A retrospective comparative study of antenatal healthy lifestyle service interventions for women with a raised body mass index.

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A retrospective comparative study of antenatal healthy lifestyle service interventions for women with a raised body mass index

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ABSTRACT

Background: Women with obesity are more likely to gain excessive gestational weight; with both obesity and excessive weight gain linked to adverse outcomes for mothers and their infant. Provision of antenatal healthy lifestyle services is currently variable, with uncertainty over the most effective gestational healthy lifestyle interventions.

Aim: To compare pregnancy and birth outcomes among women who experienced an antenatal health lifestyle service with a cohort who did not receive this service.

Methods: A retrospective comparative cohort study was undertaken in women with a BMI $\geq$ 40 kg/m^2 attending maternity care in two NHS Trusts. One Trust provided an antenatal healthy lifestyle service, while the comparison Trust provided routine maternity care. Data was collected from medical records.

Findings: No differences were observed between the antenatal healthy lifestyle service and comparison cohorts for average gestational weight gain [adjusted mean difference (aMD) − 0.70 kg (95%CI −2.33, 0.93)], rate of weight gain [aMD − 0.02 kg/week (95%CI −0.08, 0.04)] or weight gain in accordance with recommendations. The proportion of women breastfeeding at discharge was higher for the antenatal healthy lifestyle service than the comparison cohort (42.4% vs 29.8%). No other clinical outcomes were enhanced with the antenatal healthy lifestyle service.

Conclusion: Internal audit had suggested the antenatal healthy lifestyle service was successful at managing gestational weight gain in women with a BMI $\geq$ 40 kg/m^2. However, no benefit on gestational weight gain was evident once the service was evaluated against a comparison cohort with adequate adjustment for confounders. It is essential that future services are evaluated against a relevant comparison group.

Statement of significance

Issue

Rising obesity rates place women and their infants at risk, especially of excessive gestational weight gain (GWG), which is also associated with adverse outcomes.

What is already known

The best management to reduce GWG in women with obesity is uncertain.

What this paper adds

The interventional service was not superior in reducing GWG in women with a BMI $\geq$ 40 kg/m^2 compared to the comparison Trust. Even without an intervention service the average GWG was within the recommended IOM range. There were no observed improvements in other outcomes for the intervention group. Clear effective GWG management strategies are required.

Introduction

The proportion of women with obesity at the start of their pregnancy has risen significantly over recent decades, with the rate more than doubling from 7.6% in 1989 to 15.6% in 2007 across 37 maternity units in England [1]. Since then, the proportion has continued to increase, being 22.2% in 2018–2019 [2]. Furthermore, childbearing is acknowledged to contribute to the rise in women with overweight and obesity [3]. Socio-demographic disparities in maternal obesity are well known with women who are older, of a higher parity and from deprived areas

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being more likely to be obese at the start of pregnancy [1,2].

Obesity during pregnancy has been associated with a wide range of adverse outcomes including gestational diabetes, pre-eclampsia, preterm birth [4], poorer induction outcomes [5], caesarean section [6], maternal mortality [7], shoulder dystocia [8], large for gestational age (LGA) infants [4], and poorer rates of breastfeeding initiation and continuation [9]. An individual patient meta-analysis from 39 cohort studies undertaken in Europe, Australia and North America including 265,270 births estimated that of all pregnancy complications 23.9% were attributable to maternal overweight or obesity prior to pregnancy, with the highest risk of pregnancy complications for mothers with a BMI $\geq$ 40 kg/m^2 [4]. Furthermore, children born to women with obesity during pregnancy have been shown to have an increased risk of obesity themselves [10]. In addition to health risks, these complications can lead to a longer length of hospital stay which has significant implications on health service resource utilisation as well as cost, with an estimated additional cost of £ 1172 to the National Health Service in the United Kingdom (UK) for every maternity in a woman with obesity [11].

Women with obesity prior to pregnancy are also at high risk of excessive gestational weight gain [12]. Increased gestational weight gain (GWG) is itself associated with adverse maternal and neonatal outcomes such as increased risk of LGA infants [4], caesarean section [13], induction [14], maternal weight retention [3] and childhood obesity [10], as well as reduced incidence of breastfeeding [9]. In view of the many adverse effects of excessive GWG, the Institute of Medicine (IOM) [15] has proposed guidelines for GWG based on maternal pre-pregnancy BMI category. A GWG between 5 and 9 kg is recommended for women with obesity [15], however evidence suggests about 60% of women with obesity gain more weight during pregnancy than recommended [16].

Provision of maternity services for women with obesity is variable within the UK, with a need for more equitable antenatal maternal obesity services identified [17]. Despite pregnancy being recognised as a good opportunity to influence behaviour change for mothers and families [18], there is uncertainty among professionals about what constitutes the most suitable service to tackle maternal obesity [17]. The lack of certainty about the best interventions to control weight gain during pregnancy is further reinforced by numerous international studies [19–22] that have given mixed results. A recent overview of systematic reviews has suggested that while lifestyle interventions may cause a small reduction in GWG, the current data found no clear benefit on maternal and infant clinical outcomes [23]. Optimization of gestational weight gain management has recently been identified as a top research priority by the international Health in Preconception, Pregnancy and Postpartum Global Alliance [24]. Furthermore, the National Institute for Health and Clinical Excellence (NICE) has recommended more research - particularly UK based investigations into ways of managing maternal obesity and GWG to optimise pregnancy outcomes as UK based research into the efficacy of weight management interventions in pregnancy is limited [25]. Establishing the optimal management of obesity and weight gain during pregnancy is also essential given the weight stigma many women describe during pregnancy and in the postnatal period [26]. Women report healthcare providers assuming that they are lazy, lack will power and are unintelligent [26]. This stigma itself has been shown to lead to weight gain, exercise avoidance and increased nutritional intake [26]. This study therefore investigates the outcomes for women and their neonates of an antenatal healthy lifestyle service in a real-life practice setting to further inform the debate as to the most suitable service for women at this key period in their life.

Aim

To compare pregnancy and birth outcomes for mothers with a BMI $\geq$ 40 kg/m^2 who experienced an antenatal healthy lifestyle service with a cohort of mothers from a neighbouring comparison NHS Trust without this service.

Method

A retrospective comparative study from two neighbouring Trusts was undertaken.

Setting

Antenatal healthy lifestyle service

A midwife-led antenatal healthy lifestyle service was initially established in an NHS Trust in the Yorkshire and Humber region of England in 2009. As the service was established community midwives were trained in initiating conversations with women when referring them to the clinic [27,28]. From July 2012 women with a BMI $\geq$ 40 kg/m^2 were offered appointments at 16, 28 and 36 gestational weeks, with an opportunity to further access the service for additional appointments if they wished. Women's attendance or non-attendance at the antenatal healthy lifestyle service was documented. Midwives led the service and provided support and advice on lifestyle change while working alongside other professions such as obstetricians, dieticians, anaesthetists and exercise programme providers. The overall aim of the clinic was to encourage women to make lifestyle choices and behavioural changes during pregnancy, which could be sustained in the postpartum period. The approach to weight management encouraged four healthy lifestyle facets. The first of these was around healthy eating with women informed of healthy eating principles for pregnancy and individual support provided where required for example around managing pregnancy related cravings. The second facet was around being physically active during pregnancy which included advice around what exercise could safely be undertaken during pregnancy and referral to relevant local services such as aquanatal classes. The third component was around not gaining excessive gestational weight during pregnancy, with the women's current weight gain discussed within each appointment. The final element was around breast feeding. Individualised care planning was undertaken, which encouraged women to set goals such as to swap one unhealthy food for a healthy one. These goals were followed up and reassessed at subsequent appointments. Additionally, women were offered a dietician consultation [27]. Local audit data suggested this service to be effective at reducing GWG. However local midwives called for a robust and external evaluation to allow national credibility and the potential for rolling out the service.

Comparison cohort

Women attending for antenatal care in the neighbouring Trust were chosen as the comparison cohort. This neighbouring Trust was chosen due to the similar health, lifestyle and demographic profile in 2015 to that of the Trust that provided the antenatal healthy lifestyle service as seen in Table 1. No specific antenatal healthy lifestyle services were available in the neighbouring NHS Trust until a dietician provided service was established in 2012. Women could opt to use this dietician

Table 1
Health, lifestyle and demographic profiles of the two NHS Trusts.

Characteristic	Comparison Trust	Trust providing the antenatal healthy lifestyle service
Deprivation (proportion living in the most deprived 20% in England)	29.6%	29.1%
Proportion of adults with overweight or obesity	71.0%	73.4%
Smoking at birth of infant	20.5%	20.7%
Healthy eating (adults reporting eating '5 a day' on a usual day	52.4%	49.6%
Physically active adults	59.7%	58.6%
Ethnicity	97.9%	95.3%

Data from Public Health England 2015 [43] and Office for National Statistics 2011 [52]

service for antenatal weight management if they wished to do so. Referral and uptake figures for this service were however very low for the time period of this study, 2012–2015, due to poor staff training around referral to the service and high staff turnover within the service [29]. Due to the very low numbers involved, women who attended the dietician services were not included within the comparison group. The women in the comparison cohort therefore received no targeted healthy eating or physical activity support or advice.

Data collection

Maternal and neonatal pregnancy and birth data were obtained from routinely collected data for all women with a BMI $\geq$ 40 kg/m^2 booking for maternity care with a singleton pregnancy in either Trust from 2012–2015. Data was collected electronically where this was available, with the rest being obtained directly from maternal medical records.

The primary outcome for this study was maternal gestational weight gain. Secondary outcomes included maternal weight gain in accordance with IOM guidance, gestational diabetes, pregnancy induced hypertension, anaemia, mode of birth, induction, requirement of epidural or general anaesthetic for labour or birth, perineal tear, postpartum haemorrhage, birthweight, gestational age at birth, APGAR scores, breastfeeding initiation and adverse outcomes of shoulder dystocia and admission to the neonatal special care unit.

BMI was calculated from the standard formula weight/height squared (kg/m^2) using weight at booking. In a small minority of cases (n = 6) BMI was taken as recorded in the medical records as weight or height at booking was not recorded to calculate BMI independently. Weighing was routine at 36 weeks gestation within both Trusts, therefore GWG was measured by subtracting weight at booking from the final weight measured during pregnancy from the middle of the third trimester (34 +0 weeks gestation) onwards. The recommended range for weight gain for women with obesity prior to pregnancy is 5–9 kg [15]. According to IOM recommendations, women were classified as gaining too little weight, in accordance with recommendations or above recommendations (excessive weight gain). Birthweight less than 2500 g was classified as low birth weight and birthweight more than 4000 g as macrosomia. Infant birthweight centiles were calculated using GROW charts (UK version 8.0.6.1) [30,31]. This customized the centiles according to maternal height, maternal weight, ethnicity, parity, gestation and infant gender, which have been shown to be more accurate in populations with overweight and obesity [32]. Birthweight less than the 10th centile for gestational age was classified as small for gestational age (SGA) and above the 90th centile as LGA. Anaemia was classified as a haemoglobin level < 110 g/l at the booking appointment or < 105 g/l at 28 weeks and 36 weeks [33]. Pregnancy induced hypertension was taken as the need for any appointment to assess blood pressure above routine antenatal care, for example day care unit assessment. Definitions for gestational diabetes between the 2 units varied slightly, therefore for the purposes of this study gestational diabetes was defined as fasting blood glucose $\geq$ 5.3mmmol/l or 2 h post 75 g glucose challenge blood glucose $\geq$ 8.5 mmol/l, rather than gestational diabetes as diagnosed within the medical notes. Postpartum haemorrhage was defined as a blood loss of 500 ml or more at a vaginal birth and 1000 ml or more for a Caesarean birth. Occupations of the women and their partners were coded using the 3 category National Statistics Socio-economic Classification (NS-SEC) system [34]. The highest occupation category for each household (either for the woman or her partner) was utilised within the analysis. The Index of Multiple Deprivation (IMD) was used to measure deprivation, as this is the official measure of relative deprivation in England. The score for each area combines information from seven domains of deprivation (income, employment, education, health, crime, housing and living environment) to give one overall deprivation score from 1 (most deprived) to 32844 (least deprived) [35]. These scores were designated into the appropriate quintiles.

Data analysis

Logical checks and data cleaning were carried out and inconsistencies were returned to the field for clarification. An initial comparison between the Trusts for baseline characteristics was undertaken using SPSS 24.0 to identify potential confounding variables. The outcomes from women attending the antenatal healthy lifestyle service were then compared to the outcomes in the cohort of women from the neighbouring Trust. To compare differences in outcomes logistic regression analyses were used for binary outcomes, and multinomial regression analyses for categorical data with more than 2 categories with the appropriate referent group identified. Outcomes on a continuous scale were compared using independent samples t test. Multivariate logistic or multivariate linear regression were used to adjust comparisons for confounding factors. For categorical outcomes, crude and adjusted odds ratios are reported (OR and aOR) and for continuous outcomes, crude and adjusted mean difference (MD and aMD) are reported, all along with their 95% confidence interval (CI). $p < 0.05$ was regarded as statistically significant. Linear regression model assumptions were checked using standard regression diagnostics for linearity, normality, leverage, and influence. However, no cases were noted where assumptions were violated or where removal of outliers had an impact on the significance or direction of the effect size.

Findings

Demographic data

In the comparison NHS Trust, 417 women with a BMI $\geq$ 40 kg/m^2 booked for care with a singleton pregnancy between 2012 and 2015. Of these 16 records could not be found and 30 women had attended a dietician appointment, data was also missing regarding dietician appointments for 6 women, 3 of whom had an early miscarriage. After excluding these women from the analysis, 365 women were left within this cohort.

In the intervention NHS Trust within the same time period, 371 women with a BMI $\geq$ 40 kg/m^2 with a singleton pregnancy were referred to the antenatal healthy lifestyle service. Of these, four records could not be found, 31 women did not attend for an antenatal healthy lifestyle service appointment and four women miscarried prior to their expected first appointment. These women were excluded from the analysis, leaving a total of 332 women.

Baseline demographic and lifestyle data for the intervention and comparison cohorts can be seen in Table 2. Women in the comparison cohort were significantly more likely to smoke at booking (p = 0.005). Highest household occupation also significantly differed between the comparison cohort and those attending the antenatal healthy lifestyle service (p = 0.016). Women in the comparison cohort were less likely to be in a household where the highest occupation was classified as higher managerial, administrative or professional occupation or have a routine or manual occupation and they were more likely to be in a household with an intermediate occupation. Women attending the comparison Trust were also less likely to be in the most deprived quintile, but more likely to be in the second most deprived quintile. Other baseline characteristics were not significantly different between the two groups.

Maternal and Infant outcomes

Table 3 presents the maternal outcomes for the antenatal healthy lifestyle service cohort versus the comparison cohort. Odds ratios and mean differences were adjusted for smoking at booking, highest household occupation and deprivation as these were significantly different between the two Trusts. Additionally, due to the observed differences in prevalence of gestational diabetes between the two Trusts, this was adjusted for within the analysis given the potential impact of gestational diabetes on multiple outcomes.

Table 2
Baseline demographic and lifestyle data.

Characteristic	Comparison cohort 2012–2015 (n = 365)	Antenatal healthy lifestyle service 2012–2015 (n = 332)	P value
Maternal age	28.3 (± 5.5) (n = 364)	28.5 (± 5.4)	0.632
Deprivation quintile			
Quintile 1: Most deprived - IMD score 1–6568	173 (47.4%)	170 (51.2%)	0.001 * *
Quintile 2: IMD score 6569–13137	129 (35.3%)	72 (21.7%)	
Quintile 3: IMD score 13138–19706	32 (8.8%)	46 (13.9%)	
Quintile 4: IMD score 19707–26275	24 (6.6%)	33 (9.9%)	
Quintile 5: Least deprived IMD score 26276–32844	7 (1.9%)	11 (3.3%)	
Smoking status at booking			
Smoker	92 (25.4%)	55 (16.6%)	0.005 * *
Non-smoker	270 (74.6%)	276 (83.4%)	
Parity			
0	127 (34.8%)	122 (36.8%)	0.244
1	138 (37.8%)	106 (31.9%)	
2 +	100 (27.4%)	104 (31.3%)	
Ethnicity			
White British	355 (97.5%)	314 (95.2%)	0.093
Non White British	9 (2.5%)	16 (4.8%)	
Highest household Occupation ϒ			
1. Higher managerial, administrative and professional occupations	62 (17.7%)	63 (19.2%)	0.016 *
2. Intermediate occupations	111 (31.7%)	71 (21.6%)	
3. Routine and manual occupations	94 (26.9%)	115 (35.1%)	
4. Housewife/ Long-term unemployed or never worked/ student	83 (23.7%)	79 (24.1%)	
Education			
GCSE/ equivalent or lower	114 (52.5%)	74 (44.8%)	0.193
AS/A level or equivalent	63 (29.0%)	49 (29.7%)	
Degree, postgraduate or equivalent	40 (18.4%)	42 (25.5%)	
Marital status			
Married/civil partnership	112 (30.9%)	116 (35.3%)	0.096
Partner	221 (60.9%)	175 (53.2%)	
Single ɛ	30 (8.3%)	38 (11.5%)	
Booking body mass index (in kg/m^2)	44.2 (± 3.5) Range 40.01–60.3	44.0 (± 3.7) Range 40.01–67.1	0.091†
Maternal height (in m)	1.65 (± 0.06)	1.64 (± 0.07)	0.174
Gestation at booking	9.5 (± 3.6)	9.1 (± 3.1)	0.171†
Alcohol intake at booking			
None	362 (99.5%)	327 (99.4%)	0.794Θ
1–3 units	1 (0.3%)	2 (0.6%)	
4–8 units	1 (0.3%)	0 (0.0%)	

ϒ - Occupations coded using the 3 category National Statistics Socio-economic Classification (NS-SEC) system.
ɛ - The single category included 1 woman in the comparison cohort and 5 women from the antenatal healthy lifestyle service who were divorced/ separated/ widowed
† - Mann Whitney test used as data not normally distributed when assessed using the Shapiro-Wilk test
Θ - Fisher exact test used due to small cell counts
* $p < 0.05$, * * $p < 0.01$, * **$p < 0.001$

A total of 49.7% of women attended for at least three antenatal healthy lifestyle appointments, 29.5% of women attended two appointments and 20.8% of women chose to only attend one appointment. The primary outcome of average gestational weight gain was not significantly different in women attending the antenatal healthy lifestyle service versus those in the comparison cohort before or after adjusting for baseline differences [aMD − 0.70 kg (95% CI −2.33, 0.93)]. No difference between the cohorts was noted for weight gain according to IOM recommendations. Rate of weight gain was calculated as total weight gain divided by length of time from the weighing at booking to the final weight. No differences in the crude or adjusted rate of weight gain were noted between the antenatal healthy lifestyle service and comparison cohorts. Women attending the antenatal healthy lifestyle service had higher odds of breastfeeding at discharge from hospital [aOR 1.72 (95% CI 1.18, 2.51)]. No other maternal outcomes favoured antenatal healthy lifestyle service provision. Gestational diabetes was noted to be lower in the comparison group (11.8%) than in the antenatal healthy lifestyle service group (24.1%). The proportion of women tested for gestational diabetes was 85.9% in the comparison Trust compared to 93.4% of those attending the antenatal healthy lifestyle service. Of the 30 women who were excluded from the comparison cohort for attending a dietician appointment, 15 of them had gestational diabetes. If these women had been included within the analysis, the rate of gestational diabetes would have been 15.5% in the comparison Trust. This was still significantly lower than the 24.1% of women attending the antenatal healthy lifestyle service who had gestational diabetes.

Infant outcomes for the antenatal healthy lifestyle service versus the comparison group are presented in Table 4. The adjusted odds of macrosomia were reduced in women attending the antenatal healthy lifestyle service [aOR 0.65 (95% CI 0.43, 0.99)]. Gestational age at birth was however significantly lower in the cohort receiving the antenatal healthy lifestyle service. Once adjusted for this difference in gestation at birth, as well as the baseline differences in deprivation, occupation and smoking there was no difference in the odds of macrosomia between the comparison and antenatal healthy lifestyle service cohorts [aOR 0.76 (95% CI 0.49, 1.18)]. No other infant outcomes were favourable to antenatal healthy lifestyle service provision.

There were two intrauterine fetal deaths (0.5%) in women in the comparison cohort and three (0.9%) in women referred to the antenatal healthy lifestyle service. The numbers were too small for any meaningful statistical comparison.

Discussion

Through this independent evaluation, after adjusting for baseline variations, no differences were found in the primary outcome of GWG or any other maternal or infant secondary outcomes that favoured the antenatal healthy lifestyle service except for increased breastfeeding rates at discharge from hospital.

No differences were found for the primary outcome of GWG in those who attended the antenatal healthy lifestyle service compared to the cohort from the neighbouring Trust. Although women in the comparison cohort were slightly more likely to have gained weight over the IOM recommendations (31.4%) compared to those receiving the antenatal healthy lifestyle intervention (27.2%), this was not significant. Unexpectedly poor recording of weight from 34 weeks onwards was noted within the comparison cohort, being recorded in just 25% of women, compared to 79% of women who attended the antenatal healthy lifestyle service. This lack of universal weighing near to the end of pregnancy in the comparison cohort meant that women who were weighed may have been more likely to be those who were motivated to keep track of their own gestational weight gain or who had a midwife who was more proactive about promoting appropriate gestational weight gain. This could have reduced the mean gestational weight gain within this comparison cohort and therefore impacted upon the significance.

The antenatal healthy lifestyle service had been found through

Table 3
Maternal outcomes for the antenatal healthy lifestyle service versus the comparison cohort.

Outcome	Comparison cohort 2012–2015 (n = 365)	Antenatal healthy lifestyle service 2012–2015 (n = 332)	p value	Crude mean difference or odds ratio (95%CI)	Adjusted mean difference or odds ratio (95% CI) ǂ
Number of antenatal healthy lifestyle service appointments				-	-
0	365 (100.0%)	0			
1	0	69 (20.8%)			
2	0	98 (29.5%)			
3 +	0	165 (49.7%)			
Gestational weight gain (in kg)	6.54 (± 6.05) (n = 105)	5.66 (± 7.00) (n = 276)	0.254	MD − 0.88 (−2.41, 0.64)	aMD − 0.70 (−2.33, 0.93)
Gestation of final weight (in weeks)	36.9 (± 1.2) (n = 105)	36.9 (± 1.6) (n = 276)	0.864	MD − 0.02 (−0.37, 0.31)	aMD 0.12 (−0.25, 0.50)
Rate of weight gain (in kg/week)	0.23 (± 0.21) (n = 105)	0.21 (± 0.25) (n = 276)	0.326	MD − 0.03 (−0.08, 0.03)	aMD − 0.02 (−0.08, 0.04)
GWG according to Institute of Medicine recommendations					
Too little	38 (36.2%)	124 (44.9%)	0.305	OR 1.44 (0.84, 2.48)	aOR 1.52 (0.85, 2.75)
Recommended	34 (32.4%)	77 (27.9%)		REF	REF
Excessive	33 (31.4%)	75 (27.2%)		OR 1.00 (0.57, 1.78)	aOR 1.23 (0.66, 2.31)
Vaginal birth	200/331 (60.4%)	166/319 (52.0%)	0.031 *	OR 0.71 (0.52, 0.97)*	aOR 0.75 (0.54, 1.06)
Caesarean Section	106/331 (32.0%)	136/319 (42.6%)	0.005 * *	OR 1.58 (1.15, 2.17)* *	aOR 1.46 (1.03, 2.08)*
Induction of labour (excluding women who has a CS prior to labour)	164/311 (52.7%)	156/254 (61.4%)	0.038 *	OR 1.43 (1.02, 2.00)*	aOR 1.31 (0.90, 1.90)
Postpartum haemorrhage (EBL ≥500 ml at vaginal birth, ≥1000 ml at CS birth)	43/329 (13.1%)	46/270 (17.0%)	0.174	OR 1.37 (0.87, 2.14)	aOR 1.20 (0.73, 1.96)
Perineal trauma sustained (excluding women giving birth by CS)	152/227 (67.0%)	114/177 (64.4%)	0.591	OR 0.89 (0.59, 1.35)	aOR 0.80 (0.51, 1.28)
Epidural (attempted or achieved)	135/330 (40.9%)	160/303 (52.8%)	0.003 * *	OR 1.62 (1.18, 2.21)* *	aOR 1.63 (1.16, 2.30)* * aOR 1.43 (0.91, 2.24) when adjust for differences in rate of CS
General anaesthetic	26/331 (7.9%)	18/304 (5.9%)	0.338	OR 0.74 (0.40, 1.38)	aOR 0.65 (0.33, 1.28)
Breastfeeding initiation	166/324 (51.2%)	173/310 (55.8%)	0.249	OR 1.20 (0.88, 1.64)	aOR 1.15 (0.81, 1.63)
Breastfeeding at discharge from hospital	94/315 (29.8%)	129/304 (42.4%)	0.001 * *	OR 1.73 (1.24, 2.42)* *	aOR 1.72 (1.18, 2.51)* *
Day of discharge from hospital					
* day	51 (15.3%)	32 (10.1%)		REF	REF
day 1	138 (41.6%)	136 (43.1%)	0.173	OR 1.57 (0.95, 2.59)	aOR 1.40 (0.81, 2.42)
day 2	80 (24.1%)	91 (28.8%)		OR 1.81 (1.06, 3.09)*	aOR 1.62 (0.90, 2.93)
day 3 +	63 (19.0%)	57 (18.0%)		OR 1.44 (0.82, 2.55)	aOR 1.22 (0.65, 2.29)
Haemoglobin < 110 g/l at booking	9/363 (2.5%)	4/320 (1.3%)	0.241	OR 0.50 (0.15, 1.63)	aOR 0.48 (0.13, 1.79)
Haemoglobin< 105 g/l at 28 weeks	17/338 (5.0%)	12/303 (4.0%)	0.516	OR 0.78 (0.37, 1.66)	aOR 0.52 (0.20, 1.33)
Haemoglobin< 105 g/l at 36 weeks	30/331 (9.1%)	20/224 (8.9%)	0.957	OR 0.98 (0.54, 1.78)	aOR 0.93 (0.48, 1.81)
Gestational diabetes (excluding those with gastric surgery)	38/322 (11.8%)	71/294 (24.1%)	0.000 * **	OR 2.38 (1.55, 3.66)* **	aOR 2.19 (1.40, 3.42)* *ø
Additional monitoring for raised blood pressure ϒ	83/350 (23.7%)	58/281 (20.6%)	0.357	OR 0.84 (0.57, 1.22)	aOR 0.76 (0.50, 1.15)

ǂ - Adjusted for smoking at booking (non smoker = REF), highest occupation (housewife = REF), deprivation (most deprived quintile =REF) and gestational diabetes (no gestational diabetes = REF).
ϒ - Additional monitoring for raised blood pressure - women receiving monitoring over and above routine care due to raised BP, including those who went on to be diagnosed with Pregnancy Induced hypertension, pre-eclampsia or HELLP syndrome
ø not adjusted for GDM
* $p < 0.05$, * * $p < 0.01$, * **$p < 0.001$
CI – confidence interval
CS – Caesarean section
MD – mean difference
OR – odds ratio

internal audit to keep GWG among women with obesity to within the recommended range of 5–9 kg. The service was therefore seen as a success. As a result, the service was promoted on the shared learning database by the National Institute of Health and Care Excellence (NICE) within the UK [28]. However, within this study the average weight gain of women within the comparison cohort of 6.54 kg (± 6.05) was also noted to be within the IOM recommended range and to be lower than the weight gain of 8.2 kg found in women with a BMI between 40 and 49 kg/m^2 in previous UK based literature [36]. Similarly, the proportion of women gaining in excess of IOM weight gain recommendations of 31.5% in the comparison cohort varied markedly with the current literature in this area. Previous studies have noted much higher proportions of women with a BMI ≥ 30 kg/m^2 gaining above IOM recommendations including 60% [18] to 68% [37] in cohorts of Canadian women, 55% [38] to 84.6% in cohorts from the USA [39] and 44% reported in a meta-analysis of intervention trials in women with obesity prior to or at the start of pregnancy [40]. While weight gain is known to decrease with increasing BMI, even among women with a BMI ≥ 40 kg/m^2 it has been

Table 4
Infant outcomes for antenatal healthy lifestyle service versus the comparison cohort.

Outcome	Comparison cohort 2012–2015 (n = 365)	Antenatal healthy lifestyle service 2012–2015 (n = 332)	p value	Crude MD or OR (95% CI)	Adjusted MD/ OR (95% CI) ǂ
Birthweight (in gram)	3580 (± 640) (n = 332)	3505 (± 584) (n = 319)	0.122	MD − 74 (−169, 20)	aMD − 69 (−172, 35)
Gestation at birth (in weeks)	39.8 (± 1.8) (n = 332)	39.3 (± 1.9) (n = 320)	0.000 * ** ↟	MD − 0.57 (−0.86, −0.28)* **	aMD − 0.32 (−0.63, −0.02)*
Gender of infant Male	175 (52.7%)	165 (51.6%)	0.769	OR 0.96 (0.70, 1.30)	aOR 1.01 (0.72, 1.41)
Female	157 (47.3%)	155 (48.4%)			
Low birthweight (<2500 g)	19/332 (5.7%)	12/319 (3.8%)	0.240	OR 0.64 (0.31, 1.35)	aOR 0.71 (0.32, 1.56)
Macrosomia (>4000 g)	84/332 (25.3%)	60/319 (18.8%)	0.046 *	OR 0.68 (0.47, 0.99)*	aOR 0.65 (0.43, 0.99)*
Small for gestational age (<10th GROW centile)	53/331 (16.0%)	50/319 (15.7%)	0.906	OR 0.98 (0.64, 1.49)	aOR 0.98 (0.61, 1.57)
Large for gestational age (>90th GROW centile)	25/331 (7.6%)	35/319 (11.0%)	0.132	OR 1.51 (0.88, 2.58)	aOR 1.09 (0.60, 1.98)
Preterm (<37 +0 weeks)	22/332 (6.6%)	26/320 (8.1%)	0.464	OR 1.25 (0.69, 2.25)	aOR 1.06 (0.55, 2.05)
Postdates (>41 +6 weeks)	15/332 (4.5%)	9/320 (2.8%)	0.248	OR 0.61 (0.26, 1.42)	aOR 0.86 (0.36, 2.08)
Shoulder dystocia (in women with a vaginal birth)	7/226 (3.1%)	2/180 (1.1%)	0.309 ϴ	OR 0.35 (0.07, 1.71)	aOR 0.21 (0.03, 1.79)
Apgar < 7 at 1 min	30/330 (9.1%)	37/305 (12.1%)	0.213	OR 1.38 (0.83, 2.30)	aOR 1.24 (0.71, 2.18)
Apgar < 7 at 5 min	5/330 (0.8%)	4/304 (1.3%)	1.000 ϴ	OR 0.87 (0.23, 3.26)	aOR 1.03 (0.24, 4.41)
Neonatal unit admission	17/328 (5.2%)	21/311 (6.8%)	0.402	OR 1.33 (0.69, 2.56)	aOR 1.10 (0.54, 2.22)

ǂ - Adjusted for smoking at booking (non smoker = REF), highest occupation (housewife = REF), deprivation (most deprived quintile =REF) and gestational diabetes (no gestational diabetes = REF).
↟ - Mann Whitney test used when data not normally distributed when assessed using the Shapiro-Wilk tests
ϴ - Fisher exact test used due to small cell counts
* $p < 0.05$, * * $p < 0.01$, * **$p < 0.001$
CI – confidence interval
MD – mean difference
OR – odds ratio

found that 45.8% exceeded IOM recommendations in the USA [41]. Only one previous individual participant data analysis had similarly shown women with a BMI ≥ 40 kg/m^2 to gain within IOM recommendations, with the median weight gain being 6.27 kg at 40 weeks [42]. However, it should be noted that by reporting median weight gain, the influence of those with extreme weight gains would be reduced within that study. These marked differences in the proportion of women exceeding IOM recommendations within different populations highlight the essential requirement of including a comparison group when evaluating any maternal obesity service interventions, as comparing service figures to previous literature could lead to unfounded conclusions about the impact of the service. The necessity to focus on the different classes of obesity separately is also highlighted.

After adjusting for confounding factors, the odds of breastfeeding at discharge were noted to be higher among women who attended the antenatal healthy lifestyle service than among women in the comparison Trust. This was despite the comparison hospital Trust having full UNICEF Baby Friendly Initiative Accreditation from October 2012, whereas the hospital Trust running the antenatal healthy lifestyle service did not achieve full accreditation until December 2013. In both Trusts the proportion of women initiating breastfeeding were far lower than the figures reported overall within the Trusts during this time period, being 63.2–65.9% in the antenatal healthy lifestyle service intervention Trust and 61.7–64% in the comparison Trust [43]. This reflects the well-known poorer breastfeeding outcomes for women with a raised BMI. However, given that the rate of breastfeeding at discharge was markedly lower than the 52.3% of women with a BMI ≥ 40 kg/m^2 noted to breastfeed at discharge in a previous national cohort [36]; it is also likely to reflect local demographics with higher rates of deprivation than the average for England [43].

The comparison cohort had much lower rates of gestational diabetes. Some of this difference is due to the inclusion criteria of this study that excluded women in the comparison cohort who had attended any dietician appointments and excluded women who had not attended the antenatal healthy lifestyle service. Given that women who have gestational diabetes would be more likely to access dietary support services this disproportionately excluded women with gestational diabetes from the comparison cohort. However, even if women who had attended a dietician appointment in the comparison cohort had been included the rate of gestational diabetes remained significantly lower in the comparison cohort compared to those attending the antenatal healthy lifestyle service. The difference in the proportion of women being tested for gestational diabetes, being 7.5% higher among those who attended the antenatal healthy lifestyle service may additionally explain some, but not all, of the difference in rate of gestational diabetes. Interestingly, the rate of macrosomia was lower in women attending the lifestyle service, despite the higher rates of gestational diabetes, although this was not significant once adjusting for the differences in gestational age at birth. The comparison cohort had favourable outcomes for Caesarean Section which remained after adjusting for confounding factors including the differences in gestational diabetes. The reason for this difference was unclear. It may represent a difference in policy implementation and practices within the different maternity units. However, it may also be an unintentional consequence of the antenatal healthy lifestyle service. The presence of the service may have raised awareness of the risks of maternal obesity within the Trust. Some have noted that labelling women with obesity as 'high risk' can lead to an unintended cascade of interventions [44] which may have resulted in more medicalised management of women within the Trust with the antenatal healthy lifestyle service and therefore raised the proportion of births by Caesarean.

Previous lifestyle interventions for women with overweight or obesity during pregnancy have had mixed effects. A recent overview of systematic reviews of randomised controlled trial evidence has shown that women with overweight or obesity who received an intervention had a small reduction in gestational weight gain compared to women in the control groups [23]. However, this small reduction in weight gain had no impact upon other pregnancy outcomes such as gestational diabetes, pre-eclampsia or birthweight outcomes [23]. Many of the included trials within these systematic reviews had limited numbers of women with a BMI ≥ 40 kg/m^2; however within our cohort of women exclusively with a BMI ≥ 40 kg/m^2 a similar limited impact of an antenatal healthy lifestyle service on maternal and infant outcomes

compared to the comparison cohort was seen. Several reasons for this lack of effect have been suggested including that there is limited time within pregnancy for a demonstrable effect to occur upon outcomes, that increases in physical activity are difficult to achieve during pregnancy and that women with obesity are less responsive to lifestyle changes to enhance metabolic function due to their different metabolic profile to that of women with a BMI in the normal range [45]. Traditionally pregnancy has been viewed as a time when women may be particularly receptive to public health messages, especially around healthy eating and physical activity [18]. However little research has focused on women's capability or opportunity to change behaviours during pregnancy or considered the complex interplay between the numerous health messages provided to women at this time such as diet, folic acid supplementation, smoking, exercise and alcohol consumption [46]. The idea of pregnancy in and of itself not necessarily being a 'teachable moment' is supported by women's experiences themselves [47].

There is also a lack of clarity regarding what food types can improve maternal and infant outcome. During pregnancy it is suggested that diets high in fruit, vegetables and seafood and low in red meat and fried foods reduce the risk of preterm birth, however uncertainty remains over dietary links during pregnancy and birthweight outcomes [48]. More research is required to establish the best diet to maximise maternal outcomes, especially in women with overweight or obesity.

The effective components of interventions to maximise behaviour change are also poorly understood, highlighting the need for better identification of which components and specific behaviour change techniques are most effective. Michie et al. (2013) developed a structured taxonomy of behaviour change techniques which provides a framework for a more precise reporting of complex interventions [49]. A recent review of behaviour change techniques used within gestational weight management trials has found these techniques to be poorly implemented and reported [50]. Future services need to develop dietary and physical activity interventions with clarity around which behaviour change techniques are incorporated. This will allow for interventions to be more readily reproduced, better comparisons between interventions and for the active components of successful interventions to be more reliably and robustly identified. There is also a need to think of obesity and gestational weight management at societal, not just an individual level using systems approaches due to the multifaceted contributory factors including societal, environmental, social, individual and genetical factors [51] as all of these factors influence an individual's weight management during pregnancy.

In summary, the findings from this comparative study, derived from an existing practice setting, are in line with many large randomised controlled trials [19,20,22]. This provides pragmatic evidence on the ongoing debate regarding effective solutions for this growing public health challenge. Pragmatic evaluation derived from real-life practical settings with adequate controlling for confounders may provide more pertinent evidence for such ongoing public health debates as opposed to high resource demanding study designs with limited applicability outside of the trial setting. Furthermore, robust and independent evaluation of intervention effectiveness in this time of austerity is imperative before wider implementation and resource investment.

Strengths and limitations

This is one of the few studies that independently and rigorously evaluates the impact of an antenatal healthy lifestyle service within a large number of women with a BMI $\geq$ 40 kg/m^2. However, some limitations need to be acknowledged particularly over the well-known concerns over data completeness with retrospective data collection. It was particularly evident within this study that GWG in the comparison cohort was poorly documented within the maternity notes, as was maternal education level within both Trusts. Additionally, just under half of women attended all three of the offered antenatal healthy lifestyle service appointments, which may in part explain the limited impact of the service on significantly improving clinical outcomes. It was also not possible to ensure that the intervention and comparison cohorts were identical in every way except for the antenatal healthy lifestyle service. To reduce the number of potential confounders, only women with a BMI $\geq$ 40 kg/m^2 were compared within both Trusts during the same time period, from 2012 to 2105 and adjustments were made to account for baseline differences. Selection bias was minimised by collecting data on the whole cohort within both Trusts. It was not possible within this study to quantify the relationship between the provider and the client in the antenatal healthy lifestyle service which may have an impact on intervention effectiveness. Finally, generalizability of the study is limited by the higher rate of social deprivation within the cohort than across the UK as a whole [43].

Conclusion

No significant benefits were observed of an antenatal healthy lifestyle intervention in a real-life practice setting over a comparison cohort, which is in line with evidence from existing large randomised controlled trials. There is uncertainty over the best management of GWG in populations with a BMI of 40 or more. Further research is required with a particular focus on system wide approaches not just focussing at an individual level. Additionally, more focus is required on the behaviour change techniques associated with effective GWG management interventions. Independent and rigorous evaluation of maternal obesity management services are recommended prior to widespread implementation to ensure time, resource and cost efficiency.

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Ethical statement

Ethical approval was obtained for this project through East of England - Cambridge East Research Ethics Committee (IRAS project number 207998). Research Governance approvals were also obtained from both NHS Trusts. Individuals extracting data from medical records were health professionals or others under the same duty of confidentiality as a health professional. Postcode data was converted to Index of Multiple Deprivation score and all NHS numbers were pseudo-anonymised using a MD5 hash string. This ensured women's confidentiality was protected.

Author contributions

FF – conceptualization and funding acquisition, data curation, formal analysis and interpretation of the data, Writing – original draft, Writing – approval of final manuscript. HS – conceptualization and funding acquisition, specialist input regarding methodology, supervision of data analysis and interpretation of the data, Writing – review of the manuscript, Writing – approval of final manuscript.

Conflicts of interest

None declared.

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