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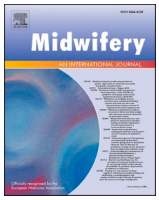

Differing intensities of a midwife-led antenatal healthy lifestyle service on maternal and neonatal outcomes: A retrospective cohort study

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ABSTRACT

Introduction: Maternal obesity and excessive gestational weight gain are associated with adverse maternal and neonatal outcomes. There is uncertainty over the most effective antenatal healthy lifestyle service, with little research determining the impact of different lifestyle intervention intensities on pregnancy outcomes.

Method: This retrospective cohort study compared pregnancy and birth outcomes in women with a body mass index of 40 or above who were offered a low intensity midwife-led antenatal healthy lifestyle service (one visit) with women who were offered an enhanced service (three visits). The primary outcome was gestational weight gain.

Results: There were no differences between the two healthy lifestyle service intensities ($N = 682$) in the primary outcome of mean gestational weight gain [adjusted mean difference (aMD) -1.1 kg (95 % CI -2.3 to 0.1)]. Women offered the enhanced service had lower odds of gaining weight in excess of Institute of Medicine recommendations [adjusted odds ratio (aOR) 0.63 (95 % CI 0.40–0.98)] with this reduction mainly evident in multiparous women. Multiparous women also gained less weight per week [aMD -0.06 kg/week (95 % CI -0.11 to -0.01)]. No overall beneficial effects were seen in maternal or neonatal outcomes measured such as birth weight [aMD 25 g (95 % CI -71 to 121)], vaginal birth [aOR 0.87 (95 % CI 0.64–1.19)] or gestational diabetes mellitus [aOR 1.42 (95 % CI 0.93–2.17)]. However, multiparous women receiving the enhanced service had reduced odds of small for gestational age [aOR 0.52 (95 % CI 0.31–0.87)]. This study was however underpowered to detect differences in some outcomes with low incidences.

Discussion: Uncertainty remains over the best management of women with severe obesity regarding effective interventions in terms of intensity. It is suggested that further research needs to consider the different classes of obesity separately and have a particular focus on the needs of nulliparous women given the lack of effectiveness of this service among these women.

Introduction

In the United Kingdom (UK) 64 % of the adult population are estimated to be overweight (body mass index (BMI) 25–29.9) or living with obesity (BMI 30 or more) (Office for Health Improvements and Disparities, 2024). Obesity alone during pregnancy in England has almost tripled over the last three decades from 7.6 % in 1989 (Heslehurst et al., 2010) to 22.2 % in 2018–2019 (National Health Service Digital, 2019). Furthermore, childbearing itself is acknowledged to contribute to the rise of women with overweight or obesity (Bello et al. 2016).

Obesity during pregnancy is associated with increased risk of adverse outcomes for both the childbearing woman and neonate. Adverse outcomes for the woman include increased risk of gestational diabetes mellitus (Najafi et al. 2019; Santos et al. 2019), pre-eclampsia (He et al. 2020; Santos et al. 2019), preterm birth (Santos et al. 2019) and caesarean section (Kim et al. 2016; D'Souza et al. 2019). Postpartum haemorrhage has also been shown to be increased in women with a BMI of 40 or more compared to women with lower levels of obesity (BMI 30–40) (Lutsiv et al. 2015). Adverse outcomes for the neonate include increased risk of being large for gestational age (LGA) (Santos et al. 2019; D'Souza et al. 2019), admission to a neonatal intensive care unit (Kim et al., 2016), stillbirth (Lutsiv et al. 2015; D'Souza et al. 2019) and poorer breastfeeding outcomes (Huang et al. 2019). It has been estimated that 23.9 % of pregnancy complications are potentially attributable to maternal overweight or obesity prior to pregnancy, with the highest risk of pregnancy complications occurring in women with a BMI

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of 40 or more (Santos et al. 2019). Additionally, women with overweight or obesity prior to pregnancy are at increased risk of excessive gestational weight gain (GWG) (Samura et al. 2016). Increased GWG has also been associated with many adverse outcomes such as increased risk of LGA (Goldstein et al. 2017; Santos et al. 2019), caesarean section (Goldstein et al. 2017), induction of labour (Xu et al. 2021), long term maternal weight retention (Samura et al. 2016) and childhood obesity (Voerman et al. 2019). To maximise the health of both the woman and the neonate, the Institute of Medicine (IOM) has proposed guidelines for GWG based on maternal pre-pregnancy BMI category (Institute of Medicine, 2009). For women with obesity a total GWG of 5–9 kg is recommended, with a rate of weight gain in the second and third trimesters of 0.17–0.27 kg/week (Institute of Medicine, 2009). A recent meta-analysis of individual patient data from 36 studies has however found 44 % of women with obesity to gain weight above these recommendations (Rogozińska et al. 2017).

The National Institute for Health and Clinical Excellence (NICE) (NICE, 2010) weight management before, during and after pregnancy guidelines identified limited UK based research into the efficacy of weight management interventions in pregnancy and therefore recommended more research into ways of managing maternal obesity and GWG to optimise pregnancy outcomes. Interviews with health care providers and commissioners have also identified uncertainty among professionals about what constitutes the most suitable service to tackle maternal obesity, despite pregnancy being recognised as a good opportunity to influence behaviour change for women and families (Fair et al., 2020). As a result of professional uncertainty, a UK based survey undertaken at the same time as the interviews, found maternal healthy lifestyle service provision for women with obesity to be variable across the country and identified a need for more antenatal weight management services for women with obesity (Fair et al., 2020). Furthermore, systematic reviews evaluating the impact of antenatal lifestyle interventions on maternal and neonatal outcomes (Thangaratinam et al. 2012; Yeo et al. 2017; Fair and Soltani, 2021) have noted current studies to be heterogenous in the format and intensity of the lifestyle advice given, for example simply providing women with training on how to use a treadmill (Kong et al. 2014) or delivering 10 individual one hour sessions with a dietician (Wolff et al. 2008). Little research to date has been undertaken to determine the impact of different intensities of lifestyle interventions on pregnancy outcomes. A recent meta-regression of 60 studies that incorporated lifestyle interventions in pregnant women of all BMI categories did not find any optimal frequency of contact for intervention delivery, with some low intensity, low-cost interventions found to be effective (Walker et al. 2018). Determining the frequency of an intervention that could improve clinical outcomes is an important consideration, particularly for those that commission services. Furthermore, pragmatic trials are increasingly recognised as an ideal way to determine the impact of interventions under real-world conditions (Battaglia and Glasgow 2018).

The objective of this study was therefore to compare pregnancy and birth outcomes in women with a BMI of 40 or more who received a midwife-led low intensity antenatal healthy lifestyle service intervention (one routine visit offered) with those who received an enhanced intervention (three routine visits offered).

Method

Study setting

In July 2009 a midwife-led antenatal healthy lifestyle service was established in a National Health Service (NHS) Trust in the Yorkshire and Humber region of England. This NHS Trust has Teaching Hospital status and provides acute care across two hospital sites. These hospitals cover both urban and rural populations. Further details around the service set up, including perinatal user involvement and training for professionals initiating conversations with the women is discussed elsewhere (West 2010; Garland 2011). When established, the service offered a low intensity intervention to pregnant women with a booking BMI of 35 or more, as well as with pre-existing diabetes, excessive GWG or previous bariatric surgery. This incorporated a visit at 16 weeks' gestation and an optional follow up visit. Given the number of women who chose to attend the optional visit and their positive evaluation of this, staff felt the opportunity for additional follow-up and input during pregnancy would be beneficial for all women. Therefore, in July 2012 service provision intensified to offer all women routine appointments at 16, 28 and 36 gestational weeks. Due to service demands the provision at this point became for women with a BMI of 40 or more. Women with pre-existing diabetes, excessive GWG or previous bariatric surgery also continued to be referred to the service. At both time points women could also seek out the service for additional appointments if they wished. The main service input was from midwives due to practical consideration (West 2010), but also to redress the imbalance many women with obesity feel during pregnancy as their pregnancies have become increasingly medicalised (McGlone and Davies 2012). Midwives ran the service alongside other professionals such as dieticians and exercise programme providers, with specialised input from obstetricians and anaesthetists as required. Women were provided with support and advice around weight management; particularly minimising GWG, healthy eating, undertaking physical activity and breastfeeding. The aim of the clinic was to encourage and support women to make lifestyle choices and behavioural changes during pregnancy, which could also be sustained after the birth. At the 16 week appointment awareness was raised about the potential risks for women and their baby of a raised BMI in pregnancy. Individualised care planning, including the offer of a dietician consultation was initiated, with women informed of healthy eating principles and healthy activity during pregnancy. Women were encouraged to identify personal goals such as swapping an unhealthy food for a healthier one. The additional appointments with the enhanced service provided opportunities to follow up progress and reassess the personal goals as required. The 36 week appointment also offered an opportunity to discuss breastfeeding and weight loss in the postpartum period, as well as to assess moving and handling and tissue viability prior to admission in labour. The changing intensity of the service provided a unique opportunity to compare the effectiveness of the differing levels of provision.

Study participants

A retrospective comparative cohort study was undertaken. All pregnant women in the Trust with a booking BMI of 40 or more who were referred to the low intensity service from 2009 to 2011 and to the enhanced service from July 2012 to July 2015 were included within the study. While the service was continuous, data was not analysed during the six-month period while the service was transitioning between the different levels of service intensity to minimise contamination. Although women with a BMI of 35 or more were referred to the service from 2009–to 2011, and women with pre-existing diabetes, excessive GWG or previous bariatric surgery were referred in both periods, to ensure comparability only women with a BMI of 40 or more were included within the analysis. These women were included regardless of underlying medical conditions such as pre-existing diabetes. Women with a twin pregnancy were excluded from the analysis.

Data collection

Maternal and neonatal pregnancy and birth data were obtained from routinely collected data. Where available, data was collected electronically, with the remainder being obtained directly from paper-based maternal health records. Where data was not available within one type of health record (i.e. paper or electronic), every effort was made to obtain the information from all medical record sources and formats to minimise missing data. Individuals extracting data from health records

were health professionals or others under the same duty of confidentiality as health professionals.

It is known that raised BMI is associated with social inequalities such as deprivation, education, maternal age, smoking, ethnicity and parity (Walker and Cresswell 2019). Baseline characteristic data were therefore obtained from medical records including maternal age, ethnicity, socioeconomic status, marital status, educational level and parity. Proxy measures to determine socioeconomic status included the highest occupation category for each household (either the woman or her partner) calculated using the three category National Statistics Socioeconomic Classification (NS-SEC) system (Office for National Statistics, 2010) and the Index of Multiple Deprivation (IMD) which is the official measure of relative deprivation in England combining information from across the seven domains of deprivation (income, employment, education, health, crime, housing and living environment) (Smith et al. 2015). The primary outcome for this study was GWG. Secondary outcomes included the antenatal outcomes (weight gain in accordance with IOM guidance (Institute of Medicine, 2009), gestational diabetes mellitus, additional monitoring for pregnancy induced hypertension); intrapartum outcomes (mode of birth, labour induction, postpartum haemorrhage); and neonatal outcomes (birth weight, gestational age, Apgar scores, breastfeeding initiation and the adverse outcomes of neonatal care admission and intrauterine fetal death).

A power calculation undertaken in Stata 15.1 determined a minimum of 58 women in each group would have 95 % power to detect a decrease in GWG of 4.1 kg with the enhanced intervention with 95 % confidence. This was the reduction in GWG achieved in a previous intervention undertaken by the research team (Soltani et al., 2015), and would be of clinical relevance (Thangaratinam et al. 2012). However, given the low incidence of some secondary outcomes, it was decided to include all eligible women.

Variable definitions

BMI was calculated using the standard equation weight/height squared using weight at booking. In a small minority of cases ($n = 9$) BMI was obtained from the health records from the current pregnancy as weight or height at booking were not recorded to calculate BMI independently. The last weight recorded in pregnancy from the middle of the third trimester (34+0 weeks') gestation onwards was taken as the final weight. GWG was measured by subtracting weight at booking from final weight. Women were classified as gaining weight below, in accordance with or above IOM recommendations of 5–9 kg. Birth weight less than 2500 g was classified as low birth weight and birth weight more than 4000 g as macrosomia. Birth weight centiles were calculated using GROW charts (UK version 8.0.6.1) (Gardosi et al. 2011; Gardosi et al. 2020), which customise centiles according to maternal height, maternal weight, ethnicity, parity, gestation and neonatal sex, as these have been shown to be more accurate in populations with overweight or obesity (Pritchard et al. 2020). Birth weight less than the 10th centile for gestational age was classified as small for gestational age (SGA) and above the 90th centile as LGA. Requiring raised blood pressure monitoring was taken as the need for any appointment to assess blood pressure above routine antenatal care, for example day care unit assessment. Throughout the study period local protocols defined gestational diabetes mellitus as a blood glucose level of 5.3 mmol/l or more after fasting or 8.5 mmol/l or more two hours after a 75 g glucose challenge. The Index of Multiple Deprivation (IMD) gives an overall deprivation score for each area from 1 (most deprived) to 32,844 (least deprived). These scores were assigned into the appropriate quintiles.

Data analysis

Logical checks and data cleaning were carried out and inconsistencies returned to the field for clarification. An initial comparison of baseline characteristics for women offered the differing service intensities was undertaken to identify potential confounding variables. Differences in antenatal, intrapartum and neonatal outcomes between the two service intensities were then analysed both with and without adjusting for baseline differences. For binary outcomes, logistic regression analyses were used and for categorical data with more than two categories multinomial regression was used to compare groups with the appropriate referent group identified. Outcomes on a continuous scale were compared using independent samples *t*-tests. Multiple logistic and linear regression were used to adjust for baseline differences in potentially confounding factors of deprivation and smoking status. Given that there were no missing cases for deprivation and only one case of missing data for smoking status within each time period, listwise deletion was used within the multiple regression analyses. Model assumptions were checked using standard regression diagnostics for linearity, normality, leverage and influence. Where any outliers or points of potentially high leverage were identified, the data analysis was rerun after removal of these points to determine if they had an impact on the effect size significance or direction. Where differences in the magnitude or direction of the effect size were noted, both effect sizes have been presented. For categorical outcomes, crude and adjusted odds ratios have been reported (OR and aOR) and for continuous outcomes, crude and adjusted mean difference (MD and aMD) have been reported, all along with their 95 % Confidence intervals (CI). Statistical significance was taken as a p value less than 0.05. All analyses were undertaken in SPSS 24.0. Given evidence within the literature that nulliparous women gain more GWG than multiparous women (Rogozińska et al. 2017) secondary analysis according to parity was also undertaken.

An important element for any service is acceptability, therefore maternal characteristics were compared between women who attended the antenatal healthy lifestyle service and those who declined to attend their provided appointment.

Results

Demographic data

Fig. 1 provides a flowchart of participant selection. Of the 330 childbearing women with a BMI of 40 or more who were referred to the service between July 2009 and December 2011, 315 were eligible for inclusion. Of the 377 women with a BMI of 40 or more referred to the service from July 2012 to July 2015, 367 were eligible for inclusion within the analysis.

Table 1 provides demographic data for the two different service intensities. There were significant differences in baseline deprivation quintile and smoking status when booking for antenatal care. Compared to women referred to the low intensity service, women referred to the enhanced service were less likely to be in the most deprived quintile or to smoke. There was a trend for women referred to the enhanced service to be more likely to be nulliparous than those referred to the service from 2009 to 2011, however this was not significant.

Maternal and neonatal outcomes

Table 2 presents maternal outcomes according to service intensity. The number of sessions attended was significantly different, with the mean number of clinic sessions attended being 1.2 (standard deviation (SD) 1.3) and mode one session (45.5 %) for the low intensity service versus mean of 2.2 (SD 1.2) and mode three or more sessions (45.5 %) for the enhanced service. There was no difference in the primary outcome, mean GWG, between the two clinic intensities. However, a significant difference in gestation at final weight was noted between the different service intensities, with final weight being recorded on average at 38.1 weeks for women offered the low intensity service and at 36.9 weeks for women offered the enhanced intervention. This also resulted in a longer average weight to birth interval for the enhanced service of 2.7 weeks compared to 1.6 weeks for the low intensity service.

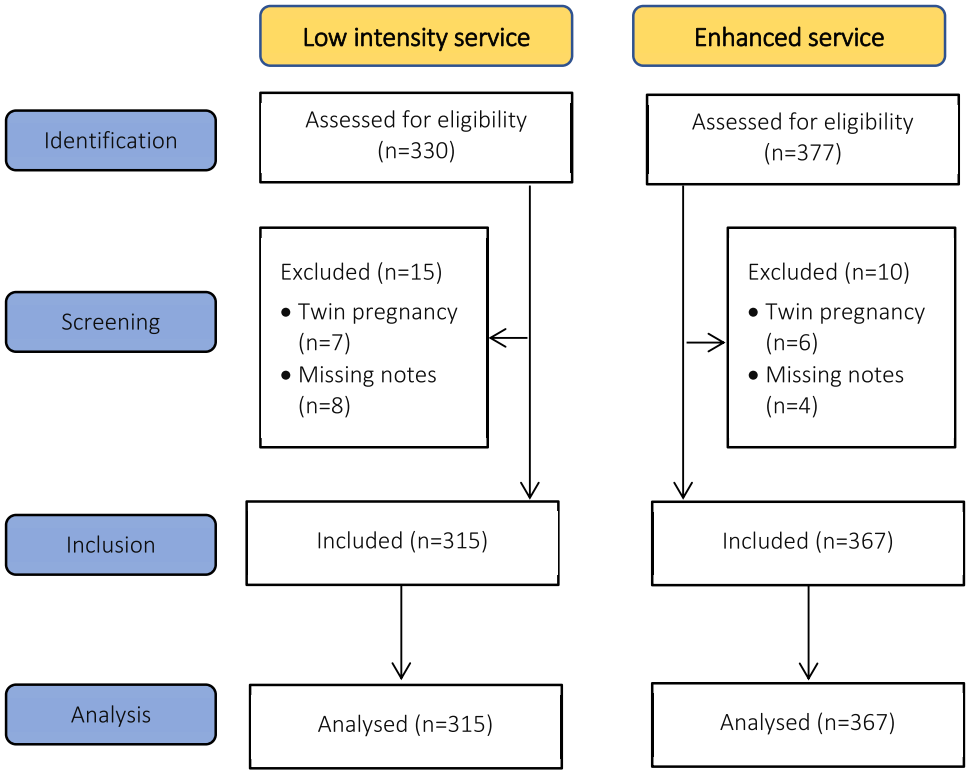

Fig. 1. STROBE flowchart of participant selection.

Therefore, GWG was additionally adjusted for gestation at which the final weight was measured and remained non-significant (aMD −0.52 (95 % CI −1.78 to 0.75). Furthermore, to eliminate the impact of gestation at which the final weight was recorded, further analysis of mean weight gain per week was also undertaken where total weight gain was divided by the length of time from booking weight to the final recorded weight. There was no significant difference in mean weight gain per week between the two different service intensities. When adjusting for baseline differences in deprivation and smoking the odds of gaining weight above IOM recommendations was lower for those receiving the enhanced intervention [aOR 0.63 (95 % CI 0.40–0.98)]. The only other differences after adjusting for baseline imbalances were the higher odds of being discharged on day one after birth [aOR 2.14 (95 % CI 1.27–3.60)] and of labour induction [aOR 1.70 (95 % CI 1.19–2.45)] in women referred to the enhanced service.

Table 3 presents neonatal outcomes according to service intensity. No differences were noted between the different service intensities for any outcomes including birth weight, gestation at birth, breastfeeding rates or adverse outcomes. The number of women who experienced an intrauterine fetal death was similar for both clinic intensities [$n = 2$ (0.6 %) low intensity intervention versus $n = 4$ (1.1 %) enhanced service]. The numbers were too small for any statistical comparison but appeared even between the groups.

The impact of changing service intensity on women of different parities was explored (maternal and neonatal outcomes for primiparous women are given in Supplementary Material: Appendix S1 and for multiparous women are given in Supplementary Material: Appendix S2). A reduction in those gaining above IOM recommendations with the enhanced service was noted in multiparous women but not nulliparous women, with the weekly weight gain also significantly less in multiparous women after adjusting for baseline differences [aMD −0.06 kg/week (95 % CI −0.11 to −0.01)]. With the enhanced service, multiparous women were noted to have a reduced odds of SGA [aOR 0.52 (95 % CI 0.31–0.87)].

The number of women declining attendance at the clinic after referral was significantly lower with the enhanced service (8.5 % versus 27.4 % for the low intensity service, $P < 0.001$). Table 4 compares the characteristics of women who chose to attend their antenatal healthy lifestyle service appointment with those who declined attendance. Women who declined attendance were significantly more likely to be from the most deprived quintile, to have two or more children, to smoke and to belong to a household where the highest occupation was classified as 'housewife /no income /student'.

Discussion

The primary outcome GWG was not significantly different between the different intensities of an antenatal healthy lifestyle service. Within this study much lower proportions of women gained more weight than IOM recommendations within both the low intensity service (37.5 %) and the enhanced service (27.4 %), than seen within a recent meta-analysis of individual patient data which suggested that 44 % of women with obesity had a GWG above IOM recommendations (Rogozińska et al., 2017). This may be because this study only included women with a BMI of 40 or more rather than all women with obesity. It however specifically highlights the need for further exploration of GWG patterns in women with different classes of obesity, particularly those with a BMI of 40 or more, to better understand the proportion of women in each obesity class who gain above IOM recommendations.

Overall fewer women gained weight above IOM recommendations when offered the enhanced service compared to those offered the low intensity intervention. However, a significant difference in gestation at which the final weight had been recorded was noted between the two different service intensities, with those attending the enhanced service having their final weight recorded at a significantly earlier gestation. The reasons behind the differences in gestation at which final weight was measured between the different service intensities is not immediately apparent given that Trust policy did not change during the study. Trust policy did not recommend routine weighing at every antenatal appointment but did recommend weighing women with obesity at 36

Table 1
Baseline demographics of women referred to the different service intensities.

Characteristic	Low intensity 2009–2011 (*n* = 315)	Enhanced service 2012–2015 (*n* = 367)	*P* Value
Maternal age, mean (SD), y	28.5 (5.5)	28.5 (5.4)	0.93
Deprivation quintile, n (%)			0.032
Quintile 1: Most deprived IMD score 1–6568	198 (62.8 %)	190 (51.8 %)	
Quintile 2: IMD score 6569–13,137	58 (18.4 %)	80 (21.8 %)	
Quintile 3: IMD score 13,138–19,706	27 (8.6 %)	50 (13.6 %)	
Quintile 4: IMD score 19,707–26,275	21 (6.7 %)	36 (9.8 %)	
Quintile 5: Least deprived IMD score 26,276–32,844	11 (3.5 %)	11 (3.0 %)	
Smoking status at booking, n (%)			0.023
Smoker	82 (26.1 %)	69 (18.9 %)	
Non-smoker	232 (73.9 %)	297 (81.1 %)	
Parity, n (%)			0.065
0	81 (25.8 %)	125 (34.1 %)	
1	114 (36.3 %)	119 (32.4 %)	
2+	119 (37.9 %)	123 (33.5 %)	
Ethnicity, n (%)			0.79
White British	297 (95.2 %)	349 (95.6 %)	
Other	15 (4.8 %)	16 (4.4 %)	
Highest household Occupation, n (%)[a]			0.65
Higher managerial, administrative and professional occupations	45 (15.0 %)	67 (18.5 %)	
Intermediate occupations	69 (22.9 %)	75 (20.7 %)	
Routine and manual occupations	107 (35.5 %)	125 (34.4 %)	
Housewife/ Long-term no income or never worked/ student	80 (26.6 %)	96 (26.4 %)	
Education, n (%)			0.27
GCSE/ equivalent or lower	32 (43.8 %)	78 (43.3 %)	
AS/A level or equivalent	16 (21.9 %)	55 (30.6 %)	
Degree, postgraduate or equivalent	25 (34.3 %)	47 (26.1 %)	
Marital status, n (%)			0.77
Married/civil partnership	113 (36.0 %)	121 (33.3 %)	
Partner	165 (52.5 %)	199 (54.8 %)	
Single[b]	36 (11.5 %)	43 (11.9 %)	
Booking body mass index, mean (SD), kg/m^2	43.98 (3.75)	43.98 (3.64)	0.96[c]
Maternal height, mean (SD), m	1.64 (0.07) (*n* = 310)	1.64 (0.07) (*n* = 365)	0.86
Gestation at booking, mean (SD), wk	9.2 (3.5) (*n* = 314)	9.2 (3.2) (*n* = 366)	0.86
Alcohol intake at booking, n (%)			0.74[d]
None	300 (98.1 %)	359 (98.9 %)	
1–3 units	5 (1.6 %)	3 (0.8 %)	
4–8 units	1 (0.3 %)	1 (0.3 %)	

IMD – Index of Multiple Deprivation (Smith et al. 2015).

[a] Occupations coded using the 3 category National Statistics Socioeconomic Classification (NS-SEC) system (ONS 2010).

[b] The single category included 4 women in 2009–2011 and 5 women in 2012–2015 who were divorced/ separated/widowed.

[c] Mann Whitney test used when the Shapiro-Wilk test showed data were not normally distributed.

[d] Fisher exact test used due to small cell counts.

weeks gestation. It may be that as women were routinely scheduled an appointment with the healthy lifestyle service at 36 weeks gestation within the enhanced service, that this helped to ensure that weight was consistently recorded at 36 weeks, while weighing at the end of pregnancy for those offered the low intensity service was more ad hoc leading to a later gestation at final weight. As a result of the differences in gestation at final weight, an additional analysis of rate of weight gain was incorporated as this controlled for the different length of time over which weight gain was measured during pregnancy for different women. This rate of weight gain was no different between the different service intensities. This emphasises the importance of considering the gestation at final weight when assessing and reporting GWG within the literature.

When considering the service impact on women of different parities, a significant reduction in those gaining above IOM recommendations was only evident among multiparous women. Additionally multiparous women attending the enhanced service also achieved a lower rate of weight gain. This larger impact of the enhanced service in multiparous women is of interest, given that primiparous women are known to gain more weight in pregnancy (Rogozińska et al. 2017). One potential explanation may be that qualitative studies have found multiparous women to voice regret over gaining excessive weight within their first pregnancy (Fair et al., 2022). This may make multiparous women more conscious of implementing any advice provided in a subsequent pregnancy and appreciative of the additional support received from the enhanced service. Several studies have also shown that parous women typically have poorer diet quality during pregnancy (Aubert et al. 2022; Deierlein et al. 2021) and are less physically active during pregnancy than nulliparous women (Meander et al. 2021), suggesting that parous women may be able to easily identify areas for behaviour change when offered appropriate lifestyle advice and support.

As would be expected women receiving the lower intensity service attended fewer dietary service appointments than women in the enhanced clinic intervention. Increased attendance with the increasing number of appointments available to women suggests a general acceptability of the appointments. However, to evaluate service acceptability it is also important to consider those who declined attendance at the antenatal healthy lifestyle service. These women were significantly more likely to be of lower socioeconomic status, to already have children, and to smoke. Others have found similar factors to influence engagement, for example in one service women with obesity who smoked were less likely to attend individual weight management appointments during pregnancy (Porteous et al. 2020). In a separate study, women from low income households or who lived in larger households engaged less with a text based health education intervention during pregnancy and the postpartum (Gazmararian et al. 2014). To ensure equitable access for all groups when developing future services additional attention is needed on structural barriers women may face, for example through offering childcare or covering the cost of transportation to appointments. There was a lower proportion of women not attending any appointments with the enhanced service (8.5 %) compared to the low intensity service (27.4 %). The slightly higher number of nulliparous women referred to the enhanced service could not account for all of this difference. It may therefore reflect that the established service had increased awareness of obesity during pregnancy within the Trust which had given community midwives more confidence to raise the issue of a woman's BMI when referring them into the service. This is important as midwives have previously been shown to avoid challenging discussions around weight with women during pregnancy (Atkinson and McNamara 2017), with women getting inadequate information about services they had been referred to as a result (Heslehurst et al. 2017).

The only other differences in outcomes between the two differing intensities of service after adjusting for baseline differences, were day of discharge from hospital and labour induction. It is believed that these differences more likely reflected changes in practice and policy over time rather than being a direct impact of the antenatal healthy lifestyle service. Nationally, over the period of this study, there was a reduction in the length of postpartum hospital stay (Bowers and Cheyne 2015) and an increasing proportion of births being induced (National Health Service Digital, 2019). Although not significant, there was an increased rate of gestational diabetes mellitus in women attending the enhanced service. This could not be explained by any changes to diagnostic criteria during the study period. While the proportion of women with a blood glucose measurement increased over time, from 84.4 % to 87.7 % this alone could not explain the increased rate of gestational diabetes mellitus. Women with gestational diabetes mellitus are more likely to have

Table 2
Maternal outcomes according to service intensity.

Outcome	Low intensity 2009–2011 (n = 315)	Enhanced service 2012–2015 (n = 367)	Crude Mean difference (MD) or Odds ratio (OR) (95 % CI)	Adjusted MD/OR (95 % CI)[a]
Number of antenatal healthy lifestyle service appointments attended, mean (SD)	1.2 (1.3) (n = 314)	2.2 (1.2) (n = 363)	MD 1.1 (0.9–1.2)***	aMD 1.00 (0.8–1.2)***
Number of antenatal healthy lifestyle service appointments, n (%)				
0	86 (27.4 %)	31 (8.5 %)	REF	REF
1	143 (45.5 %)	69 (19.0 %)	OR 1.34 (0.81–2.21)	aOR 1.27 (0.76–2.12)
2	58 (18.5 %)	98 (27.0 %)	OR 4.69 (2.78–7.91)***	aOR 4.48 (2.62–7.65)***
3 or more	27 (8.6 %)	165 (45.5 %)	OR 16.95 (9.51–30.22)***	aOR 16.08 (8.89–29.08)***
Gestation at first antenatal healthy lifestyle appointment, mean (SD), wk [b]	17.3 (5.4) (n = 228)	17.3 (4.8) (n = 331)	MD −0.0 (−0.9 to 0.8)	aMD −0.1 (−0.9 to 0.8)
Gestational weight gain, mean (SD), kg	6.6 (7.4) (n = 264)	5.7 (6.9) (n = 296)	MD −1.0 (−2.2 to 0.2)	aMD −1.1 (−2.3 to 0.1)
Gestation at final weight, mean (SD),wk	38.1 (1.9) (n = 264)	36.9 (1.6) (n = 296)	MD −1.2 (−1.5 to −0.9)***	aMD −1.2 (−1.5 to −0.9)***
Weekly weight gain, mean (SD), kg/wk	0.24 (0.28) (n = 264)	0.21 (0.25) (n = 296)	MD −0.04 (−0.08 to 0.01)	aMD −0.04 (−0.09 to 0.001)[c]
Weight gain according to Institute of Medicine recommendations, n (%)				
Too little	104 (39.4 %)	133 (44.9 %)	OR 0.95 (0.63–1.45)	aOR 1.00 (0.65–1.52)
Recommended	61 (23.1 %)	82 (27.7 %)	REF	REF
Too much	99 (37.5 %)	81 (27.4 %)	OR 0.61 (0.39–0.95)*	aOR 0.63 (0.40–0.98)*
Vaginal birth, n (%)	166/302 (55.5 %)	180/347 (51.9 %)	OR 0.88 (0.65–1.20)	aOR 0.87 (0.64–1.19)
Caesarean birth, n (%)	126/302 (41.7 %)	150/347 (43.2 %)	OR 1.06 (0.78–1.45)	aOR 1.09 (0.79–1.49)
Induction of labour (excluding Caesarean birth prior to labour), n (%)	112/229 (48.9 %)	170/273 (62.3 %)	OR 1.72 (1.21–2.46)**	aOR 1.70 (1.19–2.45)**
Postpartum haemorrhage (estimated blood loss ≥500 ml), n (%)	126/301 (41.9 %)	137/302 (45.4 %)[d]	OR 1.15 (0.84–1.59)	aOR 1.19 (0.86–1.65)
Shoulder dystocia (excluding women with a Caesarean birth), n (%)	8/174 (4.6 %)	3/193 (1.6 %)	OR 0.33 (0.09–1.26)	aOR 0.29 (0.07–1.14)
Day of discharge from hospital, n (%)				
Day of birth	46 (15.1 %)	35 (10.2 %)	REF	REF
Day 1	88 (29.0 %)	146 (42.7 %)	OR 2.18 (1.31–3.64)**	aOR 2.14 (1.27–3.60)**
Day 2	114 (37.5 %)	99 (29.0 %)	OR 1.14 (0.68–1.91)	aOR 1.31 (0.67–1.91)
Day 3+	56 (18.4 %)	62 (18.1 %)	OR 1.46 (0.82–2.57)	aOR 1.37 (0.77–2.43)
Gestational diabetes mellitus, n (%)[e]	45/262 (17.2 %)	75/314 (23.9 %)	OR 1.51 (1.00–2.29)*	aOR 1.49 (0.98–2.26)
Additional monitoring for raised blood pressure, n (%)[f]	54/282 (19.1 %)	59/305 (19.3 %)	OR 1.01 (0.67–1.53)	aOR 1.00 (0.66–1.52)

* significant at $P < 0.05$ level.
** significant at $P < 0.01$ level.
*** significant at $P < 0.01$ level.
[a] Adjusted for deprivation (REF= most deprived quintile) and smoking (REF=non smoker) as these were the only significant differences in baseline characteristics.
[b] Gestation at first antenatal healthy lifestyle appointment only available for those who attended the clinic.
[c] This was further away from reaching significance once removing the outlier aMD −0.04 (−0.08, 0.01).
[d] The new electronic health notes for recording intrapartum care from 2015 made it difficult to obtain estimated blood loss for many women who gave birth in 2015.
[e] For the gestational diabetes outcomes women with pre-existing diabetes ($n = 7$ for the low intensity service and $n = 5$ for the enhanced service) and previous gastric surgery ($n = 1$ for both service intensities) were excluded.
[f] Additional monitoring for raised blood pressure - women receiving monitoring over and above routine care due to raised blood pressure, including those who went on to be diagnosed with pregnancy Induced hypertension, pre-eclampsia or HELLP syndrome.

an induced labour (Koivunen et al. 2020), therefore the increased proportion of women with gestational diabetes mellitus in those attending the enhance service could also have impacted on the higher rates of labour induction. No other differences were noted in outcomes between the two service intensities, except for a reduction in SGA for multiparous women. It is however acknowledged that this study was underpowered to detect changes in some outcomes with low incidences and did not look at longer term maternal outcomes, such as postpartum weight retention or weight upon entering any subsequent pregnancies.

The findings within this study are in line with a recent overview of systematic reviews of randomised controlled trial evidence that showed that while lifestyle interventions during pregnancy could result in small reductions in GWG among women with overweight or obesity, this corresponded with limited or no improvements in other pregnancy outcomes such as gestational diabetes mellitus, pre-eclampsia, mode of birth or birth weight outcomes (Fair and Soltani, 2021). This therefore may indicate that rigorous service evaluations, with appropriate controlling for confounding factors, could perhaps be a good alternative for RCTs, which are often costly and less relevant to real-life situations for such complex public health challenges.

No optimal intervention frequency was found in a previous systematic review of randomised controlled trial evidence among women from all pre-pregnancy BMI categories (Walker et al. 2018). Within that review, subgroup analysis showed no difference in excessive GWG between lifestyle interventions delivered 1–3 times and those delivered 4–7 or eight or more times. This suggested clear consistent advice from professionals trained to initiate conversations around GWG had the potential to reduce excessive GWG as much as intense interventions. The systematic review grouped together interventions where the frequency of contact was between one and three times. This current study has

Table 3
Neonatal outcomes according to service intensity.

Outcome	Low intensity 2009–2011 (n = 315)	Enhanced service 2012–2015 (n = 367)	Crude Mean difference (MD) or Odds ratio (OR) (95 % CI)	Adjusted MD/OR (95 % CI) [a]
Birth weight. mean (SD), g	3466 (628) (n = 301)	3498 (609) (n = 347)	MD 32 (−64 to 127)	aMD 25 (−71 to 121)
Gestation at birth, mean (SD), wk	39.4 (2.0) (n = 302)	39.2 (2.1) (n = 348)	MD −0.1 (−0.4 to 0.2)	aMD −0.1 (−0.4 to 0.2)
Low birth weight (<2500 g), n (%)	15/301 (5.0 %)	15/347 (4.3 %)	OR 0.86 (0.41–1.79)	aOR 0.94 (0.45–1.98)
Macrosomia (>4000 g), n (%)	45/301 (15.0 %)	65/347 (18.7 %)	OR 1.31 (0.87–1.99)	aOR 1.26 (0.83–1.93)
Small for gestational age (<10th centile), n (%)	65/301 (21.6 %)	54/347 (15.6 %)	OR 0.67 (0.45–1.00*)	aOR 0.68 (0.45–1.02)
Large for gestational age (>90th centile), n (%)	29/301 (9.6 %)	38/347 (11.0 %)	OR 1.15 (0.69–1.92)	aOR 1.12 (0.67–1.88)
Preterm (<37+0 weeks), n (%)	30/302 (9.9 %)	31/348 (8.9 %)	OR 0.89 (0.52–1.50)	aOR 0.85 (0.50–1.46)
Postdates (>41+6 weeks), n (%)	3/302 (1.0 %)	10/348 (2.9 %)	OR 2.95 (0.80–10.82)	aOR 2.95 (0.80–10.93)
Apgar score at 1 min <7, n (%)	42/299 (14.0 %)	40/331 (12.1 %)	OR 0.84 (0.53–1.34)	aOR 0.83 (0.52–1.34)
Apgar score at 5 min <7, n (%)	5/299 (1.7 %)	5/330 (1.5 %)	OR 0.91 (0.26–3.16)	aOR 0.97 (0.27–3.46)
Neonatal unit admission, n (%)	20/299 (6.7 %)	25/338 (7.4 %)	OR 1.11 (0.61–2.05)	aOR 1.13 (0.61–2.10)
Breastfeeding initiation, n (%)	159/295 (53.9 %)	181/337 (53.7 %)	OR 0.99 (0.73–1.36)	aOR 0.93 (0.67–1.28)
Breastfeeding at discharge from hospital, n (%)	131/292 (44.9 %)	135/328 (41.2 %)	OR 0.86 (0.63–1.18)	aOR 0.79 (0.57–1.09)

[a] Adjusted for deprivation (REF= most deprived quintile) and smoking (REF=non smoker) as these were the only significant differences in baseline characteristics.

* significant at $P < 0.05$ level, ** significant at $P < 0.01$ level, *** significant at $P < 0.01$ level.

Table 4
Comparison of maternal characteristics in those who attended versus those who declined attendance at the healthy lifestyle service.

Characteristic	Attended service (n = 560)	Service attendance declined (n = 117)	P Value
Maternal age, mean (SD), y	28.6 (5.5)	27.8 (5.1)	0.12
Deprivation quintile, n (%)			0.006
Quintile 1: Most deprived - IMD score 1–6568	306 (54.6 %)	82 (70.1 %)	
Quintile 2: IMD score 6569–13,137	114 (20.4 %)	23 (19.7 %)	
Quintile 3: IMD score 13,138–19,706	71 (12.7 %)	4 (3.4 %)	
Quintile 4: IMD score 19,707–26,275	50 (8.9 %)	5 (4.3 %)	
Quintile 5: Least deprived IMD score 26,276–32,844	19 (3.4 %)	3 (2.6 %)	
Smoking status at booking, n (%)			0.001
Smoker	101 (18.1 %)	49 (41.9 %)	
Non-smoker	458 (81.9 %)	68 (58.1 %)	
Parity, n (%)			<0.001
0	195 (34.8 %)	9 (7.7 %)	
1	187 (33.4 %)	45 (38.5 %)	
2+	178 (31.8 %)	63 (53.8 %)	
Ethnicity, n (%)			0.10
White British	528 (94.8 %)	114 (98.3 %)	
Other	29 (5.2 %)	2 (1.7 %)	
Highest household Occupation, n (%)[a]			<0.001
Higher managerial, administrative and professional occupations	100 (18.3 %)	12 (10.4 %)	
Intermediate occupations	129 (23.7 %)	13 (11.3 %)	
Routine and manual occupations	190 (34.9 %)	41 (35.7 %)	
Housewife/ Long-term no income or never worked/ student	126 (23.1 %)	49 (42.6 %)	
Education, n (%)			0.73
GCSE/ equivalent or lower	97 (44.1 %)	11 (37.9 %)	
AS/A level or equivalent	62 (28.2 %)	8 (27.6 %)	
Degree, postgraduate or equivalent	61 (27.7 %)	10 (34.5 %)	
Marital status, n (%)			0.10
Married/civil partnership	200 (35.9 %)	33 (28.4 %)	
Partner	290 (52.1 %)	73 (62.9 %)	
Single[b]	67 (12.0 %)	10 (8.6 %)	
Booking body mass index, mean (SD), kg/m^2	44.0 (3.8)	43.8 (3.2)	0.52
Gestation at booking, mean (SD), wk	9.1 (3.4) (n = 559)	9.4 (3.1)	0.46

IMD – Index of Multiple Deprivation (Smith et al. 2015).

[a] Occupations coded using the 3 category National Statistics Socioeconomic Classification (NS-SEC) system (ONS 2010).

[b] The single category included 4 women in 2009–2011 and 5 women in 2012–2015 who were divorced/ separated/widowed.

however suggested that especially in multiparous women that rate of weight gain during pregnancy could be reduced by increasing intervention intensity, therefore further exploration of the differential impact of antenatal healthy lifestyle service for nulliparous and multiparous women is recommended, particularly for women with a BMI of 40 or more.

Strengths and limitations of the study

This cohort study explored the impact of an antenatal healthy lifestyle service within a large number of women with a BMI of 40 or more, a category often lacking in studies of lifestyle interventions in pregnancy. With over 680 women with a BMI of 40 or more during pregnancy it is one of the largest studies to date on the effects of antenatal healthy lifestyle services among this subgroup of women. Despite the increasing national prevalence of obesity, the proportion of women with a BMI of 40 or more within the Trust remained at 3.5 %, with the mean BMI also being the same in both study periods. The study took advantage of changing practices in antenatal healthy lifestyle service provision to enable a pragmatic exploration of differing service intensities within a real-life situation which is seen as an ideal way to determine the impact of interventions under real-world conditions (Battaglia and Glasgow 2018). Some limitations however need to be acknowledged. Retrospective data collection is well known for its limitations around data completeness (Song and Chung 2010). Poor documentation of maternal education within the health records was particularly evident within this study. The antenatal healthy lifestyle service was provided by the same midwives throughout the whole time-period offering consistency. However, due to the retrospective nature of the study it was not possible

to fully adjust for changes in midwifery practice or policy over time to ensure that all other care received by women in the low intensity service was identical in every way to women offered the enhanced service.

Conclusions

Among women with a BMI of 40 or more there were no overall differences on the outcome of mean GWG between women routinely provided with three sessions at an antenatal healthy lifestyle service compared to those provided with one session. However multiparous women offered the enhanced serviced were less likely to gain weight in excess of IOM recommendations and gained weight at a slower rate after adjusting for baseline differences. While no improvements were seen in maternal or neonatal outcomes with additional antenatal healthy lifestyle service visits across the whole sample, multiparous women offered the enhanced service had reduced odds of SGA, which is of potential clinical importance. However, this study was underpowered to detect changes in some outcomes with low incidences. Uncertainty remains over the best management of GWG in women with a BMI of 40 or more. Further research is required to establish the most effective intervention types and intensities for women of different classes of obesity. This is important due to its health benefits as well as enabling better determination of the economic costs of effective interventions. A specific focus on nulliparous women could be suggested given the lack of impact of this current antenatal healthy lifestyle service on nulliparous women. Additionally, given the differential impact of the service on women of different parities, a personalised approach to weight management in practice should be considered to ensure advice and support is of most benefit to the recipient. This study showed that women with lower socioeconomic status, multiparity and those who smoked prior to pregnancy were less likely to engage with the antenatal healthy lifestyle service. Any future interventions therefore need to ensure effective engagement with stakeholders from groups less likely to engage with services to enhance intervention acceptability to these groups.

Ethical-legal considerations

Ethical approval was obtained from the East England - Cambridge East Research Ethics Committee (IRAS: project number 207,998). The study was conducted in accordance with the principles of the Declaration of Helsinki. For this type of retrospective study formal consent was not required.

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Availability of data and materials

The datasets used and/or analysed during the current study are not publicly available within a repository as they belong to the Hospital Trust, but the data is available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Frankie J Fair: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. **Hora Soltani:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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