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Efficacious Lifestyle Interventions for Appropriate Gestational Weight Gain in Women with Overweight or Obesity Set in the Health Care System: A Scoping Review

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Abstract

Health care systems offer opportunities to scale up interventions for appropriate gestational weight gain (GWG); however, GWG interventions in the health care setting remain largely unavailable to women with overweight or obesity. To inform the translation of efficacious lifestyle interventions to health care delivery systems, this scoping review aimed to systematically identify randomized controlled trials for appropriate GWG in women with overweight or obesity that were set in a health care system. A scoping review allows for the systematic synthesis of knowledge on an exploratory research question aimed at mapping key concepts (e.g., time, location, source, and evidence) and gaps in a specific area of study. The Colquhoun et al. (2014) framework to conducting scoping reviews was used to develop the research question, identify relevant studies, select studies, extract data, and synthesize data. Specifically, two reviewers searched publication databases for English-language articles published from January 2009 to May 2020 using specific keywords/MeSH terms. Eight peer-reviewed journal articles were identified; six trials were based in Europe and two in the U.S. Only four included lifestyle interventions that were efficacious in reducing GWG. Three trials with efficacious interventions were among women with obesity only and encouraged them to gain at or below the lower limit for total GWG (i.e., ≤5 kg) of the Institute of Medicine (IOM) guidelines. The fourth was among women with overweight or obesity and encouraged women to gain within the IOM guidelines with a telehealth behavioral intervention. Efficacious interventions were initiated in the first half of pregnancy and included frequent contact delivered through multiple modalities (i.e., in-person visits, telephone calls, text messages, email) by trained intervention staff (i.e., dietitian, lifestyle coach, and/or physiotherapist). Only one efficacious intervention trial briefly mentioned

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Declaration of Interest Statement

This authors report no conflict of interest.

theoretical components for health promotion (e.g., self-monitoring); likewise, only one included cost-effectiveness analyses. This review systematically identified randomized controlled trials of efficacious lifestyle interventions (i.e., consisting of diet and physical activity components) for appropriate GWG in women with overweight or obesity that were set in the health care system and delivered by non-clinicians. Translation efforts could draw upon aspects of the efficacious lifestyle interventions described in this review. Future studies should examine theory-based telehealth interventions and cost-effectiveness.

Keywords

gestational weight gain; lifestyle interventions; pregnancy; overweight; obesity

Introduction

A meta-analysis [1] of over 1 million pregnant women in the U.S. found that almost half gain above the guidelines for gestational weight gain (GWG) set forth by the Institute of Medicine (IOM; now the National Academy of Medicine) [2]. Excess GWG has been associated with an increased risk of gestational diabetes, cesarean delivery, postpartum weight retention and obesity for the mother, [1,3,4] and large for gestational age and later life obesity [5,6] for the infant. Due to the increased risks of these adverse health outcomes, there has been great interest in recent years [5] in the development of efficacious lifestyle interventions for appropriate GWG.

The IOM recommends ranges of appropriate GWG based on women's pre-pregnancy body mass index (BMI), advising women with overweight (BMI 25-29 kg/m^2) and obesity (BMI ≥30 kg/m^2) to gain less weight than their healthy weight (BMI 18.5-24.9 kg/m^2) counterparts [2]. Meeting the IOM guidelines is less common among women with overweight or obesity than for healthy weight or underweight women, with 62% of women with overweight and 56% of those with obesity experiencing excessive GWG [7,8]. Over 50% of women in the U.S. are overweight or obese prior to becoming pregnant [7,8], and women with pre-pregnancy overweight or obesity are at increased risk for adverse pregnancy outcomes independent of GWG [9].

Meta-analyses of randomized controlled trials of lifestyle (i.e., healthy diet and physical activity) interventions during pregnancy for appropriate GWG in women with pre-pregnancy overweight or obesity have been conducted [10-14]. They report statistically significant reductions in GWG associated with lifestyle intervention in women with overweight or obesity, with women in the interventions gaining 1-2 kg less than their comparators [10-12,14]. Given this success, the translation and scaling up of these interventions is the logical next step and an urgent public health priority. Lifestyle interventions set specifically in the health care delivery system have potential for high levels of scalability and reach [13,14]. Pregnant women have frequent interaction with the health care system (i.e., opportunity for intervention delivery) and are motivated for health behavior changes [15].

However, lifestyle interventions for health behavior change are time consuming [16,17], making them impractical for delivery by clinicians (e.g., obstetricians, perinatologists),

who have little time during appointments to discuss lifestyle and often lack training on lifestyle/body weight counseling [18,19]. There is also some evidence to suggest that patients may benefit from a different type of communication than they are used to from traditional health care personnel [20]. Health education and promotion within a 'health coaching' context shows great promise in terms of enhancing well-being and facilitating the achievement of health- or lifestyle-related goals [21]. Health coaching is a goal-oriented, client-centered partnership that uses client enlightenment and empowerment to affect health behavior change [22]. Individuals trained in health coaching have the professional skills needed to elicit sustainable health-related behavior change by improving patient engagement and activation [23]. As such, lifestyle coaches are an attractive alternative to clinicians counseling on appropriate GWG in the health system setting. Knowledge of the strategies and components utilized by successful lifestyle interventions set in the health care system and delivered by lifestyle coaches (and other non-clinicians) are needed to inform their translation.

Siega-Ritz et al. [24] recently highlighted the need to use a health equity lens when addressing GWG in women with obesity, as well as the need for interventions with stronger study designs and more frequent and explicit reporting of data generation (e.g., content, duration, frequency of delivery, and mode of contact) to better develop interventions for appropriate GWG targeting this group. By staying within the IOM GWG guidelines, Yanit et al. calculated that nearly $12.7 billion can be saved and nearly 400,000 fewer cesarean deliveries among women with obesity would be expected [25]. The purpose of this scoping review was to systematically identify randomized controlled trials of efficacious lifestyle interventions for appropriate GWG in women with overweight or obesity that were set in the health care system and delivered by non-clinicians (e.g., life coaches), and to describe the strategies and components utilized by these successful interventions to inform their translation and scaling up.

Materials and Methods

Scoping Review Framework

A scoping review allows for the systematic synthesis of knowledge on an exploratory research question aimed at mapping key concepts (e.g., time, location, source, and evidence) and gaps in a specific area of study [26]. As such, the Colquhoun et al. [26] framework to conducting scoping reviews was used to develop the research question, identify relevant studies, select studies, extract data, and synthesize data. Additionally, aspects of the PRISMA-P 2015 guidelines were used to strengthen the methodology (e.g., specifying *a priori* a rationale, objectives, eligibility criteria, search strategy, selection process, outcomes and prioritization, etc.) [27].

Inclusion Criteria

The inclusion criteria for this review were: 1) lifestyle intervention trials of pregnant women with overweight or obesity, or presenting GWG data for a subset of lifestyle intervention trial participants with overweight or obesity, 2) behavioral lifestyle interventions that included both diet and physical activity components, 3) lifestyle interventions delivered

by non-physicians (e.g., a life coach, dietician) within a health care system (e.g., sessions at a clinic) and/or feasible for implementation within a health care system (e.g., telehealth interventions), 4) randomized controlled trials with a parallel control group published in a peer-reviewed journal, 5) outcome data presented included group differences in GWG as well as GWG according to the 2009 IOM guidelines; 6) journal articles published from January 2009 [2] to May 2020, and 7) published in English.

Data Collection

We used a four-step procedure to identify relevant journal articles for this scoping review. In step 1, two reviewers (PGP, ED, or AY) independently performed literature searches in PubMed, CINAHL, PsycINFO, Academic Search Complete, and Google Scholar (last search date: May 31, 2020). Each search used the following keywords/MeSH terms: ("gestational weight gain") AND (pregnancy) AND (obese or overweight or high risk or excessive weight or during pregnancy) AND ("lifestyle intervention" or limit weight or program or counseling or advice or lifestyle in pregnancy or prevent*) AND ("dietary habits" or healthy eating or nutrition or "physical activity" or exercise or dietary and lifestyle counseling) AND (healthcare provider or midwife or clinical setting or clinical care) AND ("randomized controlled trial"). A total of 819 journal articles were identified. In step 2, duplicates (trials indexed by two or more search engines) were excluded (n=76), leaving 743 articles for further assessment.

Step 3 entailed screening the titles and abstracts of the 743 articles, which were conducted independently by two reviewers (PGP, ED, or AY). A total of 32 articles meeting the inclusion criteria were identified by the title and abstract screen. The full manuscripts were then assessed by two independent reviewers (PGP, ED, or AY). A third reviewer (CSB) resolved any discrepancies. We excluded 24 articles that did not meet the inclusion criteria, such as, for example, not presenting any GWG data for women with overweight or obesity (n=5) and not presenting GWG data classified according to the 2009 IOM guidelines (n=8). This screening left eight trials for inclusion in this scoping review (Figure 1).

Data extracted from the identified trials included study location, study description, GWG outcomes, and major findings. For trials reporting a statistically significant difference in GWG, data extracted included description of intervention (setting, delivery, mode of contact, and frequency), information on the healthy diet, physical activity and GWG tracking components of the intervention, intervention adherence, theoretical framework used and cost-effectiveness analyses. Methodological evaluation and assessment of the risk of bias were not included, as is typical of scoping reviews [26,28].

Results

Table 1 summarizes the eight trials included in this scoping review. Six trials were conducted in Europe (i.e., Denmark, Germany, Netherlands, Norway, and a multi-site study conducted in several European countries) [29,31,33-36] and two were conducted in the U.S. [30,32]. Trials of interventions efficacious in lowering GWG are presented and described in Table 2; most of them included women with obesity only (Redman et al. [32]: BMI 25-39.90 kg/m^2 at the first measured pregnancy weight; Renault et al. [33]: prepregnancy

BMI ≥30 kg/m^2; Simmons et al. [35]: prepregnancy BMI ≥29 kg/m^2, in order to allow for sufficient recruitment from countries with lesser rates of maternal obesity; Vinter et al. [36]: BMI 30-45 kg/m^2, as calculated from prepregnancy weight or the first measured pregnancy weight). Simmons et al. [35], Vinter et al. [36], and Redman et al. [32], calculated GWG outcomes from a measured pregnancy weight; Renault et al. [33] utilized self-reported prepregnancy weight and weight measured at a visit during gestational weeks 36-37 to calculate GWG. It is unknown if studies measured weight for research purposes or if weight was pulled from the electronic health record [32,33,35,36]. Analyses were intention-to-treat for three [32,33,35] of the four trials. In three of the trials, attrition was higher in those assigned the intervention compared to usual care conditions Renault et al. [33]: 8% vs 5%; Simmons et al. [35]: 9% vs 5%; Vinter et al. [36]: 17% vs 14%). Redman et al. [32] did not report on attrition. Participants withdrawing from the trial was the most commonly cited reason for missing follow-up data.

The efficacious lifestyle interventions were delivered in university hospitals [33,36], a clinic-based setting [32], and hospitals or midwife practices (for the multi-site study) [35]. Only one intervention was designed to help pregnant women with overweight or obesity gain weight within the IOM recommendations for their respective BMI class [32]. The GWG goal for the other efficacious interventions, which were among women with obesity only, was to limit GWG to or below the lower limit of the IOM recommendation (i.e., ≤5 kg) for women with obesity [33, 35,36]. The efficacious interventions were initiated by 14 weeks [32,36], 16 weeks [33], and 20 weeks gestation [35]; they either concluded at 35-37 weeks gestation [35,36] or lasted through the end of gestation [32,33] (Table 2).

The four lifestyle interventions efficacious in lowering GWG [32,33,35,36] (Table 2) were delivered primarily face-to-face by dietitians [33,36], a lifestyle coach [35], a physiotherapist [36], or study staff [32]. One trial used a telehealth tool (i.e., mobile phone app) to assist in the delivery of the intervention for one of the two intervention arms [32]. The frequency and duration of sessions in the efficacious lifestyle interventions were not always explained in sufficient detail, and there was substantial variation observed among those reporting this information: in one study, 11-13 consultations were delivered every two weeks (median number of consultations = 11, range 0-14) [33]; another included five in-person consultations lasting 30-45 minutes each, along with ≤ 4 telephone calls up to 20 minutes in duration [35]; another study included 4 dietary consultations plus 1-hour per week of physical activity training in conjunction with 4-6 physical activity discussion sessions [36], and the last study used weekly (between 13 and 24 weeks gestation) and bi-weekly (25 weeks gestation until delivery) counseling sessions [32].

Strategies employed by the efficacious lifestyle interventions included dietary advice (increased consumption of ‘food-based’, lower simple and complex carbohydrate, low fat, high fiber, and high protein foods [35]; portion control [35]; corrective dietary advice [33] (i.e., only for report of non-adherence to the prescribed diet or measured weight greater than target); dietary advice based on official Danish recommendations [36]; or individually estimated energy requirements [32,36]) and advice on appropriate GWG [32,33,35,36]. To increase physical activity (i.e., both aerobic [32,33,35,36] and strength/resistance training) [35,36], efficacious interventions provided resources such as pedometers to track daily

step counts [32,33,35,36], a mobile phone app [32], elastic bands for strength training [34,35], and a free six month membership to a fitness center [36]. For one trial, intervention participants were given a daily step goal and received text message reminders to meet their daily step goal every four weeks [33] and in another, the daily step count from the pedometer was automatically uploaded to their health charts [32]. Intervention participants also kept daily self-monitoring logs, in which they were instructed to record step counts and weight, but limited [32] or no feedback [33] was given on the information tracked in the logs.

Three [32,33,36] of the four trials with efficacious lifestyle interventions reported unadjusted effect estimates only. Renault et al. [33] reported lower GWG between the lifestyle intervention [median range: 8.6 kg (95% CI −9.6 to 34.1)] and control [10.9 kg (95% CI −4.4 to 28.7)] arms (p=.01; estimated group difference not reported). Vinter et al. [36] reported a statistically significant difference (p=.01) in GWG between the lifestyle intervention [median: 7.0 kg (IQR 4.7 to 10.6)] and control [8.6 kg (IQR 5.7 to 11.5); estimated group difference not reported]. Redman et al. [32] reported a statistically significant difference (p=.04) in GWG between the overall lifestyle intervention [in-person and mobile phone: least square mean 9.2, SE 0.9 kg] and control [least square mean 12.8, SE 1.5 kg], and found that the in-person intervention [least square mean 8.0, SE 1.3 kg) and mobile phone intervention [least square mean 10.0, SE 1.5 kg] were comparable (p=.04). Simmons et al. [35] was the only trial to adjust analyses for maternal BMI at baseline and the number of weeks between measurements; the trial reported a statistically significant difference in GWG between the lifestyle intervention and control arms of −2.02 kg (95% CI −3.58, −0.46). The lifestyle interventions of Renault et al. [33] and Simmons et al. [35] additionally resulted in statistically significant improvements in the proportion of women and the odds, respectively, of *not* exceeding the 2009 IOM GWG guidelines; there was also the suggestion (i.e., $p = .058$) that the intervention of Vinter et al. [36] reduced the proportion of women *not* exceeding the 2009 IOM GWG guidelines (Table 1).

Three of the trials with efficacious interventions reported adherence to the intervention components. Redman et al. [32], which had two intervention arms, reported that 60.8% of participants in the in-person intervention arm recorded daily weight and step counts compared to 76.5% of participants in the mobile phone intervention arm. Renault et al. [33] reported that 64% of participants had submitted a log with daily weight measurements and step counts at the start of the intervention at 13 weeks; this dropped to 53% completion at 33 weeks. Vinter et al. [36] reported that 92% of women in the lifestyle intervention completed the four requested dietary consultations and 98% completed three dietary consultations, though only 56% attended at least half of the physical activity training classes. In regards to satisfaction with the intervention, at gestational week 35, 85% of women in the Vinter et al. [36] lifestyle intervention reported that participation resulted in more healthy eating habits, whereas only 21% in the control arm thought that their dietary habits were positively influenced by participation.

None of the effective interventions reported a theoretical framework (Table 2). Nonetheless, Renault et al. [33] stated that women received encouragement (reinforcement) during the dietary consultations to follow a hypocaloric, Mediterranean style diet. Simmons et al.

[35] reported using lifestyle intervention messages based on patient-centered care and motivational interviewing, a communication approach. Only Redman et al. [32] included cost-effectiveness analyses. While accounting for session attendance and intervention adherence, costs incurred per participant for travel to and from treatment sessions and time spent with the counselor in the Redman et al. trial resulted in mean US $97, SD $6 for the mobile phone intervention arm and mean US $347, SD $40 for in-person intervention ($p<.001$). Cost of interventionist time and equipment was US $215 for mobile phone intervention arm and US $419 for in-person intervention arm [32].

Discussion

This scoping review systematically identified randomized controlled trials of efficacious lifestyle interventions (i.e., consisting of diet and physical activity components) for appropriate GWG in women with overweight or obesity that were set in the health care system and delivered by non-clinicians. We reviewed the strategies employed by these successful lifestyle interventions to inform their translation to the health care delivery system. Only four [32,33,35,36] of the eight trials [29-36] that we identified had lifestyle interventions were efficacious in improving GWG. However, there was considerable variation in several key concepts mapped, including mode and duration of the counseling sessions and the diet and physical activity advice prescribed. The four efficacious lifestyle interventions were all intensive in terms of frequency, with contacts every week or every other week through 35 weeks gestation [35,36] or delivery [32,33], but used a variety of modalities (i.e., in-person visits, telephone calls, text messages, mobile phone app, and email). Only one efficacious intervention included women with overweight or obesity [32]. Three efficacious interventions were conducted among women with obesity only, and encouraged women to gain at or below [33,35,36] the lower bound of the range for total GWG recommended by the IOM.

All of the efficacious lifestyle interventions were initiated in early to mid -pregnancy (i.e., 10-20 weeks gestation) and lasted for the remaining duration or nearly the remaining duration of the pregnancy [32,33,35,36]. Consistent with the literature suggesting that greater intervention intensity leads to better weight management outcomes in non-pregnant populations [16,17], intensity of the GWG intervention (i.e., frequency and duration of the intervention sessions) may also have influenced the participants' GWG. Trials of efficacious interventions identified by this review utilized 4-6 in-person intervention sessions [33,35,36] or 18 in-person or mobile phone lessons [32]. Only one of the four trials reported a duration for the in-person intervention sessions (30-45 minutes) [35]. Some in-person sessions were augmented by 4-6 telephone intervention sessions in two trials [33,35]; only one of those trials reported the duration of the telephone interventions sessions, stating they lasted for a maximum of 20 minutes [35]. More data on the duration of the intervention sessions, by modality, are needed to inform the translation of efficacious lifestyle interventions [24].

Certain intervention features have implications for scalability and translation to health system settings. The lifestyle intervention of Vinter et al. [36] may be difficult to translate into a health system setting, as it was the only one to use separate intervention staff for the diet (i.e., dietician) and physical activity (i.e., physiotherapists) components. The use

of a lifestyle coaches [23] with expertise in both diet and physical activity (i.e., health behavior) counseling may be more cost-effective and logistically simpler, and was shown to be effective in the Simmons et al. [35] and Renault et al. [33] trials. Redman et al. [32] and Vinter et al. [36] included personalized estimates of energy required based on weight and level of activity for the diet component. The use of technology in one arm of the trial facilitated the prescription of personalized lifestyle messaging in the Redman et al. [32] trial. Caloric intake and activity levels are not routinely assessed in the health system setting. However, counseling on healthy diet and portion control [35] or energy restriction [32] and physical activity [32,33,35] with corrective dietary advice for those gaining too quickly [32,35], as employed by the other efficacious lifestyle interventions, may be better suited for adoption by health systems. Smart phone apps and other technology can assist health systems connect with patients to deliver these interventions.

The physical activity component of the Vinter et al. [36] lifestyle intervention included training classes with physiotherapists for 1 hour every week (i.e., aerobics, light weights training, elastic bands, and balance exercises); 4-6 of these training classes were followed by group exercise discussion sessions. Attendance to the weekly training classes was low and many participants reported time conflicts [36]. Indeed, lack of time and having to attend sessions have been reported by pregnant women as barriers to receipt of weight management services [37,38]. Although some health insurance carriers in the U.S. have begun to provide incentives to enrollees who engage in healthy lifestyle programs and offer rebates to or reimbursements of health club/fitness center dues [39], there is currently no universal mechanism for providers to refer all patients, beyond certain high-risk patients such as those with pre-diabetes, to fitness centers or exercise training programs. The findings of Vinter et al. [36] additionally suggest against the use of fitness center membership, exercise training classes and exercise group discussion sessions in GWG interventions that are scaled up. Educational materials on physical activity [35] and providing pedometers [32,35] or pedometers along with a step goal and behavioral counseling [32,33,36] are likely better suited to translation to the health care delivery system setting.

Telehealth methods (text messaging, mobile phone applications, email, websites and video) have been used to address GWG in pregnant women across BMI classes but with varying results [40,41]. In women with overweight or obesity, Redman et al. [32] reported success with sending personalized lifestyle advice for appropriate GWG to participants based on their dietary intake data received through a mobile phone app, which also automatically uploaded the prescribed energy intake to their electronic health record. Furthermore, the mobile phone arm of the Redman et al. [32] trial was more cost-effective than the in-person arm of their intervention. Other efficacious interventions to use telehealth components included text messaging [33] and telephone calls [35]. Telehealth may increase the accessibility of interventions since requiring in-person counseling with multiple visits to a clinic may not be feasible for many busy pregnant women and may be difficult to implement in the health care setting.

Three of four efficacious interventions identified by this review were limited to women with obesity [33, 35,36]. A decade ago, Kiel et al. [42] first proposed limited or no gestational weight gain in women with obesity based on observational data. However, it remains to be

determined whether GWG below the current IOM guidelines for women with overweight increases the risk of adverse outcomes and could thus be an acceptable target for lifestyle interventions for appropriate GWG in this sub-population [42].

Interestingly, Simmons et al. [35] excluded those who developed gestational diabetes (prior to randomization). The findings of the Simmons et al. [35] trial should thus be interpreted cautiously in terms of translation to a health system setting, where such an exclusion may be impractical.

To advance the translation of theory-based lifestyle interventions targeting GWG, future studies must report greater detail regarding the theoretical frameworks utilized as well as the operationalization of the theoretical constructs employed. Self-monitoring is a construct of several cognitive-behavioral theories, and self-monitoring both behavior and behavioral outcomes (e.g., weight) are useful tools for self-regulation. Renault et al. [33] used GWG logs as an intervention tool to help participants monitor their GWG and to initiate additional dietary counseling if GWG exceeded IOM GWG guidelines, though specifics on what that dietary advice entailed were not available. Simmons et al. used principles of women's empowerment and cognitive behavioral techniques [35], but how these were operationalized were not reported. This lack of detail on the operationalization of theoretical constructs is an on-going critique for lifestyle interventions [43,44] (only Simmons et al. [35] briefly discussed techniques based on Motivational Interviewing, a client-centered communication approach); such details are necessary to support the successful translation of these lifestyle interventions to the health care system. The inclusion of cost-effectiveness analyses, as done by Redman et al. [32], will help inform and facilitate adoption by the health care system.

Additional research is also needed to determine the potential impact of efficacious lifestyle interventions for appropriate GWG on infant birthweight and adverse perinatal outcomes. The results of several meta-analyses suggest no intervention effects on infant birthweight or perinatal complications, except for a reduction in cesarean births [12,45]. It is possible that efficacious lifestyle interventions for appropriate GWG could reduce the risk of obesity in the offspring via epigenetic changes [46], suggesting the need for long-term follow up of trial participants and their offspring.

A limitation to the current study was the inclusion of English-only publications. Given that the identified interventions were conducted in numerous countries, it is possible that our search missed literature published in other languages. It is also worth noting that efficacious intervention strategies used in other countries may not be generalizable to the U.S. health care system. Components of the interventions identified by this review varied in regards to pragmatism for the current health care system, and thus their potential for translation (i.e., telephone counseling sessions versus weekly 1-hour training classes at a fitness center). Currently, integrated health care delivery systems in the U.S. [47] may be well suited to implement similar intervention strategies [48,49]. Health care facilities that currently provide these telehealth services (i.e., U.S. Veterans Affairs Hospital System) and health care insurance companies that cover them (i.e., Medicaid) [50] should be looked to as a guide for their scaling up in obstetrical practice.

In conclusion, this scoping review identified characteristics of successful lifestyle interventions set in health care systems for appropriate GWG in women with overweight or obesity and recommends the points listed in Figure 2 to guide those preparing such interventions. Interventions should start early in pregnancy and end at or near term [12], and include frequent contact (e.g., weekly) with lifestyle coaches trained in health behavior change counseling (i.e., diet and physical activity). Lifestyle coaches should be trained in and use Motivational Interviewing techniques to help women set small, achievable lifestyle goals and employ self-monitoring strategies, such as GWG charts, food diaries, and physical activity logs, to track their progress. Lifestyle coaches should give feedback given on progress made during subsequent sessions. Due to the on-going COVID-19 pandemic and the population's need for flexibility, relying entirely or partially on telehealth delivery modalities are likely to improve adherence and cost-effectiveness. The one efficacious intervention trial in this scoping review to include women with overweight used telehealth as an intervention strategy, and found the telehealth arm to be as efficacious as the in-person arm and more cost-effective [32]. Further research in this area should include cost-effectiveness analyses (i.e., of intervention implementation and that of related complications) to better understand and facilitate the scaling up of these services.

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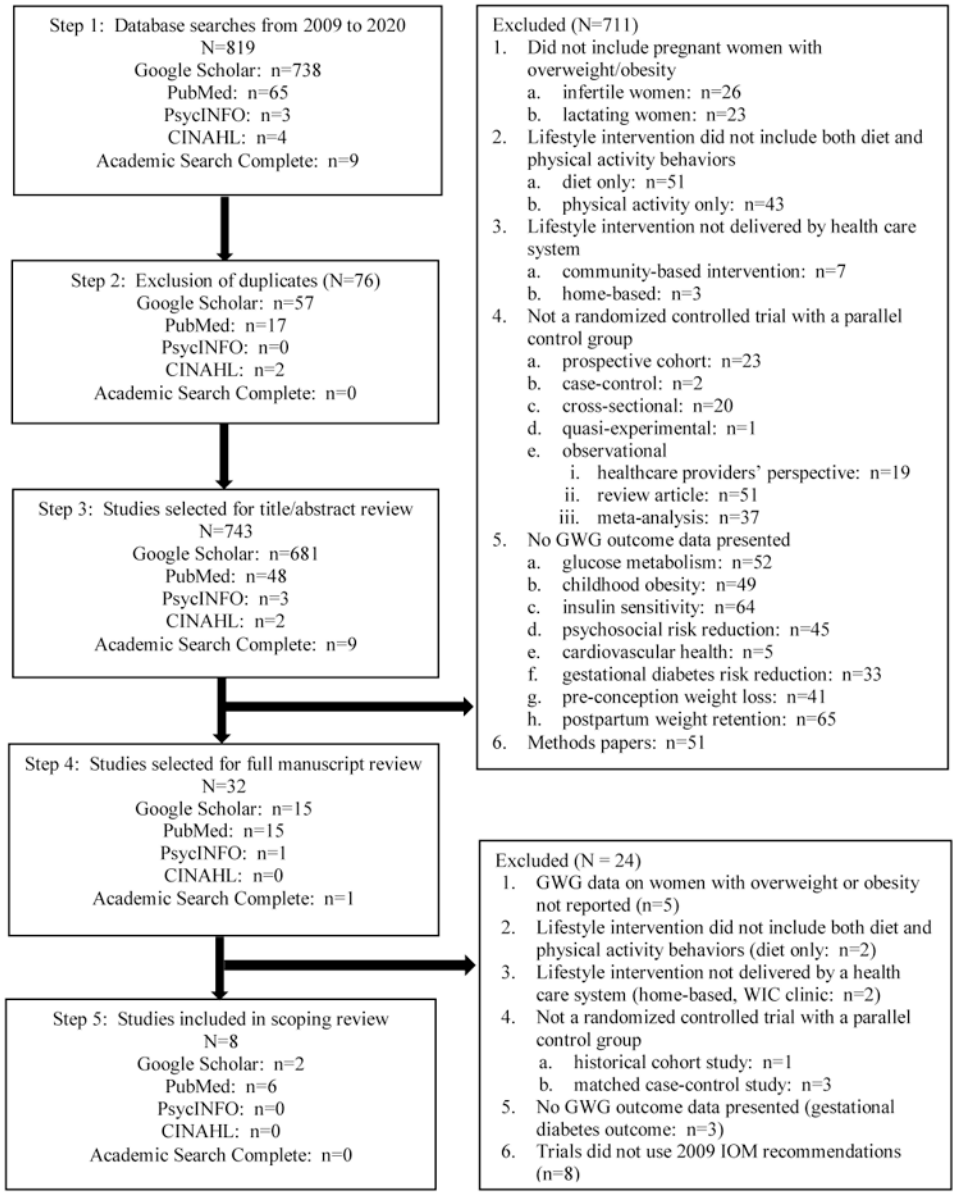

Figure 1.
Flow Diagram of Trials Identified and Included in the Scoping Review.

- Start early in pregnancy (e.g., first trimester) and end at or near term
- Consider telehealth delivery modalities
- Frequent contacts (e.g., weekly sessions) that are brief in duration (e.g., < 30 minutes)
- Lifestyle coaches use motivational interviewing techniques to help women set small, achievable lifestyle goals
- Women use self-monitoring strategies, including GWG charts, food diaries, and physical activity logs, to track progress towards their lifestyle goals
- Lifestyle coaches provide feedback on progress

Figure 2.
Recommendations for Future Interventions

Table 1.

Trials that Met Inclusion Criteria (n=8).

Trial	Country	Description	GWG Outcomes	Results*
Althuizen et al. (2012) [29]	Netherlands	Pre-pregnancy weight category NW, OW, OB Enrolled at 15 weeks of gestation Sample size N_I=106 (N_{OW}=10, N_{OB}=15) N_C=111 (N_{OW}=9, N_{OB}=13)	GWG Outcome Weight at 35 weeks minus weight at 15 weeks	GWG Outcome No difference between conditions: 10.6 kg (SD 5.2) intervention vs 12.1 kg (SD 3.8) control
			IOM Recommendations GWG exceeding IOM recommendations for total GWG	IOM Recommendations 75% intervention vs 100% control exceeded IOM recommendations
Chao et al. (2017) [30]	USA	Pre-pregnancy weight category OW, OB Enrolled at ≤16 weeks of gestation Sample size N_I=20 (N_{OW}=10, N_{OB}=10) N_C=21 (N_{OW}=12; N_{OB}=9)	GWG outcome Weight at last prenatal visit minus self-reported weight at 16 weeks	GWG Outcome No difference between conditions: 15.5 ± 5.3 kg intervention vs 13.3 ± 6.8 kg control, *p=.29*
			IOM Recommendations GWG exceeding IOM recommendations for total GWG	IOM Recommendations 83.3% intervention vs 70% control exceeded IOM recommendations, *p=.74*
Kunath et al. (2019) [31]	5 regions of Bavaria (a federal state in south-eastern Germany)	Pre-pregnancy weight category UW, NW, OW, OB (self-reported) Enrolled at ≤12 weeks of gestation Sample size N_I=1139 (N_{NW}=732, N_{OW}=271, N_{OB}=136) N_C=1122 (N_{NW}=735, N_{OW}=249, N_{OB}=138)	GWG Outcome Weight at last prenatal visit minus weight at first routine prenatal visit	GWG Outcome No difference between conditions: OW: 14.0 kg (SD 6.0) intervention 14.1 kg (SD 5.5) control OB: 11.5 kg (SD 6.8) intervention vs 10.6 kg (SD 6.5) control
			IOM Recommendations GWG exceeding IOM recommendations for total GWG	IOM Recommendations OW: 65% intervention vs 69% control exceeded IOM recommendations OB: 64% intervention vs 58% control exceeded IOM recommendations
Redman et al. (2017) [32]	USA	Pre-pregnancy weight category OW, OB Enrolled at 10.4-13.6 weeks of gestation Sample size N_{I1}=18 (in-person) N_{I2}=19 (mobile phone) N_C=17	GWG Outcome Weight at final study visit minus weight at initial study visit	GWG Outcome GWG in SmartMoms intervention (in-person and mobile phone) (LS mean 9.2, SE 0.9 kg) statistically less than in control (LS mean 12.8, SE 1.5 kg), *p =.04* GWG in in-person intervention (LS mean 8.0, SE 1.3 kg) statistically less than in control (LS mean 12.8, SE 1.5 kg), *p=.04* GWG in mobile phone intervention (LS mean 10.0, SE 1.2 kg) moderately less than in control (LS mean 12.8, SE 1.5 kg), *p=.07* GWG in in-person intervention (LS mean 8.0, SE 1.3 kg) equivalent to mobile phone intervention (LS mean 10.0, SE 1.3 kg), *p=.04*
			IOM Recommendations GWG exceeding IOM recommendations for total GWG	IOM recommendations GWG exceeding the IOM recommendations (i.e., ≤9 kg):

Trial	Country	Description	GWG Outcomes	Results*
				56% in-person intervention (*p=.03*) and 58% mobile phone intervention (*p=.04*) vs 84.6% control
Renault et al. (2014) [33]	Denmark	Pre-pregnancy weight category OB Enrolled at <16 weeks of gestation Sample size N_{I1}=130 (lifestyle intervention: physical activity and diet) N_{I2}=125 (physical activity only intervention) N_C=134	GWG Outcome Weight at 36-37 weeks minus pre-pregnancy weight (self-reported)	GWG Outcome GWG in lifestyle intervention [median (range): 8.6 kg (−9.6 to 34.1)] statistically significantly less than in control [10.6 kg (−4.4 to 28.7)], *p=.01*
			IOM Recommendations GWG below (<5 kg), within (5-9 kg), or above (>9 kg) IOM recommendations for total GWG	IOM Recommendations GWG not exceeding IOM recommendations (i.e., ≤9 kg): 55% in lifestyle intervention and 49% in physical activity only intervention vs 37% in control, *p=.013*
Sagedal et al. (2017) [34]	Norway	Pre-pregnancy weight category UW, NW, OW, OB Enrolled at ≤20 weeks of gestation Sample size N_I=296 (N_{OW}=69, N_{OB}=24) N_C=295 (N_{OW}=54, N_{OB}=21)	GWG Outcome Weight at delivery (≥37 weeks) minus pre-pregnancy weight (self-reported) Weight at delivery (≥37 weeks) minus weight at enrollment (measured)	GWG Outcome GWG (self-reported): No difference between conditions OW: 15.3 ± 7.4 kg intervention vs 16.7 ± 7.1 kg control, *p=.321* OB: 10.3 ± 9.0 kg intervention vs 13.4 ± 5.8 kg control, *p=.221* GWG (baseline weight at enrollment): No difference between conditions OW: 12.8 ± 5.8 kg intervention vs 13.9 ± 5.3 kg control, *p=.320* OB: 9.8 ± 7.8 kg intervention vs 12.0 ± 3.9 kg control, *p=.287*
Simmons et al. (2017) [35]	9 European countries: United Kingdom, Ireland, Netherlands, Austria, Poland, Italy, Spain, Denmark, and Belgium	Pre-pregnancy weight category OB (BMI≥29kg/m^2) free of gestational diabetes Enrolled at <20 weeks of gestation Sample size N_{I1}=108 (lifestyle intervention: healthy eating and physical activity) N_{I2}=113 (healthy eating only) N_{I3}=110 (physical activity only) N_C=105	GWG Outcome Weight at 35-37 weeks minus baseline weight (<20 weeks)	GWG Outcome GWG in lifestyle intervention statistically significantly lower than in controls [−2.02 kg (95% CI −3.58, −0.46), *p<.05*]°
			IOM Recommendations GWG not exceeding IOM recommendations for total GWG among women with obesity (BMI ≥30)	IOM Recommendations GWG not exceeding the IOM recommendations (i.e., <9 kg): lifestyle intervention had 2.13 the odds (95% CI 1.05, 4.33) of not exceeding the IOM recommendations compared to control Adjusted for BMI at baseline and number of weeks between measurements
Vinter et al. (2011) [36]	Denmark	Pre-pregnancy weight category OB Enrolled at 10-14 weeks of gestation Sample size N_I=150 N_C=154	GWG Outcome Weight at 35 weeks minus baseline weight (10-14 weeks gestation) IOM Recommendations GWG below (<5 kg) IOM recommendations for total GWG GWG not exceeding (≤9 kg) IOM recommendations for total GWG	GWG Outcome Median GWG in intervention (7.0 kg; IQR 4.7-10.6) statistically significantly lower than median GWG in control (8.6 kg; IQR 5.7-11.5), *p=.014* IOM Recommendations GWG below IOM recommendations (i.e., <5 kg): No difference between conditions GWG not exceeding IOM recommendations (i.e., ≤9 kg): 64.6% in intervention vs 53.4% in control, near significant *(p=.058)*

* If all BMI categories were included in the trial, results presented are specific to the subgroup with overweight or obesity.

GWG = gestational weight gain

UW = underweight

NW = normal weight

OB = obese, obesity

OW = overweight

N_I= intervention sample size

N_C = control sample size

IOM = Institute of Medicine

SD = standard deviation

LS = least square

SE = standard error

IQR = interquartile range

Table 2.

Characteristics of Efficacious Interventions (n=4).

Trial	Control Description	Intervention(s) Description	Diet Component	PA Component	GWG Goal and Weight Tracking	Intervention Adherence	Theoretical Framework
Redman et al. (2017) [32] SmartMoms Study Population Women with BMI 25-39.9 kg/m^2 Setting Various local obstetrician clinics	Usual care	Duration 13 weeks gestation to delivery Delivery Study staff Mode of contact In-person, mobile phone Frequency 18 lessons and behavior modification counseling: weekly between 13 and 24 weeks gestation and bi-weekly from 25 weeks gestation until delivery	Individualized calorie intake advice based on IOM GWG recommendations, data-driven feedback about energy intake General dietary advice	General PA advice Pedometer provided (in-person: Omron Healthcare and mobile phone: Fitbit Zip, FitBit) to self-monitor daily step counts In-person intervention: pen and paper to record step counts, mobile phone intervention: mobile phone app Data driven feedback about PA	Goal GWG within (5-9 kg) IOM recommendations for total GWG Tracking Wireless Internet-connected bathroom scale (in-person and mobile phone) to self-monitor body weight IOM weight graph (hard copy) reviewed during counseling sessions	Percentage of days participants recorded daily weight and step counts vs expected number of days 60.8% in in-person intervention vs 76.5% in mobile phone intervention, *p=.049* Costs incurred per participant for travel to and from treatment sessions and time spent with counselor (adjusted for session attendance and intervention adherence) mean US $97, SD $6 in mobile phone intervention vs mean US $347, SD $40 in in-person intervention, *p<.001* Cost of interventionist time and equipment US $215 for mobile phone intervention vs US $419 for in-person intervention	None specified
Renault et al. (2014) [33] Treatment of Obese Pregnant Women (TOP) Study Population Women with BMI ≥30kg/m^2 Setting Hvidovre	Usual care, which included consultation with dietitian at 11-14 weeks gestation recommending GWG <5 kg and a hypocaloric low-fat diet (1200-1675 kcal), Mediterranean style diet (i.e.,	Duration <16 weeks gestation to delivery Delivery Dietitian Modes of Contact Diet: Alternated between in-person visits and telephone calls PA: text message reminder to reach the step	Received correcting dietary advice if clinic measured weight was greater than target or if women reported non-compliant diet	Pedometer provided (Yamax Digiwalker CW 700/750) and given goal of 11,000 steps per day at first in-person diet consultation; if that goal was unobtainable, women set their own target Women recorded daily step counts in diary log for 7 consecutive days, every 4 weeks	Goal GWG <5 kg Tracking Women recorded their weight in diary log for 7 consecutive days, every 4 weeks – they received no feedback on the weight measurements reported in their diary log	Gestational week 13 64% submitted diary log with daily weight measurements and step counts Gestational week 33 53% submitted diary log with daily weight measurements and step counts	None specified, but women received encouragement/ reinforcement to follow hypocaloric Mediterranean style diet

Trial	Control Description	Intervention(s) Description	Diet Component	PA Component	GWG Goal and Weight Tracking	Intervention Adherence	Theoretical Framework
Hospital, University of Copenhagen	only oral advice given)	goal set at the first in-person diet consultation Frequency of contact Diet: Counseling every 2 weeks (i.e., 11-13 contacts total) PA: Text message reminder to reach step goal sent every 4 weeks		Women received a text message encouraging them to meet the step goal at the start of each recording period Women received no feedback on the daily step counts reported in their diary log			
Simmons et al. (2017) [35] Vitamin D and Lifestyle Intervention for Gestational Diabetes Mellitus Prevention (DALI) Study Population Women with BMI ≥29 kg/m^2 free of gestational diabetes Setting Two university hospitals in 9 European countries (United Kingdom, Ireland, Netherlands, Austria, Poland, Italy, Spain, Denmark, and Belgium)	Usual care	Duration <20-35 weeks gestation Delivery Lifestyle coach, educational materials (i.e., 'Toolkit') Modes of Contact In-person, telephone Frequency 5 face-to-face consultations total (30-45 minutes each) in hospital or midwife practice ≤4 telephone calls (≤20 minutes per call) or contact via email	Food-based, lower simple and complex carbohydrate, lower fat, higher fiber, higher protein diet Also focused on portion size to limit total calories	Aerobic and resistance PA: Pedometers (Yamax Digiwalker SW 200) and Flexible elastic Dyna-Bands (Thera-Band) provided Educational materials based on the FITT model (frequency, intensity, time, type)	Goal GWG ≤5 kg, or if GWG was beyond this before the start of or during the intervention, women advised to maintain their weight Tracking Provided scales if women did not have one at home	Not reported	Message delivery built on principles of patient empowerment, cognitive behavioral techniques, and aspects of motivational interviewing
Vinter et al. (2011) [36] Lifestyle in Pregnancy (LiP) Study Population Women with BMI 30-45 kg/m^2 Setting	Usual care plus access to website with advice on dietary habits and PA in pregnancy	Duration 15-35 weeks gestation Delivery Dietitian, physiotherapist Mode of Contact In-person Frequency Diet: 4 consultations (i.e., at 15, 20, 28, 35 weeks	Dietary advice based on official Danish recommendations Energy requirements were individually estimated according to weight and level of activity	Moderate intensity PA: encouraged 30-60 minutes daily Provided: Pedometer, free full-time fitness center membership for 6 months where they had training classes with physiotherapists for 1 hour per weekly; training consisted of aerobic (low-	Goal GWG below (<5 kg), within (5-9 kg), or above (>9 kg) IOM recommendations for total GWG Tracking Not reported	Diet component 92% of women completed all 4 dietary consultations; 98% of women completed 3 dietary consultations PA component 56% of women attended at least half of the training classes	None specified

Trial	Control Description	Intervention(s) Description	Diet Component	PA Component	GWG Goal and Weight Tracking	Intervention Adherence	Theoretical Framework
Two university hospitals in Denmark, Odense and Aarhus		gestation) PA: 1 hour per week training plus 4-6 discussion sessions		step), light weights and elastic bands, and balance exercises Small group discussions: 4-6 sessions, coach-inspired methods to increase integration of PA in to daily life			

PA = physical activity

GWG = gestational weight gain

BMI = body mass index

IOM = Institute of Medicine