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Virtually delivered lifestyle interventions for overweight and obese pregnant people: A systematic review

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Abstract

Background: Gestational weight gain (GWG) impacts both foetal and maternal health outcomes, with excessive GWG in overweight and obese people further increasing the risk of complications for this population. Lifestyle changes including consuming a healthy diet and physical activity are core strategies for management. Since 2020 and the emergence of the COVID-19 pandemic, use of telehealth has increased; however, little is known about the effectiveness of virtually delivered strategies for maintaining healthy gestational weight during pregnancy.

Objectives: To describe the effect of virtually delivered lifestyle interventions on promoting healthy GWG and reducing maternal and foetal complications associated with excessive GWG, with the view to inform future clinical practice.

Design: This systematic review followed preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines and targeted quantitative studies assessing virtually delivered lifestyle interventions for maintaining healthy gestational weight for overweight and obese pregnant individuals aged 18 and older.

Data sources and methods: Six databases (MEDLINE, CINHAL, EMBASE, EMCARE, MIDIRS and APA PsycINFO) were searched using a rigorous search strategy. Data extraction investigated mode of telehealth delivery, intervention type and GWG outcomes. Quality appraisal was conducted using the Critical Appraisal Skills Programme tool and risk of bias was assessed using the Risk of Bias assessment (RoB-2).

Results: Nine studies met inclusion criteria and within those studies, six different telehealth modalities were identified. Interventions varied and included GWG tracking, step counts, diet and exercise goal setting. Effectiveness of studies was inconsistent, with five studies demonstrating lower GWG.

Conclusion: Results suggest that lifestyle interventions delivered via telehealth may be effective at reducing excessive GWG. The development of targeted interventions integrated into obstetric guidelines aimed at reducing excessive GWG via telehealth platforms should be considered as a strategy not only for pandemic situations, but to increase antenatal care and service access.

Registration: PROSPERO International Prospective Register on 26 January 2023 (CRD42023392095).

Keywords

gestational weight gain, overweight, pregnancy, nutrition, diet, exercise

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Introduction

Healthy gestational weight gain (GWG) during pregnancy, irrespective of pre-pregnancy body mass index (BMI), is one aspect of antenatal care known to positively influence maternal, foetal and neonatal outcomes.[1] Healthy GWG refers to GWG within the National Academy of Medicine (NAM) recommended guidelines compared with pre-pregnancy BMI, whilst excessive GWG is defined as exceeding the weight target stratified by pre-pregnancy BMI.[2] Globally, estimates suggest between 30% and 50% of pregnant people gain more gestational weight than recommended within healthy weight guidelines.[3–5] Compared with people of a healthy preconception weight, overweight or obese individuals are at a higher risk of excessive GWG during pregnancy,[4,5] with excessive GWG further increasing the risk of complications for this population.[6–8] Given the potential impact on pregnant people and their baby, maternal obesity represents a serious and ongoing challenge to midwifery and antenatal care.[1]

Pregnancy complications known to impact overweight and obese people may include maternal and foetal disease, injury or death, either antenatally, during delivery or postpartum.[6,7] Maternal complications resulting from excessive GWG can include hypertensive disorders of pregnancy, gestational diabetes mellitus (GDM) and caesarean delivery.[4,6–8] Excessive GWG also increases the risk of foetal/infant complications, including macrosomia, large for gestational age, preterm birth and congenital abnormalities.[4,6–8] The impacts of excessive GWG extend beyond pregnancy and postpartum, having been associated with an increased risk of childhood overweight/obesity.[9]

Lifestyle and/or behavioural interventions involving nutrition and physical activity are recommended strategies for promoting healthy GWG in pregnant people and general weight loss within the wider community.[10] Standard antenatal care guidelines provide basic information on lifestyle interventions during pregnancy.[11,12] Whilst informative, these guidelines lack specificity around how to implement behavioural changes during pregnancy.[13] Dietary modification interventions have focussed on portion-control of carbohydrate, protein and fat intake, as portion control has been linked to greater weight reduction during pregnancy and an overall decrease in pregnancy complications.[14–16] Exercise-only interventions, including participation in aerobic and muscle-strengthening exercises, have significantly reduced the risk of people exceeding GWG guidelines,[13,17–19] whilst interventions combining dietary modification and physical activity have been found more successful in reducing GWG than diet or exercise alone, reducing the risk of excessive GWG by up to 20%.[14,20,21]

Traditionally, lifestyle interventions have been delivered to pregnant people through face-to-face antenatal care appointments; however, disadvantaged populations such as low-income earners, people of minorities and/or rural populations may contend with barriers in accessing face-to-face healthcare.[22] People with poor access to antenatal care are more likely to experience GWG outside recommended guidelines regardless of pre-pregnancy BMI.[23] Whilst pregnant people experiencing socioeconomic, cultural or environmental barriers are known to access face-to-face antenatal care less frequently,[22] telehealth has been demonstrated as a useful alternative in delivering antenatal care and advice.[24]

Defined as the use of a technology-based virtual platform to deliver aspects of health information, telehealth is one of the fastest growing sectors of healthcare provision.[25] With increased use of mobile phone applications, short messaging services (SMS)/text messages, wearable devices, live audio-visual communication and multimedia and services offered via telehealth have rapidly proliferated.[25–27] Reported successes of telehealth include a reduction in health disparities, improvement in health literacy and elimination of access barriers, particularly in low socioeconomic status populations.[26,27] Inclusive of all virtually delivered interventions, telehealth has been found effective in improving obstetric outcomes, with demonstrated equivalence to in-person care.[26] More specifically, telehealth interventions have been associated with improvements in perinatal smoking cessation, breastfeeding, appointment optimisation for high-risk obstetrics and early access to medical abortion services.[26] Whilst the COVID-19 pandemic provided a catalyst for the uptake of telehealth globally,[28] evidence-based use and implementation of telehealth platforms in obstetric and maternal care continues to be informed by ongoing research, including GWG.[26]

The complex nature of GWG, pregnancy and postpartum outcomes, particularly in overweight and obese pregnant people, necessitates a comprehensive approach to antenatal care. Through leveraging the innovative strategies of telehealth and lifestyle/behaviour change interventions, healthcare professionals can strive to reduce rates of excess GWG, thereby limiting associated maternal and foetal complications. Despite a number of primary studies having been conducted examining telehealth interventions aimed at managing and preventing excessive GWG, there is currently a lack of evidence-based detail informing the practice of telehealth-delivered lifestyle and behavioural interventions in antenatal care. The purpose of this systematic review was to inform future practice by describing the effect of virtually delivered lifestyle interventions in promoting healthy GWG in pregnant people with a BMI over 25 kg/m^2, and the effect of those interventions on reducing maternal and foetal complications associated with excessive GWG.

Methods

Search procedures

This review followed the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines[29]

Table 1. Inclusion criteria and exclusion criteria.

Inclusion criteria	Exclusion criteria
People aged 18 years or over	Intervention included face-to-face delivery
Currently pregnant	Publications prior to 2001
BMI $>25\,kg/m^2$	Participants aged <18 years
Virtually delivered lifestyle interventions	Participants with BMI $<25\,kg/m^2$
Interventions delivered by healthcare practitioners	Participants who were not pregnant, post-partum, pre-conception or with other co-morbidities
Outcomes addressing GWG or GWG and diet or physical activity outcomes	Outcomes related to diet or physical activity only
Outcomes related to maternal or foetal complications	Qualitative research
Study designs including randomised controlled trials, intervention studies, quasi randomised controlled studies or secondary analysis of randomised controlled trials	Publications not available in English
Publications available in English	Theses, dissertations, conference abstracts or proceedings, book chapters
Peer-reviewed journal articles published between 2001 and January 2023	

GWG: gestational weight gain; BMI: body mass index.

to identify and analyse relevant studies. The protocol was registered with PROSPERO International Prospective Register on 26 January 2023 (CRD42023392095).[30] Search terms were *pregnancy, obesity, overweight, BMI, physical activity, diet, behavioural interventions* and *telehealth* and databases were MEDLINE, CINHAL, EMBASE, EMCARE, MIDIRS and APA PsycINFO (see Supplemental Appendix 1, for example, search strategy). The literature search was limited to peer-reviewed articles published between 2001 and January 2023.

Retrieved studies were exported to a shared reference managing system (EndNote).[31] Duplicates were removed, and the remaining studies were exported into a systematic review management tool (Covidence)[32] for title and abstract screening. Two researchers independently completed the screening process, and conflicts were resolved through team consensus. See Table 1 for inclusion and exclusion criteria.

Data extraction

Information was collected and tabulated with regard to study characteristics, study participants; health professional involvement; intervention type; mode of telehealth delivery and outcomes related to GWG, foetal and maternal complications.

Quality assessment

Two researchers independently evaluated methodological quality using the Critical Appraisal Skills Programme (CASP) randomised controlled trial (RCT) checklist,[33] and three researchers independently completed the Risk of Bias assessment (RoB-2).[34] Discrepancies were resolved via group consensus. Findings were consolidated into a summary table and discrepancies were resolved through consultation with the research team.

Results

Figure 1 presents the PRISMA flowchart outlining study selection process. The initial search identified 2897 articles across the 6 databases. After 1198 duplicates were identified and removed, and an additional 5 articles were marked ineligible by automation tools, 1694 articles underwent title and abstract screening. Following this, 110 articles were deemed eligible and underwent full-text evaluation. Of those, nine articles met the inclusion criteria and were selected for this review.

Study characteristics

All nine included studies were RCT, published between 2014–2022. Most included studies were conducted in the United States,[35–40] with one in Australia,[41] one in Spain[42] and one in Taiwan[43] (see Table 2). Sample sizes ranged widely, from 35 to 1689, with an accumulated sample size of 2215. Of the nine included articles, two studies (one authored by Olson et al.[39] and one authored by Graham et al.[35]) were secondary analyses of one primary Olson et al. study.[38] For the purpose of this systematic review, the Olson et al. primary study has been referred to as Olson et al. (a)[38] and the secondary analyses authored by Olson et al. is referred to as Olson et al. (b)[39]

Study participants

All study participants were aged 18 years and over, with mean ages varying from 25.0 to 33.4 years. Participant BMIs ranged from $\geqslant 18.5$ to $<45\,kg/m^2$. Aligning with inclusion criteria, this systematic review only included data from participants with a BMI $\geqslant 25\,kg/m^2$. Participants were recruited during the first and second trimester, between 10 and 21 gestational weeks.

Health professional involvement

Telehealth interventions were delivered by seven different healthcare providers, including dietitians, physiotherapists, obstetricians, paediatricians, nurses, midwives and health coaches. In seven studies, research team members were involved in intervention delivery [35,37–42]

Modality of telehealth intervention

Six types of telehealth were used to deliver interventions across the nine studies, including SMS, video messaging,

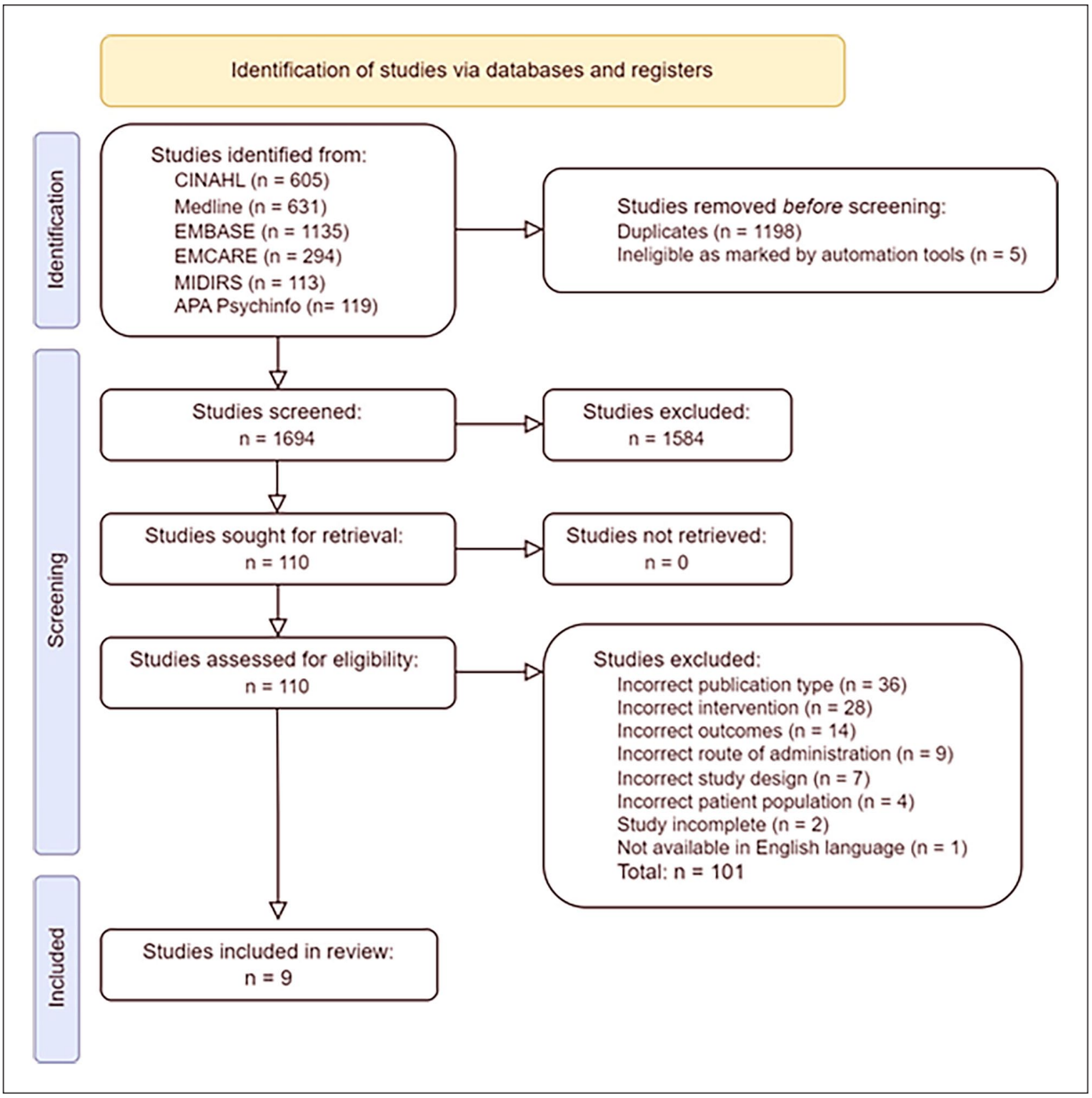

Figure 1. PRISMA flowchart.
PRISMA: preferred reporting items for systematic reviews and meta-analysis.

phone calls, mobile applications, websites and social media platforms/chatrooms (Table 3). All of the included studies with the exception of the Olson studies used SMS,[36,37,40–43] with five using individually tailored SMS to encourage participant monitoring and motivation throughout the study.[36,40–43] Eight of the nine studies reported using at least two platforms to deliver behavioural intervention(s).[35,36,38–43] The study by Holmes et al. was the exception, using only SMS as the mode of telehealth delivery.[37] As an adjunct to telehealth platforms, four studies used pedometers to promote physical activity goals, [36,40,42,43] with Herring et al.[36] also providing a listener soundtrack to encourage activity.

All included studies introduced behavioural and/or lifestyle change interventions, including GWG tracking, physical activity/exercise prescription and/or dietary goal setting/monitoring. Four studies utilised all three intervention types,[36,40,41] two studies implemented only GWG tracking and exercise interventions,[42,43] whilst one study used only nutrition and exercise interventions.[37]

Types of intervention

GWG tracking was a common intervention type, with all but one of the studies requiring participants' track their weight gain throughout pregnancy as a means to increase

Table 2. Study characteristics.

Author (year) Country	Title, study design	Population characteristics Sample size (*n*) Age	Intervention type Health professionals involved	Results
Olson et al. (2018)[38] USA	The effectiveness of an online intervention in preventing excessive gestational weight gain: the e-moms roc randomised controlled trial Three arm RCT	*N* = 1689 I = 1126 C = 563 I: mean early pregnancy BMI 24.7. BMI was stratified with income classes: Normal BMI low income *n* = 242 Normal BMI not-low income *n* = 359 Overweight + obese low income *n* = 252, Overweight + obese not-low income *n* = 273. C: mean early pregnancy BMI 24.7. BMI was stratified with income classes: Normal BMI low income *n* = 115 Normal BMI not-low income *n* = 186, Overweight + obese low income *n* = 125, Overweight + obese not-low income *n* = 137	Internet-based intervention to prevent excessive GWG. Website features I: GWG tracking, goal setting, health-related information, blogs, resources Weekly email reminders to log in and see content and use tracking and goal setting features. C: Health-related information, blogs, resources, weekly email reminders to log in and see content. Based on Fishbein and Yzer's Integrative Model of Behavioural Prediction. Research staff	Engagement with treatment: control and intervention women logged in a median of 3.2% and 5.6% of the 199 and 196 days, respectively, of website access. Median number of logins for control and intervention groups were 6 and 10 respectively, with 15- and 24-page views, respectively. Weekly GWG: no statistically significant difference between treatment arms was found. Clinical outcomes: within strata 4 women (overweight plus obese class 1 high income) of the intervention group there was a significantly greater proportion of repeat caesarean deliveries than in the control arm (92.3% versus 66.7%), and macrosomia was significantly less common in the intervention than control arm (6.8% versus 14.0%).
Olson et al. (2019)[39] USA	Use of an online diet goal-setting tool: relationships with gestational weight gain Intervention arm of RCT included	*N* = 898 Inclusion criteria: aged 18–35 years and ⩽20 weeks gestation at time of enrolment, available for 24 month intervention, singleton pregnancy lasting at least 20 weeks gestation, participation in intervention during pregnancy. Demographics: BMI normal BMI (*n* = 480) overweight BMI (*n* = 278) obese BMI (*n* = 140) Age at entry <25 years (*n* = 259) 25–29 years (*n* = 303) ⩾30 years (*n* = 336)	Internet-based intervention to prevent excessive GWG. Website features I: GWG tracking, goal setting, health-related information, blogs, resources, weekly reminders to log in, see content and use tracking and goal setting features. C: Health-related information, blogs, resources, weekly reminders to log in and see content. Based on Fishbein and Yzer's Integrative Model of Behavioural Prediction Research staff	Participant diversity: 60.9% of participants were of 'not-low income', 72.1% of white race, 84.8 married and co-habiting. Overweight and obese class 1 participants those who set ⩾2 behavioural goals gained 2.37 kg more than those who set no goals ($p = 0.01$) and were at an increased risk of excessive total GWG ($p = 0.03$).
Graham et al. (2017)[35] USA	Does usage of an eHealth intervention reduce the risk of excessive gestational weight gain? Secondary analysis from a randomised controlled trial RCT	*N* = 1,335 Age (range) 18–35 years I: *n* = 898 BMI 18.5–24.9 = 497 BMI 25–29.9 = 269 BMI >30 = 132 Intervention groups were further stratified into four BMI/income groups normal range BMI and low income (*n* = 179) normal range BMI and higher income Overweight (*n* = 319) or obese BMI and low income (*n* = 172) Overweight or obese BMI and high income (*n* = 228) C: *n* = 437 BMI 18.5–24.9 = 247 BMI 25–29.9 = 139 BMI >30 = 51	Internet-based intervention to prevent excessive GWG. Website features I: GWG tracking, goal setting, health-related information, blogs, resources, weekly reminders to log in, use features and highlight new content C: Health-related information, blogs, resources, weekly reminders to log in, use features and highlight new content Based on Fishbein and Yzer's Integrative Model of Behavioural Prediction. Consistency of use was automatically captured, with users categorised as 'consistent trackers', 'almost consistent trackers' or a 'non-tracker'. Quantity of use was categorised into three levels, including 'high', 'low' or 'none'. Usage patterns were assessed via latent class analysis, and outcome measures were obtained through GWG data. Research staff	Higher usage groups were more likely to have higher income, of white race, be older and ever been married. Overweight and obese BMI and high-income group, those considered 'consistent trackers' gained 2.78 kg less than the non-users in the intervention arm ($p = 0.02$) Overweight and obese high income participants who were 'consistent trackers' and 'super-users' gained 2.17 kg less than those in the medium user, almost consistent or inconsistent tracker, or the nonuser groups ($p = 0.003$) Note: Super users – consistent weight trackers very likely to regularly use blogs and likely to use diet and lifestyle goal setting. Medium users were almost consistent weight trackers and likely to use frequently blogs and goal setting. Consistent trackers were consistent weight trackers, likely low blog users and unlikely to set goals. Inconsistent trackers were likely to be almost consistent weight trackers, and unlikely to utilise goal setting tools or the blog.

(Continued)

Table 2. (Continued)

Author (year) Country	Title, study design	Population characteristics Sample size (*n*) Age	Intervention type Health professionals involved	Results
Willcox et al. (2017)[41] Australia	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 RCT	*N* = 91 I: *n* = 45 C: *n* = 46 Inclusion criteria: women with a singleton, live gestation between 10 and 17+6 weeks; BMI >25; able to speak, read and write English; owning a mobile phone. I: Mean age 33.0 years, mean early pregnancy BMI 32.5, mean gestational age at baseline 15.2 weeks. C: mean age 32.0 years, mean early pregnancy BMI 29.6, mean gestational age at baseline 15.8 weeks.	I: Tailored text messages (4–5/week), access to a responsive information website, video messages (from healthcare professionals), and a Facebook interactive chatroom. Participants were also given a booklet that described the txt4two programme, weight tracking and goal setting; at this meeting, a researcher also discussed appropriate GWG targets study. C: Mailed brief brochures which contained information about diet and physical activity. The information is part of usual maternity care at the study hospital. Dietitian Physiotherapist Obstetrician Research staff	Engagement with treatment: 78% chose to set physical activity rather than dietary goals as their focus behaviour, all study participants read the booklet. At 36 weeks, 40/42 participants reported setting regular behaviour change goals. About 57% reported recounting weighing once or twice per month, 31% once per week. Website averaged 1248 hits per month, with the most popular pages including food ideas, maintaining core strength and role of nutrients in pregnancy. Impact on GWG: The intervention group demonstrated a reduction in total GWG compared to the control group (7.8 kg versus 9.8 kg) ($p = 0.041$). No significant differences reported in the proportion of participants exceeding the IOW GWG recommendations between intervention (21/45) and control (28/46).
Holmes et al. (2020)[37] USA	Effect of a short message service intervention on excessive gestational weight gain in a low-income population: a randomised controlled trial paralleled RCT	*N* = 83 Inclusion criteria: Age ⩾18 years; BMI 20–45 in the first trimester; 10–20 weeks gestation; possession of a cell phone with the ability to receive text messages without charge. I: *n* = 41 C: *n* = 42 Inclusion criteria: Age ⩾18 years; BMI 20–45 in the first trimester; 10–20 weeks gestation; possession of a cell phone with the ability to receive text messages without charge. I: mean age 27.2, mean pre-pregnancy BMI 29.8. C: mean age 26.9, mean pre-pregnancy BMI 30.4.	I: Participants received one text message per week for 18 weeks Text messages were developed in line with WIC recommendations for pregnant women, focusing on energy intake and physical activity for healthy weight gain in pregnancy. Nutrition messages promoted adequate diet quality and quantity and physical activity text messages encouraged 20–30 min of moderate-intensity physical activity daily; in conjunction with ACOG recommendations. C: Participants received one message per week for 18 weeks, Texts were on general health during pregnancy-related topics. Based on Social cognitive theory Research staff paediatrician	Participant demographics: 65.5% identified as Native Hawaiian, Pacific Islander or American Indian, 54.8% had some college education or more and 37.8% were employed. Of the overweight and obese participants, 51.8% (*n* = 14) and 52.8% (*n* = 19) exceeded GWG guidelines; the difference across intervention and control groups was not statistically significant. A greater weight gain before pregnancy was negatively associated with weight gain during pregnancy.
Chen et al. (2022)[43] Taiwan	Effectiveness of a nurse-led mHealth app to prevent excessive gestational weight gain among overweight and obese women: a randomised controlled trial RCT	*N* = 90 I: *n* = 46 (67% aged ⩽35 years) C: *n* = 44 (75% aged ⩽35 years) I: Ages ⩽35 years *n* = 31, ages >35 years *n* = 15, pre-pregnancy BMI 25–29.9 *n* = 30 and BMI ⩾30 *n* = 16 C: ages ⩽35 years *n* = 35, ages >35 years *n* = 11, pre-pregnancy BMI 25–29.9 *n* = 35 and BMI ⩾30 *n* = 11 BMI ⩾25 kg/m^2 at antenatal check-up Inclusion criteria: female; BMI ⩾25 at antenatal check-up; <17 weeks of gestation; ⩾20 years of age; fluent in Mandarin Chinese; able to understand basic technologies.	I: Smart watch with reminders to ear for 16 h daily and smart phone app. Physical activity goals. App encouraged goal setting, self-monitoring, self-evaluation and self-monitoring. Tailored SMA messages for healthy eating behaviours. C: Standard care including regular maternal/foetal monitoring. Optional participation in healthy lifestyle counselling available to all participants Nurse-led.	Excessive GWG outcomes: Nil statistically significant results between intervention and control arms exceeding total GWG. Intervention participants' weekly GWG was gained significantly lower than their controls in the second trimester ($p = 0.039$). Control group was more likely to exceed weekly and total GWG guidelines – both per trimester and when comparing between overweight and obese participants. Intervention versus control likelihood of exceeding GWG recommendations was 21.6% versus 32.6% ($p = 0.275$) Factors related to weight gain: Obese participants who were ⩾35 years, had pre-pregnancy exercise habits, had perceived self-efficacy of diet and higher amounts of physical activity, had lower GWG ($p < 0.05$). For overweight and obese participants, intervention effects were significant for the increase (more steps) and maintenance (keeping daily count) of physical activity. Obese women ($\beta = -2.68$; $p = 0.021$) and women who perceived better self-efficacy of diet ($\beta = -0.05$; $p = 0.007$) were less likely to gain weight in the intervention group only.

(Continued)

Table 2. (Continued)

Author (year) Country	Title, study design	Population characteristics Sample size (*n*) Age	Intervention type Health professionals involved	Results
Gonzalez-Plaza et al. (2022)[42] Spain	Effectiveness of a step counter smartband and midwife counselling intervention on gestational weight gain and physical activity in pregnant women with obesity (Pas and Pes study): randomised controlled trial Paralleled RCT	*N* = 150 I: 78 C: 72 Pre-pregnancy BMI ⩾30 kg/m^2 Inclusion criteria: Pregnant women at 12–18 weeks gestation; pre-pregnancy BMI ⩾30 kg/m^2; singleton pregnancy; aged ⩾18 years; iPhone or android smartphone users with an internet connection I: Mean age 32.4 years, mean pre-pregnancy BMI 33.1. Obesity classes (1) BMI 30–34.9 *n* = 63, (2) BMI 35–39.9 *n* = 13, (3) BMI ⩾40 *n* = 2. C: mean age 33.4, mean pre-pregnancy BMI 32.7. Obesity classes (1) BMI 30–34.9 *n* = 61, (2) BMI 35–39.9 *n* = 8, (3) BMI ⩾40 *n* = 3.	I: Smartband provided, worn daily, 10,000 steps target per day, at least 5 days per week – equivalent to 30 min of moderate physical activity daily. The smartband would vibrate to motivate women to move after prolonged periods of inactivity and send prizes when goals were achieved. The smartband was linked to the Mi Fit app, where participants could set weight goals, and activate alerts. Participants accessed Hangouts app weekly. App provided personalised information or videos through SMS twice a week, tailored to the woman's gestational weight and health counselling and support from midwives through the app. C: All study participants received standard prenatal care by midwives and obstetricians, including health education relating to physical activity GWG and food habits. Midwives Research staff	Intervention engagement and satisfaction: No adverse effects using smartband, which was used daily by 61% of the women. All participants reported using information provided in the app at least once/week, with satisfaction regarding messages, health counselling and midwife support was 4.8/5 (SD = 0.6) points. GWG outcomes: The median total GWG in the intervention group was statistically significantly lower than that of the control group (7.0 kg versus 9.3 kg; $p = 0.04$). An adjusted mean weight gain per week that was 0.5 (95% CI 0.4–0.6) kg per week for the control group and 0.3 (95% CI 0.3–0.4) kg per week for the intervention group; (df = 0.1, 95% CI −0.2 to 0.03; $p = 008$) Maternal and perinatal complications: No differences were observed between the study groups in the incidence of maternal and perinatal outcomes.
Herring et al. (2015)[36] USA	Preventing excessive gestational weight gain among African American women: A randomized clinical trial. Two arm pilot RCT	*N* = 66 Eligibility criteria included: (1) age 18 years; (2) self-identification as African American; (3) gestational age <20 weeks; (4) first trimester BMI 25–45 kg/m^2; (5) Medicaid recipient (income proxy); (6) cell phone ownership with unlimited text messaging and (7) Facebook member. I: *n* = 33 C: *n* = 33. **I**: mean age 25.9 years, mean early pregnancy BMI 33.5, mean gestational age at baseline 11.5 weeks. BMI 25–29.9 *n* = 11, BMI 30–45.0 *n* = 22. C: mean age 25.0 years, mean early pregnancy BMI 32.2, mean gestational age at baseline 13.4 weeks. BMI 25–29.9 *n* = 13, BMI 30–45.0 *n* = 20	I: Technology-based behavioural intervention with behaviour change goals surrounding appropriate energy intake, physical activity and self-weighing. Skills training and support were delivered via text messages, Facebook, and health coach calls. Participants received daily text messages tailored to each behavioural goal to build skills and self-efficacy, and 3–4 self-monitoring texts per week to reinforce behavioural adherence. A private Facebook group provided support and encouraged behavioural skills training via links to websites and videos. A health coach delivered 15–20 min counselling calls weekly for the first two study weeks and then twice monthly thereafter to reinforce skills and aid in problem solving to overcome barriers. After the first 12 weeks, the health coach individually prioritised the order with which goals were repeated – based on participant progress and preference. C: Standard obstetric care Based on Social Cognitive Theory and Social Ecological Model University qualified health coach	Intervention engagement and acceptability: Majority of participants (70%) responded to ⩾50% of self-monitoring text prompts. Of those who completed acceptability questionnaire (*n* = 22, 81%), 96% reported learnt skills extremely helpful. Weight change: Control group were more likely to exceed total GWG as compared to the intervention group (66% versus 37%, $p = 0.033$), with similar pattern observed when stratified for weight. Intervention participants gained less weight than controls (8.7 versus 12.3 kg, respectively, $p = 0.046$) Obstetric/neonatal outcomes: No significant differences between intervention and control for mean birth weight or prevalence of caesarean section delivery.

(Continued)

Table 2. (Continued)

Author (year) Country	Title, study design	Population characteristics Sample size (*n*) Age	Intervention type Health professionals involved	Results
Pollak et al. (2014)[40] USA	Weight-related SMS texts promoting appropriate pregnancy weight gain: a pilot study. Paralleled RCT	*N* = 33 Note: two additional participants were recruited but excluded from analysis due to miscarriage I: Age ⩾18 years; English speaking; registered for prenatal care at participating clinics; pre-pregnancy BMI 25–40; 12–21 weeks gestation; possession of a cell phone with an unlimited texting plan for the duration of the trial. I: *n* = 22 C: *n* = 11. I: mean age 29, mean gestation 16 weeks, mean pre-pregnancy BMI 29. C: mean age 32, mean gestation 17 weeks, mean pre-pregnancy BMI 28.	I: 'Preg CHAT text arm': Participants received text messages 3 days per week for approximately 16 weeks. These text messages were based on counselling protocols developed to target GWG through targeting four weight-related behaviours. For the first 10 weeks, women had 2 goals, walking 10,000 steps and avoiding sweetened drinks. After this, eating at least five fruits and vegetables per day and eliminating fast food intake. Participants received a monthly text message reminder of the appropriate weight gain guidelines. C: 'Text4baby text arm': Participants signed up for a free mobile information service, 'Text4baby', which provided women with 3× text messages per week, tailored to their due date, these messages promote maternal and child health and are general in nature. Based on social cognitive theory Obstetricians research staff	Study feasibility and engagement: 10 women withdrew from the study for the following reasons: problem wearing pedometer (*n* = 3), programme not for them (*n* = 3), unreliable phone (*n* = 2), medical reasons (*n* = 1), inconsistency in their schedule (*n* = 1). Most women in the intervention group reported reading and responding to text (86%). Sixty-four percent of women in the intervention arm rated the programme helpful in attaining recommended weight (⩾ 5 on a 7-point Likert item), compared to 0% in the control arm. GWG outcomes: Participants in the Preg CHAT text arm had a mean gain of two less pounds than participants in the Txt4Baby arm (95% CI −9.8 to 5.7; *p* = 0.61) at 40 weeks gestation

RCT: randomised controlled trial; T: total number of participants; I: number of intervention participants; C: number of control participants; GWG: gestational weight gain; BMI: body mass index; SMS: short messaging service; SD: standard deviation; CI: confidence interval.

Table 3. Mode of telehealth delivery, intervention type and outcomes for each included study.

Mode of intervention	Olson (2018)[38]	Olson (2019)[39]	Graham (2017)[35]	Willcox (2017)[41]	Holmes (2020)[37]	Chen (2022)[43]	Gonzalez-Plaza (2022)[42]	Herring (2015)[36]	Pollak (2014)[40]
SMS									
Individually tailored				✓		✓	✓	✓	✓
General					✓			✓	✓
Video messages				✓			✓		
Phone calls								✓	
App	✓	✓	✓			✓	✓		
Website	✓	✓	✓					✓	
Social media group/Chat room				✓				✓	
Adjuncts to modes of intervention									
Soundtrack/DVD								✓	
Pedometer/Smartwatch						✓	✓	✓	✓
Type of intervention									
GWG tracking	✓	✓	✓	✓		✓	✓	✓	✓
Exercise strategies									
Step count (daily)						8500	10,000	5000	10,000
Timed exercise	✓	✓	✓		✓				
Exercise goals set by researchers	✓	✓	✓			✓	✓	✓	✓
Exercise goals set by individuals				✓					
Exercise self-monitoring	✓	✓	✓	✓		✓	✓	✓	✓
Dietary strategies									
Dietary goals set by researchers	✓	✓	✓		✓q			✓q	✓q
Dietary goals set by individuals	✓	✓	✓	✓q					
Dietary self-monitoring	✓	✓	✓			✓		✓	✓
Rewards	✓	✓	✓			✓	✓		
Incentives	✓	✓	✓	✓				✓	✓
GWG outcomes and statistical significance									
GWG: excessive	NS	✗*	NS	NS	NS	✓*	NS	✓*	
GWG: total	NS	✗*	✓*	✓*	NS	✓*	✓*	NS	NS

SMS: short messaging service; DVD: digital versatile disc; GWG: gestational weight gain; ✓: study included the mode of intervention or the type of intervention; q: goals were set and articles discussed both quality and quantity of nutrition intervention; NS: outcome assessed but not significant; ✓*: outcome assessed and statistically significant positive result noted; ✗*: outcome assessed and statistically significant negative result.

motivation and encourage programme adherence.[36,38,40–43] All studies included a physical activity target, with six of the seven primary studies specifying either the amount of time spent exercising[37,38] and/or a daily step count.[36,40,42,43] The study by Willcox et al.[41] allowed individuals to set a non-specified exercise target aimed towards meeting physical activity guideline recommendations, whereas two studies focussed on time spent exercising as the physical activity goal.[37,38] One study-based exercise targets on the American College of Obstetrics and Gynaecology (ACOG) Guidelines,[44] recommending 20–30 min of moderate-intensity physical activity per day.[37] Olson et al. (a)[38] researchers based the physical activity goal on participant's pre-pregnancy activity levels, creating three targets correlating to 'sedentary', inadequately active and 'adequately active'.[38,45] Of those studies that included a step count, all participants received pedometers to assist in achieving a step count goal.[36,40,42,43] Six studies allowed participants to monitor their physical activity goal progress via telehealth platforms and/or a supplied pedometer.[36,38,40–43]

Dietary interventions based on goal setting and/or self-monitoring of participants' current diet were implemented in all but the Gonzalez-Plaza et al. study.[35–41,43] Within most studies, dietary goals were set by researchers and/or participants as part of the intervention,[36–38,40,41] where Olson et al. (a)[38] used input from both researcher and participants to formulate the dietary goal via a quiz.[39] Four studies incorporating dietary interventions specified the quantity and quality of foods to help achieve a healthy diet, including increasing vegetable intake, replacing sugar-sweetened beverages and increasing the total daily calories by 300 per day during pregnancy.[36,37,40,41] Whilst excluding a dietary goal setting component, one study required participants monitor their current diet to increase daily intake awareness.[43] Similarly, three other studies also required participants monitor their dietary intake via the telehealth platform.[36,38,40]

Outcomes related to GWG, foetal and maternal complications

Given the range of telehealth platforms and variety of behavioural interventions implemented across studies, measures and study outcomes relating to GWG, and foetal/maternal complications, were varied (Table 2).

Eight of the nine studies included control groups,[35–38,40–43] of which three showed no statistically significant difference in total or excessive GWG between intervention and control groups.[37,38,40] Of those studies that included a control group, four received standard antenatal care,[36,41–43] two received generic pregnancy-related SMS[37,40] and two received access to a website containing standard antenatal health information.[37,40]

Three studies yielded no statistically significant difference in total or excessive GWG between intervention and control groups.[37,38,40] Eight studies included excessive GWG as an outcome measure, where excessive GWG was reported as a percentage of those participants exceeding recommended GWG guidelines in total kilograms, or as a relative risk.[35–39,41–43] Three of those studies showed statistically significant results;[36,39,43] two of which demonstrated the control group was more likely to exceed both total[36,43] and weekly[36,43] GWG recommendations. The primary Olson et al. (a) study provided two datasets, with one dataset unadjusted and the other adjusted for covariates including BMI, age, parity and other pregnancy variables.[38] Datasets were further stratified by income, including low-income (Medicaid eligible) and not-low-income.[38] When comparing healthy weight versus overweight and obese participants, Olson et al. (b) found that for higher BMI participants, setting two or more behavioural goals was significantly associated with an increased risk of excessive total GWG.[39]

All included studies measured total GWG, five of which reported statistically significant results.[35,39,41–43] Of those five studies, two demonstrated that participants in the intervention arm gained less total GWG than the control arm.[41,42] The role of weight tracking using telehealth platforms was inconsistent across studies, whereby not-low-income participants who consistently tracked their weight resulted in less total GWG than those who did not.[35] In the adjusted dataset, not-low-income overweight and obese pregnant participants who were consistent trackers and super users (defined by consistent log-ins to the website and GWG tracking), gained less than those not as engaged with the intervention.[35] The study by Chen et al. demonstrated a statistically significant reduction in total GWG (5.44 kg) in the intervention arm only during the third trimester.[43]

Four of the nine studies measured maternal and foetal complications, including GDM, pre-eclampsia, macrosomia, pre-term birth, birth weight and caesarean deliveries.[36,38,42,43] Olson et al. (a) demonstrated a statistically significant reduction in pregnancy complications in the intervention arm compared to the control, reporting significantly fewer macrosomic babies whose mothers had participated in an intervention.[38] Olson et al. (a) also identified that high-income overweight and obese mothers participating in an intervention had significantly increased rates of repeat caesareans when compared to control participants.[38]

Overall, five studies demonstrated statistically significant results in relation to telehealth-delivered behavioural intervention effectiveness in promoting healthy GWG in overweight or obese pregnant participants and/or reducing maternal and foetal complications associated with excessive GWG.[36,38,39,41–43] All five of those studies used a variety of virtual platforms, and utilised GWG tracking, exercise goal setting and goal-specific self-monitoring as behavioural interventions.[36,38,39,41–43] Additionally, all five studies incorporated a reward for progress throughout the

study and/or an incentive to participate.[36,38,39,41–43] The most commonly used virtual platform was SMS,[36,41–43] with all five studies using greater than one platform compared to non-statistically significant studies that used only SMS. These results suggest multiple virtual platforms designed to deliver behavioural interventions that include the ability to track GWG, and set and monitor exercise goals, are effective at promoting healthy GWG throughout pregnancy.[35–39,41–43]

Quality appraisal

A comprehensive illustration of results from the CASP and RoB-2 is presented in Supplemental Appendix 2. In summary, completion of the CASP identified all studies included similar groups at the start of the RCT, received similar levels of care during the studies and the intervention effects were reported comprehensively. Due to the nature of telehealth interventions, six articles were unable to include blinding and were limited by their small sample sizes.[36,37,40–43] Assessment of the risk of bias utilising the RoB-2 tool revealed no study as 'low risk'; however, four of the nine studies were evaluated as 'some concerns'[35,38,39,41] and the remaining were evaluated as 'high risk'.[36,37,40,42,43]

Discussion

This systematic review described the effective of telehealth-delivered behavioural interventions designed to reduce GWG in overweight or obese pregnant people and explored the effect of those interventions in reducing maternal and foetal complications associated with excessive GWG. Across the nine studies, a variety of telehealth platforms were used to deliver behavioural interventions, including SMS, video messages, phone calls, phone applications, websites and social media platforms. All platforms used unique features that allowed GWG-tracking and self-monitoring of dietary and physical activity goals. Aligning with previous research exploring the effectiveness of eHealth weight loss interventions for overweight and obese populations, four studies included in this review identified that individualisation of text messages increased intervention adherence.[28,40–43] Findings from this systematic review complement separate research identifying the addition of behavioural components, such as self-monitoring, or the use of technology platforms such as social media, as more effective than standard telehealth programmes.[46] The result suggests that future telehealth interventions would benefit from the inclusion of personalised messaging to promote sustained engagement, alongside the use of population focussed interventions via social media.

Consistent with previous studies exploring the effectiveness of behavioural interventions delivered in-person, most studies included in this review identified significant reductions in total and/or excessive GWG as per NAM guidelines for virtually delivered care, thus demonstrating that telehealth-delivered interventions appear as effective in reducing GWG as those traditionally delivered face-to-face.[14,20,35,36,41–43] Whilst measurements of GWG were standardised using NAM guidelines across the studies included in this review, exercise and diet interventions were informed by separate guidelines specific to the geographical location and year each study was conducted. Similar to previous reviews, findings from this systematic review support the development and implementation of a standardised guideline for exercise, diet and lifestyle interventions during pregnancy.[7,13]

Excessive GWG is known to be associated with a higher risk of maternal and foetal complications during and after pregnancy.[2–4] Whilst Olson et al. (a) was the only study to find a statistically significant reduction in foetal macrosomia,[38] both Chen et al. and Gonzalez-Plaza et al. found a non-statistically significant correlation between reduced GWG and lower prevalence for multiple maternal and foetal complications,[42,43] further supporting results from previous research investigating adverse pregnancy outcomes.[8,9,13] Given the lack of statistically significant findings in those studies that included this outcome measure, it is recommended that all future studies examining excessive GWG include the exploration of maternal and foetal complications as an outcome measure.

Virtually delivered healthcare can play an important role in reducing barriers and improving access options for weight management interventions,[47] providing healthcare providers opportunities to bridge social and cultural challenges potentially impacting intervention uptake and adherence. When considering the diverse geographical locations and socioeconomic status of participants across the studies included in this review, telehealth was reported to be well received, with virtual-care platforms offering an accessible delivery method of antenatal care.[35–43] This finding supports the inclusion of telehealth as an intervention delivery option, supporting those who may experience socio-economic and/or environmental disadvantage and have limited access to face-to-face maternity care.[5] Whilst the methods for telehealth-delivered care continue to evolve, virtual-care platforms offer a cost-effective, culturally sensitive and individualised alternative to traditional methods of antenatal care.

Limitations

As identified in the quality appraisal, studies included in this review were limited to nine overall, with small sample sizes affecting reliability, consequently affecting accuracy when considering the effects of virtually delivered lifestyle interventions across a broad population. Additionally, six of the studies [36,37,40–43] included in this review were unable to blind participants, thus potentially affecting participant behaviour and individual study outcomes. To

support reliability, thus improving intervention guideline development, it is recommended that more studies examining the effect of telehealth interventions on GWG are undertaken, with larger sample sizes.

Conclusion

This systematic review evaluated telehealth-delivered behavioural interventions in overweight or obese pregnant people. Results suggest that lifestyle interventions delivered via telehealth may be effective at reducing excessive GWG. This information can be used to develop targeted interventions integrated into obstetric guidelines aimed at reducing excessive GWG via telehealth platforms. However, strategies to address the limitations of cost and inaccessibility of telehealth to the wider community are required before full integration into the healthcare sector.

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