explanation for why they preferred one modality over the other.

GWG (exploratory)

We calculated GWG from delivery admission weight abstracted from participants' obstetric records and pre-pregnancy weight self-reported at eligibility screening. We used pre-pregnancy weight self-reported at study screening to calculate GWG to be consistent across participants because pre-pregnancy weight recorded in UMMMC obstetric records was preferentially recorded as (I) self-reported pre-pregnancy weight from first prenatal visit, (II) self-reported pre-pregnancy weight upon presentation for delivery, or (III) measured weight at first prenatal visit, depending on availability (38). In this clinical population, self-reported pre-pregnancy weight was on average 2.9 pounds less than weight measured within 12 months of conception for women with pre-pregnancy overweight and an average of 5.1 pounds less for women with pre-pregnancy obesity (39). We categorized GWG as excessive, adequate, or inadequate based on pre-pregnancy BMI-specific recommendations: 15–25 lbs for women with overweight pre-pregnancy and 11–20 lbs for women with obesity pre-pregnancy (1). We also categorized GWG versus IOM recommendations at gestational age at delivery, assuming constant rates of gain in the second and third trimesters, as we have done in previous research (38). For all participants, categorization of GWG versus IOM recommendations (i.e., inadequate, adequate, or excessive) was identical when accounting for gestational age at delivery and when using total GWG; we report results based on total GWG.

Two participants moved out of state during the intervention, and we conducted a sensitivity analysis in which we estimated their total GWG based on their weekly rate of gain during the study from self-reported follow-up and measured baseline weight and assuming delivery at 40 weeks. We calculated weekly rate of GWG during the intervention as follow-up minus baseline weight, and categorized whether weekly rate of gain was below, within, or above IOM-recommended ranges for weekly gain (1).

Participant characteristics

Participants reported demographics, reproductive and weight history, and social media use. Participants were asked how difficult it was for them to pay for basics like food, housing, medical care, and heating (not at all versus somewhat or very hard) (40).

Statistical analysis

We summarized participant characteristics and feasibility outcomes. As engagement variables were not normally distributed, we described their distributions with median, interquartile range (IQR), and range. Research staff transcribed interviews, and a second member of the team reviewed transcripts to confirm accuracy of transcriptions. We used a conventional content analysis approach to analyzing participant feedback from post-intervention interviews (41). First, the first author read through the transcripts, identified themes related to website usability and intervention acceptability, and developed a codebook. Then, after coding two transcripts and refining the codebook, two members of the research team independently reviewed all transcripts and coded the presence or absence of each theme in each utterance. Then, the full coding team met to discuss discrepantly-coded utterances and reach consensus. We calculated percent agreement as a measure of inter-rater reliability (92.0–99.6% across themes). Management and analyses of quantitative data were conducted using SAS 9.4 (SAS Institute, Inc., Cary, NC).

Results

Recruitment and retention

We screened 27 women, of whom 18 were eligible (67%). Two-thirds of eligible women participated in the intervention (n=12). Eleven participants completed the follow-up assessment, for a retention rate of 92%. We were able to contact the twelfth participant at follow-up; she declined to complete the follow-up assessment and noted

Table 1 Characteristics of pregnant women participating in a feasibility pilot study of a web-based intervention to prevent excessive gestational weight gain (N=12)

Characteristic	N [%] or mean ± SD
Age (years)	31.7±5.5
Gestational age at intervention start (weeks)	16.8±2.0
Pre-pregnancy body mass index (BMI; kg/m^2)	30.5±4.8
Overweight	6 [50]
Obesity	6 [50]
First pregnancy	2 [17]
Race/ethnicity	
Non-Hispanic white	5 [42]
Non-Hispanic Black	3 [25]
Hispanic/Latina	2 [17]
Asian	0
Non-Hispanic multiracial	2 [17]
Marital status	
Married	8 [67]
Living with partner	1 [8]
Single/divorced/separated/widowed	3 [25]
Education	
At most high school or GED	4 [33]
Some college or Associate's degree	2 [17]
Bachelor's degree	3 [25]
Graduate degree	3 [25]
Employment status	
Works full-time	7 [58]
Works part-time	1 [8]
Homemaker/stay-at-home mom	4 [33]
Somewhat or very difficult to pay for basic expenses	5 [42]
Owns a smartphone	12 [100]
Ever used a mobile app for weight loss	6 [50]
Ever used an online weight loss program	2 [17]
Social media use	
Facebook	12 [100]
Instagram	9 [75]
Pinterest	8 [67]
Twitter	4 [33]

BMI, body mass index; GED, General Educational Development test; SD, standard deviation.

that personal issues had prevented her from participating in the intervention past the first week. On average, participants (n=12) were 31.7 (SD: 5.5) years old and 16.8 (SD: 2.0) weeks pregnant at intervention start. Mean pre-pregnancy BMI was 30.5 (SD: 4.8) kg/m^2, and 50% had overweight and 50% had obesity pre-pregnancy. Other participant characteristics are shown in *Table 1*.

Engagement and sustained participation

Over 12 weeks, participants logged into the website a median of 21 times (IQR, 8–37), made a median of 24.5 (IQR, 4–31.5) posts to the Forum, and logged a median of 2.5 (IQR, 0–8.5) weights in the GWG tracker (*Table 2*). In terms of sustained participation through the end of the 12-week intervention, 58% (n=7) logged into the intervention website, 42% (n=5) posted in the Forum, and 25% (n=3) logged their weight in the GWG tracker during week 12 (*Table 2*).

Intervention acceptability

Sixty-four percent (n=7) of participants said they would be very likely and 36% (n=4) said they would be likely to participate again if they became pregnant again, and 73% (n=8) said they would be very likely and 27% (n=3) said they would be likely to recommend the intervention to a pregnant friend. Common themes from post-intervention interviews were a sense of a community and support from other pregnant women (mentioned by n=11, 100%), helpful and responsive interventionists (n=10, 91%), and helpful information (n=11, 100%).

Website usability

The median usability score was 75 (IQR, 67.5–97.2; range, 60–100); 45% (n=5) rated the website as highly usable [>80] and 55% (n=6) rated the website to have above-average usability [58–80]. In post-intervention interviews, 64% (n=7) explicitly said that the website was easy to use, but 100% (n=11) mentioned usability issues including the website being cumbersome to use on their smartphones, the Forum message preview didn't show capital letters, and slow refresh rates led participants to submit their Forum posts multiple times resulting in duplicate posts.

When asked what they thought of the GWG tracker, four participants (36%) reported that they had not used it—three because they were tracking their weight elsewhere

Table 2 Engagement and sustained participation in a 12-week web-based gestational weight gain intervention

Engagement metric	Website logins	Forum posts	Weights tracked
Engagements, median [IQR; range]	21 [8–37; 2–98]	24.5 [4–31.5; 0–81]	2.5 [0–8.5; 0–19]
Latest engagement, n [%]			
Never	0	1 [8]	4 [33]
Week 1	3 [25]	2 [17]	2 [17]
Week 8	0	2 [17]	1 [8]
Week 9	2 [17]	1 [8]	1 [8]
Week 10	0	0	1 [8]
Week 11	0	1 [8]	0
Week 12	7 [58]	5 [42]	3 [25]

IQR, interquartile range.

(e.g., paper log, another app) and one because she didn't like to see her weight going up. Fifty-five percent (n=6) reported positive feedback about the GWG tracking, including that it was helpful to see their weight gain during the intervention. One participant commented that she didn't think tracking cumulative GWG was useful and suggested instead showing weekly gains.

When asked in post-intervention interviews what they thought about offering the Healthy Moms, Healthy Babies program via a private website (like in the current study) versus via a private Facebook group, 91% (n=10) voiced advantages of Facebook, the flipside of which were perceived to be limitations of private websites including familiarity with the platform, building on existing daily routines, and a robust user interface (*Table 3*). Fifty-five percent (n=6) shared limitations of a private Facebook group, many of which were perceived as advantages of private websites, notably privacy/confidentiality concerns and concerns that the GWG tracker would not be available in a Facebook-delivered intervention (*Table 3*). After discussing strengths and limitations of different modalities, interviewers asked whether participants preferred a private website (as in the current study) or a private Facebook group—9% (n=1) said they strongly preferred a private website, 9% (n=1) somewhat preferred a private website, 18% (n=2) had no preference, 18% (n=2) somewhat preferred Facebook, and 45% (n=5) strongly preferred Facebook. One of the participants who somewhat preferred Facebook said she would strongly prefer Facebook if she had access to the GWG tracker as part of a Facebook-delivered intervention.

GWG (exploratory)

We examined GWG among the 10 women who delivered at UMMMC. Overall, 70% (n=7) gained more than recommended, 10% (n=1) gained less than recommended, and 20% (n=2) gained within recommended ranges. Participants with pre-pregnancy overweight (n=5) gained a median of 27 pounds (IQR, 23–30 pounds); 60% (n=3) gained more than recommended (>25 lbs). Participants with pre-pregnancy obesity (n=5) gained a median of 29 pounds (IQR, 22–36 pounds); 80% (n=4) gained more than recommended (>20 pounds). Two participants moved out of state during the intervention, and we conducted a sensitivity analysis in which we estimated their total GWG based on their weekly rate of gain during the study from self-reported follow-up and measured baseline weight. One participant had already gained more than the total recommended GWG by the end of the intervention, and the other participant was estimated to have inadequate gain. In this sensitivity analysis, 80% (n=8) were estimated to have excessive GWG. In terms of weekly rates of gain during the intervention, 64% (n=7) gained faster than recommended, 18% (n=2) had weekly gain within the recommended range, and 18% (n=2) gained slower than recommended.

Discussion

This one-arm feasibility study found that our digital intervention to prevent excessive GWG was feasible and acceptable, but not without usability concerns. Retention

Table 3 Advantages and limitations of offering a GWG intervention via a private Facebook group versus private website shared by pregnant women in post-intervention interviews

Private Facebook group
Advantages
Already know how to use platform
Engaging on Facebook already part of daily routine
Notifications in app prompt engagement
Organization of conversation threads and robust search functionality makes it easy to catch up on missed interventionist posts and find previous discussions
Easy to engage from phone
Option to keep in touch with other participants after the intervention by friending them
Limitations
Concerns about privacy and confidentiality, including expectation that people use their real names on Facebook
Concern that GWG tracker would not be available
Private website
Advantages
Can join group anonymously
GWG tracker available through website
Limitations
Have to learn how to use a new platform
Have to remember to log into the website and add to daily routine
Email notifications of new posts may not be seen regularly
Hard to find previous conversations and limited search functionality
Website not optimized for mobile use

GWG, gestational weight gain.

was 92%. Acceptability was high such that 100% said they would be likely to participate again in a subsequent pregnancy, 100% would recommend the program to a pregnant friend, and feedback from post-intervention interviews was quite positive. While more than half of the participants posted during the last week of the intervention, participants only contributed a median of 24.5 posts over the 12-week intervention, and in post-intervention interviews, every participant mentioned one or more usability issues that frustrated them or hindered engagement. Results from this pilot study indicate that additional work is needed to address usability concerns before moving to testing intervention efficacy.

We observed sustained participation in the intervention, with 50% of participants posting in the forum during the two last weeks of the 12-week intervention, and another 25% last posting in weeks 8 or 9. However, three participants (25% of the sample) stopped logging into the intervention website in week 1 of the intervention. Other digital health interventions have ranged widely in their ability to keep women engaged in treatment. In a recent meta-analysis of digital lifestyle interventions for pregnant persons, 6 of the 11 studies included in the review had intervention attrition rates of less than 10%, while the other 5 studies reported treatment attrition rates of 30–51% (16). Connecting with other pregnant women and an interventionist remotely is convenient, and women are able to keep participating even if they move or their work schedules or other obligations change. Indeed, in post-intervention interviews, several participants remarked on the convenience of the online format. To note, two participants moved out of state during the intervention period, yet they

were able to continue participating in the intervention. However, we were unable to obtain total GWG as we did not have access to their obstetric records through their new prenatal care providers. Future studies to develop and test digital GWG interventions may want to provide participants with digital scales to increase ascertainment of follow-up weight regardless of geographic location or barriers to attending in-person follow-up visits (42). Availability of regular weights via a digital platform can also aid interventionists in providing tailored feedback during the intervention.

Despite being able to retain most women in the intervention, participants only contributed a median of 24.5 Forum posts per participant—which over 12 weeks, averages to about 2 posts per week—though some women engaged more often (IQR, 4–31.5, range, 0–81 forum posts). While digital GWG interventions have also reported challenges engaging participants at the intended level, interventions that were able to engage participants to a greater extent saw bigger impacts on GWG (16). For example, in the Australian text4two trial which tested a multimodal mHealth GWG intervention, 96% of participants replied to intervention text messages, and 98% reported reading most or all of these messages, and participants in the intervention condition gained less weight than those in the control condition (43). Studies that were less effective at engaging participants as intended in the intervention have been less effective at impacting GWG. For example, in the e-Moms of Rochester trial, 46% of participants in the intervention condition logged into their website at least once every 45 days as instructed, and participants only logged in on a median of 5% of days they had access to the website; this trial did not observe an impact on GWG or rates of excessive GWG (44). Future work in this line of research should explore how to more effectively engage participants in conversation, and promote the types of engagements that have been associated with better weight outcomes in research with adults generally (45). Addressing the usability issues identified with the intervention platform is a first step towards improving participant engagement in the lifestyle intervention to help them with pregnancy weight gain.

While this pilot study focused on feasibility and acceptability, we described GWG as an exploratory outcome. Because the current study was a small one-arm pilot, we do not know how women would have gained weight in absence of the intervention. Future studies should compare digital GWG interventions to a suitable comparison condition to assess the impact of intervention on weight gain. Seventy percent of participants gained more than recommended, 60% of women with pre-pregnancy overweight and 80% of those with pre-pregnancy obesity, similar to rates of excessive GWG in this clinical population (4). Women who volunteer to participate in an intervention study may be more likely to be concerned about weight gain, and thus may be more likely to gain more than recommended for their entire pregnancy regardless of intervention. Rates of excessive GWG of 50% or more have been observed in other digital GWG intervention studies, including those that showed an overall effect on GWG (43,46,47). In our study, 64% of participants had average weekly weight gain during the intervention higher than recommended, similar to an analysis of data from the LIFE-Moms consortium, a group of 7 independent but coordinated clinical trials with the goal of identifying effective interventions for reducing GWG in women with pre-pregnancy overweight or obesity which reported that 62% of women in the intervention condition had excessive weekly GWG (compared to 75% in the standard care group) (48). A recent systematic review and meta-analysis of digital health interventions targeting diet, physical activity, and weight gain during pregnancy found that only 2 of the 11 included studies had an impact on GWG (16). Together, our findings and those of previous studies highlight the difficulty of preventing excessive GWG, and the importance of engaging patients early in pregnancy—and perhaps even pre-conception for women planning a pregnancy. The lessons learned about feasibility and acceptability in the current study can inform the next generation of digital health intervention to prevent excessive GWG.

This study has strengths and limitations. While our sample was racially/ethnically diverse (42% non-Hispanic white versus 51% nationally) and a third were unmarried (versus 40% nationally), our sample was more educated than US women giving birth overall (50% with a Bachelor's or higher education versus 34% nationally) (49). Almost half the sample reported that it was somewhat or very difficult to pay for basic expenses. Including participants with a range of economic resources in pilot testing provides useful information about feasibility, as challenges to healthy eating and physical activity faced by women may differ by socioeconomic status (50). As noted above, the current feasibility pilot was a one-arm study, and thus does not provide information on expected GWG in absence of intervention.

Feedback from participants and our own notes and reflections on designing and conducting this study suggest that the intervention website created for this study does

not have adequate usability. While average participant ratings of the usability of the intervention website were in the above-average to high range, and 64% of participants explicitly said that the website was easy to use in post-intervention interviews, every single participant also mentioned one or more usability issues in their interview. Instead of creating a digital platform on which to deliver a behavioral intervention, researchers can also leverage commercial social media platforms for intervention delivery (19,51). During the post-intervention interviews, we asked participants their preferred intervention platform, and 18% indicated that they strongly or somewhat preferred a private website, 18% had no preference, and 64% strongly or somewhat preferred a private Facebook group—indicating that participant preferences vary. While researcher-created websites or mobile apps may be able to provide participants with more anonymity and confidentiality, it can be expensive to develop, update, and maintain these platforms (52). Further, participants may come to expect the high quality and user-friendliness of commercial platforms which will be hard to achieve in an academic research budget. Commercial social media platforms often have existing functionality to sync data from other mobile apps or activity trackers. While commercial social media platforms have attractive interfaces with robust features and regular software updates, changes to how users view, share, and interact with content can pose challenges to researchers leveraging these platforms for intervention delivery [e.g., (53,54)]. Changes to algorithms that control what content users see can also influence treatment receipt if intervention posts are missed (55,56), and plans to examine engagement patterns can be disrupted by changes to platforms' application programming interfaces (APIs) (57). In addition to providing researchers with easier access to and greater control over participants' data, investigator-created platforms have the additional advantage of ready access to back-end data on user logins and views, which allows examination of lurking (i.e., reading without visible engaging) (58). As mentioned by several participants in the current study, privacy and confidentiality is a concern when using commercial social media platforms—a concern that is well founded (59) but also inherent to technology that is scalable to billions of users without charging them for use. Researchers developing digital health interventions must consider the tradeoffs of developing their own intervention platform versus leveraging a commercial social media platform, including issues of privacy, data access, scalability, intervention delivery costs, and costs to participants.

In this study, we asked participants about their interest in receiving an intervention via Facebook because it is by far the most popular social media platform among US adults (60). However, as social media use trends change over time, researchers may want to consider whether other popular social media platforms have the desired functionality for intervention delivery (19). While a greater proportion of US adults aged 30–49 years currently use Facebook compared to Instagram (77% versus 48%), Instagram is similarly popular among those aged 18–29 years (70% versus 71%) (61) and more popular among teen girls (69% use Instagram versus 34% use Facebook) (62), suggesting that Instagram may be a desired platform for contemporary and future cohorts of pregnant persons. Many people turn to Instagram for information and support during their pregnancies (63), and as of late November 2022, 24.6 million and 20.7 million Instagram posts included the hashtags #pregnant or #pregnancy, respectively. In our previous work, we found that creating a private group on Instagram was feasible and acceptable to pregnant women, including switching to a second account to view intervention content, and that the majority of women in the study would be interested in receiving a lifestyle intervention on this platform (64). Future research is needed to develop and test the efficacy of digital lifestyle interventions to support pregnant persons with healthy GWG, and lessons learned from the current study can inform these future efforts.

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Footnote

Reporting Checklist: The authors have completed the TREND reporting checklist. Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-22-49/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The studies were conducted in accordance with the Declaration of Helsinki (as revised in 2013). This work was approved by the University of Massachusetts Medical School Institutional Review Board (formative work: protocol No. H00001690; pilot study: protocol No. H00008907). Informed consent was obtained from all individual participants.

References

1. Rasmussen KM, Yaktine AL, Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines, eds. Weight Gain During Pregnancy: Reexamining the Guidelines. Washington (DC): National Academies Press (US), 2009.

2. Siega-Riz AM, Viswanathan M, Moos MK, et al. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: birthweight, fetal growth, and postpartum weight retention. Am J Obstet Gynecol 2009;201:339.e1-14.

3. Stotland NE, Cheng YW, Hopkins LM, et al. Gestational weight gain and adverse neonatal outcome among term infants. Obstet Gynecol 2006;108:635-43.

4. Simas TA, Waring ME, Liao X, et al. Prepregnancy weight, gestational weight gain, and risk of growth affected neonates. J Womens Health (Larchmt) 2012;21:410-7.

5. Gould Rothberg BE, Magriples U, Kershaw TS, et al. Gestational weight gain and subsequent postpartum weight loss among young, low-income, ethnic minority women. Am J Obstet Gynecol 2011;204:52.e1-11.

6. Oken E, Taveras EM, Kleinman KP, et al. Gestational weight gain and child adiposity at age 3 years. Am J Obstet Gynecol 2007;196:322.e1-8.

7. Goldstein RF, Abell SK, Ranasinha S, et al. Association of Gestational Weight Gain With Maternal and Infant Outcomes: A Systematic Review and Meta-analysis. JAMA 2017;317:2207-25.

8. Deputy NP, Sharma AJ, Kim SY. Gestational Weight Gain - United States, 2012 and 2013. MMWR Morb Mortal Wkly Rep 2015;64:1215-20.

9. Cantor AG, Jungbauer RM, McDonagh M, et al. Counseling and Behavioral Interventions for Healthy Weight and Weight Gain in Pregnancy: Evidence Report and Systematic Review for the US Preventive Services Task Force. JAMA 2021;325:2094-109.

10. Teede HJ, Bailey C, Moran LJ, et al. Association of Antenatal Diet and Physical Activity-Based Interventions With Gestational Weight Gain and Pregnancy Outcomes: A Systematic Review and Meta-analysis. JAMA Intern Med 2022;182:106-14.

11. Carter-Edwards L, Østbye T, Bastian LA, et al. Barriers to adopting a healthy lifestyle: insight from postpartum women. BMC Res Notes 2009;2:161.

12. Mailey EL, Huberty J, Dinkel D, et al. Physical activity barriers and facilitators among working mothers and fathers. BMC Public Health 2014;14:657.

13. Chang MW, Nitzke S, Guilford E, et al. Motivators and barriers to healthful eating and physical activity among low-income overweight and obese mothers. J Am Diet Assoc 2008;108:1023-8.

14. Waring ME, Moore Simas TA, Xiao RS, et al. Pregnant women's interest in a website or mobile application for healthy gestational weight gain. Sex Reprod Healthc

2014;5:182-4.

15. Willcox JC, van der Pligt P, Ball K, et al. Views of Women and Health Professionals on mHealth Lifestyle Interventions in Pregnancy: A Qualitative Investigation. JMIR Mhealth Uhealth 2015;3:e99.

16. Rhodes A, Smith AD, Chadwick P, et al. Exclusively Digital Health Interventions Targeting Diet, Physical Activity, and Weight Gain in Pregnant Women: Systematic Review and Meta-Analysis. JMIR Mhealth Uhealth 2020;8:e18255.

17. Sherifali D, Nerenberg KA, Wilson S, et al. The Effectiveness of eHealth Technologies on Weight Management in Pregnant and Postpartum Women: Systematic Review and Meta-Analysis. J Med Internet Res 2017;19:e337.

18. The Diabetes Prevention Program (DPP): description of lifestyle intervention. Diabetes Care 2002;25:2165-71.

19. Pagoto S, Waring ME, May CN, et al. Adapting Behavioral Interventions for Social Media Delivery. J Med Internet Res 2016;18:e24.

20. Bandura A. Social foundations of thought and action: a social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall, 1986.

21. Fisher W, Piazza C, Roane H. Handbook of Applied Behavior Analysis. New York, NY: Guildford Press, 2011.

22. Atkinson NL, Saperstein SL, Desmond SM, et al. Rural eHealth nutrition education for limited-income families: an iterative and user-centered design approach. J Med Internet Res 2009;11:e21.

23. De Vito Dabbs A, Myers BA, Mc Curry KR, et al. User-centered design and interactive health technologies for patients. Comput Inform Nurs 2009;27:175-83.

24. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly 1989;13:319-40.

25. Jen WY. The adoption of mobile weight management services in a virtual community: the perspective of college students. Telemed J E Health 2010;16:490-7.

26. Ma Q, Liu L. The Technology Acceptance Model: a meta-analysis of empirical findings. J. Organ. End User Comput 2004;16:59-72.

27. Godiwala P, Appelhans BM, Moore Simas TA, et al. Pregnancy intentionality in relation to non-planning impulsivity. J Psychosom Obstet Gynaecol 2016;37:130-6.

28. Kushniruk A, Patel V, Cimino JJ, et al. Cognitive evaluation of the user interface and vocabulary of an outpatient information system. Proc AMIA Annu Fall Symp 1996;22-6.

29. Brooke J. SUS: A 'Quick and Dirty' Usability Scale. In: Jordan PW, Thomas B, McClelland IL, et al. editors. 1st edition. CRC Press,1996:189-94.

30. Hyzy M, Bond R, Mulvenna M, et al. System Usability Scale Benchmarking for Digital Health Apps: Meta-analysis. JMIR Mhealth Uhealth 2022;10:e37290.

31. Pagoto SL, Waring ME, Schneider KL, et al. Twitter-Delivered Behavioral Weight-Loss Interventions: A Pilot Series. JMIR Res Protoc 2015;4:e123.

32. United States Department of Agriculture, National Agricultural Library. DRI Calculator for Healthcare Professionals. Available online: https://www.nal.usda.gov/ human-nutrition-and-food-safety/dri-calculator

33. Otten JJ, Hellwig JP, Meyers LD. Dietary Reference Intakes: the Essential Guide to Nutrient Requirements. The National Academies Press; 2006.

34. ACOG Committee Opinion No. 650: Physical Activity and Exercise During Pregnancy and the Postpartum Period. Obstet Gynecol 2015;126:e135-42.

35. Eysenbach G. The law of attrition. J Med Internet Res 2005;7:e11.

36. Waring ME, Moore Simas TA, Oleski J, et al. Feasibility and Acceptability of Delivering a Postpartum Weight Loss Intervention via Facebook: A Pilot Study. J Nutr Educ Behav 2018;50:70-74.e1.

37. Pagoto S, Waring M, Olendzki E, et al. The feasibility of incentivizing participation in an online social network weight loss program. Proceedings of the 50th Hawaii International Conference on System Sciences. 2017. Available online: http://hdl.handle.net/10125/41615

38. Waring ME, Moore Simas TA, Liao X. Gestational weight gain within recommended ranges in consecutive pregnancies: a retrospective cohort study. Midwifery 2013;29:550-6.

39. Bannon AL, Waring ME, Leung K, et al. Comparison of Self-reported and Measured Pre-pregnancy Weight: Implications for Gestational Weight Gain Counseling. Matern Child Health J 2017;21:1469-78.

40. Hall MH, Matthews KA, Kravitz HM, et al. Race and financial strain are independent correlates of sleep in midlife women: the SWAN sleep study. Sleep 2009;32:73-82.

41. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. Qual Health Res 2005;15:1277-88.

42. Krukowski RA, Ross KM. Measuring Weight with Electronic Scales in Clinical and Research Settings During the Coronavirus Disease 2019 Pandemic. Obesity (Silver Spring) 2020;28:1182-3.

43. Willcox JC, Wilkinson SA, Lappas M, et al. A mobile

health intervention promoting healthy gestational weight gain for women entering pregnancy at a high body mass index: the txt4two pilot randomised controlled trial. BJOG 2017;124:1718-28.

44. Olson CM, Groth SW, Graham ML, et al. The effectiveness of an online intervention in preventing excessive gestational weight gain: the e-moms roc randomized controlled trial. BMC Pregnancy Childbirth 2018;18:148.

45. Pagoto S, Waring ME, Jake-Schoffman DE, et al. What type of engagement predictors success in a Facebook weight loss group? Proceedings of the 51th Hawaii International Conference on System Sciences 2018:3304-12. Available online: http://hdl.handle.net/10125/50307

46. Redman LM, Gilmore LA, Breaux J, et al. Effectiveness of SmartMoms, a Novel eHealth Intervention for Management of Gestational Weight Gain: Randomized Controlled Pilot Trial. JMIR Mhealth Uhealth 2017;5:e133.

47. Ferrara A, Hedderson MM, Brown SD, et al. A telehealth lifestyle intervention to reduce excess gestational weight gain in pregnant women with overweight or obesity (GLOW): a randomised, parallel-group, controlled trial. Lancet Diabetes Endocrinol 2020;8:490-500.

48. Peaceman AM, Clifton RG, Phelan S, et al. Lifestyle Interventions Limit Gestational Weight Gain in Women with Overweight or Obesity: LIFE-Moms Prospective Meta-Analysis. Obesity (Silver Spring) 2018;26:1396-404.

49. Matthews TJ, Hamilton BE. Educational Attainment of Mothers Aged 25 and Over: United States, 2017. NCHS Data Brief 2019;(332):1-8.

50. Graham M, Uesugi K, Olson C. Barriers to weight-related health behaviours: a qualitative comparison of the socioecological conditions between pregnant and post-partum low-income women. Matern Child Nutr 2016;12:349-61.

51. Waring ME, Jake-Schoffman DE, Holovatska MM, et al. Social Media and Obesity in Adults: a Review of Recent Research and Future Directions. Curr Diab Rep 2018;18:34.

52. Turner-McGrievy GM, Hales SB, Schoffman DE, et al. Choosing between responsive-design websites versus mobile apps for your mobile behavioral intervention: presenting four case studies. Transl Behav Med 2017;7:224-32.

53. Reactions Now Available Globally: Facebook Inc., 2016. Available online: http://newsroom.fb.com/news/2016/02/reactions-now-available-globally/

54. Rosen A, Ihara I. Giving you more characters to express yourself: Twitter; 2017 [updated 26 September 2017.

Available online: https://blog.twitter.com/official/en_us/topics/product/2017/Giving-you-more-characters-to-express-yourself.html

55. Mosseri A. News Feed FYI: Bringing People Closer Together: Facebook, Inc.; 2018 [updated 11 January 2018. Available online: https://newsroom.fb.com/news/2018/01/news-feed-fyi-bringing-people-closer-together/

56. Cooper P. 2021. [September 15, 2021]. Available online: https://blog.hootsuite.com/facebook-algorithm/

57. Schroepfer M. An Update on Our Plans to Restrict Data Access on Facebook [updated 4 April 2018. Available online: https://newsroom.fb.com/news/2018/04/restricting-data-access/

58. Han JY, Hou J, Kim E, et al. Lurking as an active participation process: a longitudinal investigation of engagement with an online cancer support group. Health Commun 2014;29:911-23.

59. Chiauzzi E, Wicks P. Digital Trespass: Ethical and Terms-of-Use Violations by Researchers Accessing Data From an Online Patient Community. J Med Internet Res 2019;21:e11985.

60. Duggan M. Mobile Messaging and Social Media - 2015 Washington, DC: Pew Research Center; 2015 [updated 19 August 2015]. Available online: http://www.pewinternet.org/files/2015/08/Social-Media-Update-2015-FINAL2.pdf

61. Auxier B, Anderson M. Social Media Use in 2021 Washington, DC: Pew Research Center; 2021 [updated 7 April 2021]. Available online: https://www.pewresearch.org/internet/2021/04/07/social-media-use-in-2021/

62. Vogels EA, Gelles-Watnick R, Massarat N. Teens, Social Media, and Technology 2022 Washington, DC: Pew Research Center; 2022 [updated 8/10/2022]. Available online: https://www.pewresearch.org/internet/2022/08/10/teens-social-media-and-technology-2022/

63. Oviatt JR, Reich SM. Pregnancy posting: exploring characteristics of social media posts around pregnancy and user engagement. Mhealth 2019;5:46.

64. Waring ME, Pagoto SL, Moore Simas TA, et al. Feedback on Instagram posts for a gestational weight gain intervention. Transl Behav Med 2022;12:568-75.