

1 **Limiting antenatal weight gain improves maternal health outcomes in**
2 **severely obese pregnant women: findings of a pragmatic evaluation of a**
3 **midwife-led intervention**

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17

18 **Abstract**

19 **Background:** Antenatal obesity in pregnancy is associated with complications of
20 pregnancy and poor obstetric outcomes. Although most guidance on pregnancy
21 weight is focused on the pre-pregnancy period, pregnancy is widely viewed as a
22 period where women are open to lifestyle change to optimise their health.

23 **Method:** The hospital-based Bumps and Beyond intervention invited all
24 pregnant women with a BMI of over 35 kg/m² to take part in a programme of
25 health education around diet and exercise, accompanied by one-to-one guidance
26 and monitoring of dietary change. This service evaluation compares 89 women
27 who completed at a programme of 7 sessions with healthy lifestyle midwives and
28 advisors (intervention) with a group of 89 women who chose not to attend (non-
29 intervention).

30 **Results:** Weight gain in the intervention group (4.5±4.6 kg) was less than in the
31 non-intervention group (10.3±4.4 kg) between antenatal booking and 36 weeks
32 gestation (<0.001). This was associated with a 95% reduction in the risk of
33 gestational hypertension during pregnancy and a general reduction in pregnancy
34 complications. There was no effect of the intervention upon gestational diabetes
35 or complications in labour other than post-partum haemorrhage (reduced 55%).
36 The impact of the intervention on gestational weight gain was greater in women
37 with BMI over 40 kg/m² at booking. There were no adverse effects of the
38 intervention, even though 21% of the intervention group lost weight during their
39 pregnancy.

40 **Conclusion:** Intensive, personalised weight management intervention may be an
41 effective strategy for prevention of hypertensive disorders during pregnancy.

42 **Introduction**

43 The worldwide increase in the prevalence of overweight and obesity is
44 increasingly impacting across all age-groups in the population (Ogden *et al.*,
45 2013; WHO 2013). As a result all developed countries are reporting high levels of
46 obesity among women of childbearing age and this has important consequences
47 for maternal and fetal health during pregnancy, and potentially for the longer-
48 term health of the children of obese women (Normia *et al.*, 2013; Langley-Evans
49 2014; Taylor *et al.*, 2014). In the UK 13 % of 21- to 30-year-old and 22 % of 31-
50 to 40-year-old women were estimated to be obese in 2007, and this was
51 expected to rise to 30 and 47 % respectively by 2050 (Foresight, 2007). 20% of
52 UK women aged 16-44 were obese in 2010 (National Obesity Observatory, 2014)
53 and in the USA (Ogden *et al.*, 2013) this figure was approximately 32% in the 20-
54 39 year old population. A dramatic increase in the prevalence of severe or
55 morbid obesity has occurred alongside the increasing prevalence of obesity in
56 young women and in 2009 approximately 5% of all pregnancies in England were
57 associated with maternal BMI of over 35 kg/m², with approximately 2% of
58 pregnant women having BMI in excess of 40 kg/m² (National Obesity
59 Observatory 2014). Pregnancy is recognised as a period during which women
60 are vulnerable to excessive weight gain that they may find difficult to reverse,
61 thereby increasing risk for subsequent pregnancies and their longer-term health
62 (Groth *et al.*, 2013; Von Rueslen *et al.*, 2014).

63

64 Maternal obesity during pregnancy increases the risk of adverse pregnancy
65 outcomes, including miscarriage, gestational diabetes and hypertensive
66 disorders (Sebire *et al.*, 2001; Wang *et al.*, 2002; Jensen *et al.*, 2003; Maconochie

67 *et al.*, 2007; Centre for Maternal and Child Enquiries 2010; Li *et al.*, 2013;
68 Sommer *et al.*, 2014). Obesity is recognised as a significant risk factor for
69 maternal and fetal death (Centre for Maternal and Child Enquiries 2010). The
70 risks associated with maternal overweight and excessive weight gain are
71 recognised by the US Institute of Medicine (2009), which has published guidance
72 on optimal ranges of weight gain during pregnancy. These are based upon
73 maternal weight prior to pregnancy, with obese mothers advised to gain 5-9 kg
74 across pregnancy, compared to the 12.5-16 kg recommendation for women of
75 healthy weight. The UK does not have any formal, evidence-based
76 recommendations for healthy weight gain in pregnancy, although a guidance
77 range of 10-12.5 kg is included within Department of Health literature. However,
78 National Institute of Health and Clinical Excellence (NICE) guideline of 2010
79 recommends that health professionals carefully manage maternal weight. The
80 emphasis of these guidelines is on weight loss prior to, or after pregnancy (NICE
81 2010). Weight loss is not advised during pregnancy as it may pose a risk to fetal
82 nutrition and development.

83

84 The antenatal period puts women into greater contact with health professionals
85 and is therefore an ideal time for health education. Mothers are generally open
86 and more readily motivated to make lifestyle changes that could benefit the
87 health of themselves and their baby (Ritchie *et al.*, 2010; Wilkinson & McIntyre
88 2012; Wilkinson *et al.* 2014; May *et al.*, 2014). A number of studies have
89 evaluated the impact of antenatal diet, exercise or weight management
90 programmes upon pregnancy outcomes. Thornton and colleagues (2009) found
91 that monitoring the food intake of obese women was associated with lower

92 gestational weight gain and lower prevalence of gestational hypertension.
93 Shirazian *et al.*, (2010) reported that a lifestyle modification in obese pregnant
94 women reduced weight gain, but had no effect on adverse pregnancy outcomes
95 such as pre-eclampsia. The meta-analysis of Thangaratinam *et al.*, (2012) found
96 that weight management interventions in pregnancy reduced the risk of pre-
97 eclampsia, but had no impact upon other obstetric outcomes. There are also a
98 number of ongoing studies evaluating intervention strategies, such as the LIMIT
99 trial in Australia (Dodd *et al.*, 2011) and the UK UPBEAT study (Poston *et al.*,
100 2013). LIMIT has recently reported that a researcher-led diet and physical
101 activity intervention did not achieve lower gestational weight gain, or improved
102 maternal outcomes (Dodd *et al.*, 2014). Alongside randomised controlled trials of
103 interventions, there are many clinical interventions mounted on a local level that
104 aim to reduce the impact of maternal obesity upon health in the community. In
105 this paper we report the findings of a service evaluation of one such programme.
106 The primary aims of the evaluation were to determine whether one-to-one
107 antenatal guidance from midwives and healthy lifestyle advisors resulted in
108 lower gestational weight gain and prevalence of the common complications of
109 pregnancy and labour that are associated with severe obesity.

110

111 **Methods**

112 *The Bumps and Beyond Intervention*

113 The Bumps and Beyond intervention was designed by the Healthy Lifestyle
114 Midwife lead for Lincolnshire Community Health Services in 2009-10 and
115 Lifestyle midwife lead for Lincolnshire United NHS Trust in 2008-9. Between
116 April 2012 and February 2013, all pregnant women attending first dating

117 antenatal ultrasound clinics at Lincoln Hospital (UK) with a BMI of ≥ 35 kg/m²
118 were invited to take part in the intervention, which was delivered on a one-to-
119 one basis by either a midwife or healthy lifestyle advisors at hospital antenatal
120 clinics or local community 'health shops'. The latter enabled a wider
121 geographical coverage for the intervention across the county of Lincolnshire.
122 Lincolnshire lies in the east of England and has a largely rural economy. In terms
123 of income and employment rates it is one of the most deprived regions of the
124 country (15th out of 149 local authorities). The full intervention comprised eight
125 sessions, beginning when women were around 16 weeks pregnant and
126 continuing every 2-4 weeks until week 36 of pregnancy. Women were weighed
127 at each session and encouraged to attend all of the sessions. The final session
128 (session 8) was delivered postnatally, around 6 weeks after the women had
129 given birth.

130

131 Women with BMI >35 kg/m² were first identified at their dating scan, where
132 height and weight were recorded. Identification of high BMI triggered referral to
133 a consultant-led antenatal care plan and the offer of the intervention at between
134 16 and 18 weeks gestation, via the consultant clinic. The intervention was
135 delivered by a specialist healthy lifestyle midwife and three healthy lifestyle
136 advisors, all of whom were trained and experienced in delivering behaviour
137 change for weight loss and interventions for families. Women attending the
138 intervention received a pack of information via an intervention booklet, which
139 was used as the focus for the seven antenatal sessions. This comprised an
140 introduction and overview of lifestyle changes and the benefits of avoiding
141 excessive weight gain during pregnancy along with general and pregnancy-

142 specific nutrition guidance including food safety information, the Eatwell plate
143 model (Public Health England, 2014), population-based dietary advice such as
144 reducing intakes of fat, sugar and salt and increasing consumption of fruit,
145 vegetables and fibre and guidance on food labelling, shopping cooking and eating
146 out. The main focus of the intervention was upon healthy eating due to the
147 practicalities of trying to increase exercise during pregnancy. However, one of
148 the intervention sessions focused on physical activity and included
149 recommendations to increase light activities such as walking or swimming from
150 15 minutes continuous activity 3 times per week to 30 minutes continuous 5
151 times per week. Advice was given on eating behaviour, the benefits of
152 breastfeeding for weight loss/maintenance and guidance on the maintenance of
153 healthy lifestyle changes beyond the intervention. Whilst breastfeeding was
154 suggested to aid the return to pre-pregnancy weight, this was in the last session
155 of the intervention where the main focus was on maintaining a healthier lifestyle.
156 All women who took part in the intervention kept a food diary to help identify
157 and modify individual dietary patterns or behaviours. Delivery of the
158 programme did not differ between the clinical and health shop settings.

159

160 For the purposes of this evaluation of the efficacy of the intervention, women are
161 classified as having taken part in the intervention if they attended all 7 antenatal
162 sessions. None of the data reported here considers the postnatal period and so
163 attendance at session 8 is not considered here. Women with a BMI over 35
164 kg/m² who declined the offer of the intervention comprise the non-intervention
165 group in this analysis. In total 194 women were approached to take part in the
166 study and there were 97 in the intervention group and 97 in the non-

167 intervention group. 13 women were excluded from analysis as they suffered a
168 miscarriage or stillbirth, or were carrying multiple foetuses, leaving only
169 singleton pregnancies with live births in the evaluation. This left 92 and 89
170 women in the intervention and non-intervention groups respectively. 3
171 intervention group women failed to attend all antenatal 7 sessions and were
172 excluded from the analysis. The non-intervention group comprised only women
173 who had attended none of the sessions. Whilst women in the intervention group
174 were slightly older (1.7 years) and more likely to report taking a 10
175 microgram/day supplement of vitamin D at baseline, the two groups of women
176 were otherwise similar in terms BMI at booking, socioeconomic status, ethnicity
177 (this was predominantly a white Caucasian population) and use of folate
178 supplements (Table 1).

179

180 *Data collection*

181 Information on **the most common** complications experienced in pregnancy
182 (gestational diabetes, gestational hypertension, preeclampsia, thrombosis,
183 musculo-skeletal disorders, symphysis pubis disorder, premature rupture of
184 membranes, polyhydramnios, small-for-gestational age, large-for gestational
185 age) or labour (post-partum haemorrhage, shoulder dystocia, failure to progress,
186 induction, non-vaginal delivery, manual removal of placenta), along with the
187 mode of infant feeding adopted after delivery were obtained from the medical
188 records of the women by the intervention team (AM and SF). **Many of these**
189 **outcomes are known to be influenced by maternal obesity (Mission *et al.*, 2013).**
190 Height and body weights of the women at antenatal booking (average 12 weeks

191 gestation) and at 36 weeks gestation were similarly obtained from the records of
192 their antenatal care.

193

194 *Ethical approval*

195 This paper reports the analysis of outcomes of an ongoing clinical intervention
196 using wholly anonymised data provided by the intervention lead (AM) to the
197 evaluation team (JP, SM, MAT and SLE). No ethical approval was required for this
198 service evaluation, which was registered with the clinical audit department of
199 Lincoln County Hospital NHS Trust.

200

201 *Statistical analysis*

202 Data on weight in pregnancy are expressed as mean \pm standard deviations and
203 were analysed by independent samples T-test. Weight gain over pregnancy was
204 analysed using ANOVA with adjustment for weight at booking. Odds ratios for
205 pregnancy and labour complications were determined by binary logistic
206 regression to determine the effect of the intervention with adjustment for
207 potential confounding factors (maternal age, parity, gravidae, socioeconomic
208 status, marital status, and ethnicity). The impact of the intervention on mode of
209 feeding on delivery of infants was determined as a simple unadjusted odds ratio.

210

211 **Results**

212 Women in the non-intervention and intervention groups were of similar weight
213 at the time of antenatal booking (10-13 weeks gestation) and for the whole
214 population the mean BMI was 38.9 ± 3.7 kg/m² (Table 1). Weight and BMI at 36
215 weeks gestation were not significantly different between the groups, but overall

216 weight gain was significantly lower in the intervention group (Table 2). Among
217 the women taking part in the intervention sessions, pregnancy weight gain was
218 on average 5.8 kg less than in those who did not take part. For 19 out of the 92
219 women in the intervention group there was weight loss of up to 4.05 kg (Mean
220 2.04 ± 1.25 kg range 0.2-4.05) across the pregnancy. All women in the non -
221 intervention group gained weight (range 0.20 to 25.95 kg). To assess whether
222 weight gain was similar across the full range of BMI in each group, the
223 population was stratified into quartiles based upon BMI at booking. Whilst
224 weight gain was not significantly different between the quartiles in the non-
225 intervention women, the women of higher BMI (Q3, Q4) at booking in the
226 intervention group gained significantly less weight than those in the lower
227 quartile for BMI (Figure 1).

228

229 Weight gain in pregnancy was strongly related to the risk of all maternal
230 pregnancy complications combined and hypertensive conditions, but not
231 gestational diabetes or complications in labour. Figure 2 shows the OR for these
232 complications for the total population of women, divided into quartiles based
233 upon weight gain. Weight gain over 8.25 kg was associated with significantly
234 greater risk of pregnancy complications (Q4 adjusted OR 4.29 [1.46-12.57]),
235 whilst risk of gestational hypertension increased when weight gain exceeded
236 11.10 kg (adjusted OR 7.31 [1.52-35.10]). No significant relationship between
237 booking BMI or BMI at 36 weeks was noted for any of the conditions.

238

239 Table 3 shows unadjusted and adjusted odds ratios for complications
240 experienced during pregnancy among women in the two groups. Overall,

241 maternal pregnancy complications were reduced by 76.4% among women taking
242 part in the intervention. As many of the recorded complications (musculo-
243 skeletal problems, large-for-gestational-age, SPD, PROM and reduced fetal
244 movements) were rare or absent (thrombosis, small-for-gestational age) in this
245 population, no benefits of the intervention with respect to each specific condition
246 could be demonstrated (data not shown). However, gestational hypertension
247 was reduced by 95%. A similar trend was observed for pre-eclampsia (90%
248 reduction). In keeping with the fact that the intervention group remained
249 severely obese throughout pregnancy, there was no beneficial effect of the
250 intervention upon diabetes during pregnancy. Delivery was by elective
251 caesarean for 16% of the women and among the remaining group complications
252 during labour, resulting in emergency section or instrumented delivery were
253 experienced by 48%. As shown in Table 3, the intervention did not alter the risk
254 of labour complications overall, or specifically in terms of labour induction,
255 failure to progress, emergency section or instrumented delivery. Women who
256 had completed the intervention were significantly less likely to suffer post-
257 partum haemorrhage (OR 0.451).

258

259 The intervention had no impact upon the risk of delivery of babies prior to 37
260 weeks gestation (OR 0.78 [0.18-3.38]). Mean weight at birth did not differ
261 between the two groups (non-intervention 3.61 ± 0.60 ; intervention group $3.69 \pm$
262 0.59 kg). After delivery of the babies up to discharge from hospital, 75% of
263 women in the intervention group were exclusively breastfeeding compared to
264 49.5% in the non-intervention group (OR for breastfeeding 3.068 [1.623-5.80]
265 for intervention group compared to non-intervention). There was no difference

266 in terms of length of stay in hospital for either mothers or infants (non-
267 intervention 2.18 ± 1.42 days; intervention 2.19 ± 1.52 days).

268

269 **Discussion**

270 The Lincoln antenatal weight management intervention comprised a one-to-one
271 programme involving pregnant women with specialist midwives or healthy
272 lifestyle advisors. The health professionals delivered a programme of health
273 education, dietary advice, recommendations on physical activity and monitored
274 dietary changes made by the participants. The intervention aimed to achieve
275 lower weight gain in a cohort of severely obese women at risk of excessive
276 weight gain, and the adverse sequelae associated with obesity. The current
277 analysis of the outcomes of the programme, indicates that women taking part in
278 the intervention gained significantly less weight than those who did not.
279 Although all women had a BMI of over 35 kg/m^2 at booking, the majority who
280 took part in the programme gained less weight than the US Institute of Medicine
281 (2009) guidance of 5-9kg for obese pregnant women (89.8% compared to 27.6%
282 of non-intervention women). Associated with this, there was a marked reduction
283 in the risk of pregnancy complications, specifically gestational hypertension and
284 preeclampsia. Women who had taken part in the intervention were more likely
285 to initiate breastfeeding, which was an additional benefit in this obese
286 population, where breastfeeding rates were low.

287

288 The benefits of limiting gestational weight gain in obese women are well-
289 established and the existence of guidelines such as those issued by the US
290 Institute of Medicine (2009) and the National Institute for Health and Clinical

291 Excellence (NICE) in the UK (NICE 2010) should provide the basis for routine
292 monitoring of weight gain in the at-risk population. The literature, however,
293 suggests that routine weight screening and advice to control weight gain is often
294 lacking. A study in the UK found that 16% of a group of pregnant women did not
295 have their weight taken at all during antenatal care and that although women
296 wanted advice on weight gain they did not receive this from midwives or doctors
297 (Brown & Avery, 2012). Experience is similar in the USA, where advice on weight
298 gain is not the norm, even where that weight gain is routinely monitored (Phelan
299 *et al.*, 2011; Stengel *et al.*, 2012). Obese and overweight women are often advised
300 to gain more weight than the Institute of Medicine guidance due to a lack of
301 knowledge among health practitioners (Herring *et al.*, 2010). Against a
302 background of inconsistency in the monitoring of gestational weight gain and
303 provision of advice on management of weight gain in obese women, it is
304 important to understand the effectiveness of intervention strategies that may
305 limit the obstetric risks associated with extreme overweight.

306

307 Thangaratinam *et al.*, (2012) reported the outcomes of a systematic review and
308 meta-analysis of 44 randomised controlled trials examining weight management
309 strategies in pregnancy. These strategies included interventions with a purely
310 dietary focus, a focus on physical activity, or a mixed approach including diet and
311 exercise. The meta-analysis showed that all interventions combined could limit
312 gestational weight gain and were associated with lower risk of pre-eclampsia.
313 Interventions that included only dietary change also reduced risk of gestational
314 diabetes and hypertension. No interventions were found to impact upon the
315 likelihood of labour induction or caesarean section. However, the majority of

316 studies included in the meta-analysis included women of all BMI classes and not
317 just obese or severely obese women. Among studies that focused solely on the
318 overweight and obese population the impact of intervention was often less than
319 seen with the current study. Whilst Thornton *et al.*, (2009) found similar
320 outcomes to the present study, Rae *et al.*, (2000) reported that a 30% restriction
321 of maternal energy intake had only subtle effects on glucose homeostasis in
322 pregnancy. Dietary counselling and exercise reduced the prevalence of excessive
323 weight gain in the study of Hui *et al.*, (2012) but did not impact upon gestational
324 diabetes, the prevalence of large-for-gestational age or caesarean delivery rates.
325 The LIMIT trial (Dodd *et al.*, 2011, 2014) found that a researcher-led
326 intervention based upon dietary advice and guidance on physical activity had no
327 effect upon gestational weight gain or pregnancy complications. This trial
328 recruited women of lower initial BMI ($>25 \text{ kg/m}^2$) than the present study (>35
329 kg/m^2). Guelincx *et al.*, (2010) reported that whilst education around lifestyle
330 change altered eating patterns in pregnancy, it had no effect upon gestational
331 weight gain or obstetric outcomes. The findings of the present study are
332 therefore important as they show clear benefits associated with a 'mixed
333 approach' intervention in severely obese women, consistent with the analysis of
334 Gardner *et al.*, (2011). The reduction in risk of hypertension (95%),
335 preeclampsia (90%) and of complications overall (74%) was greater than
336 reported in the Thangaratinam *et al.*, meta-analysis (pre-eclampsia reduced by
337 33%, gestational hypertension 70%).
338
339 The women taking part in the intervention gained less weight than those who
340 did not, but remained severely obese. In spite of this, their risk of pregnancy

341 complications was lower and this highlights that limiting weight gain in
342 pregnancy that is complicated by severe obesity, is a worthwhile target for
343 public health intervention. This can stand as a supplementary strategy to pre-
344 pregnancy guidance that guide women towards attaining a healthier weight.
345 There were strong relationships between weight gain and pregnancy
346 complications and hypertensive conditions, but the lack of impact of lower
347 weight gain upon diabetes or labour complications emphasises the continuing
348 obesity of the women and the effect this has on metabolic health and the
349 management of delivery.

350

351 Weight loss during pregnancy is not advised, but in approximately 21% of the
352 women in the intervention group there was either no weight gain between
353 booking and 36 weeks, or some degree of loss. There was no evidence of any
354 negative impact of this loss either on maternal outcomes, or fetal outcomes. This
355 is consistent with the meta-analysis of Thangaratinam *et al.*, (2012) who
356 reported that interventions in pregnancy were safe with no evidence of small-
357 for-gestational age or fetal death. In the current study, birthweights were not
358 significantly different between women who gained weight in pregnancy and
359 those who did not (gained weight 3.69 ± 0.56 kg, lost weight 3.38 ± 0.67 kg,
360 $P > 0.05$). Within the intervention group, there were no differences in risk of
361 pregnancy complications (OR 0.94 [0.30-2.97] or labour complications (OR 0.81
362 [0.29-2.32], between women who lost weight and those who gained weight
363 during pregnancy.

364

365 This brief paper does not report the findings of a randomised controlled trial and
366 as such the limitations of the work must be acknowledged. All women with a BMI
367 in excess of 35 kg/m² were invited to take part in the intervention but half (the
368 non-intervention group chose not to do so. This means that the intervention
369 group may have been more motivated to control their weight, representing a
370 selection bias. It is unlikely however, that these women could have achieved the
371 observed restriction of weight gain without the healthy lifestyle advice and
372 monitoring. As such, the observed effects of the intervention must therefore be
373 regarded as an effect of the intervention protocol combined with the selection
374 bias. Given the one-to-one nature of the intervention, the personalised nature of
375 the advice provided by the intervention team may have introduced some
376 variability into the experience of the women on the programme. However, this
377 study does provide an appropriate evaluation of putting weight management
378 interventions into practice, using an individualised and patient-centred
379 approach. Whilst a follow-up using a robust randomised design is now desirable,
380 there were no systematic differences in the characteristics of the women in the
381 two groups that could explain or confound the observed reduction in weight gain
382 or benefits or benefits in terms of obstetric outcome. This evaluation was not
383 designed to consider the way in which the intervention impacted upon the
384 behaviour of the participants and no data was available on eating patterns,
385 energy or nutrient intake or physical activity. Understanding the process
386 underlying the success of the intervention is essential if the scheme is to have a
387 wider application, with training for health professionals to deliver it in other
388 locations.

389

390 This study adds to the literature that supports the implementation of weight
391 maintenance interventions during pregnancy as well as in the pre-pregnancy and
392 post-partum periods. As described above, in the UK most of the guidance relating
393 to weight management and reproduction is focused on pre-pregnancy and the
394 need to attain a healthy weight in order to aid conception and to minimise
395 complications during pregnancy (NICE 2010). It is recognised that weight gain
396 during a pregnancy is a factor which determines the pre-pregnancy weight and
397 weight gain trajectory for subsequent pregnancies, and so managing weight
398 between conceptions is desirable. Walsh and colleagues (2007) showed that
399 increasing BMI by 3 kg/m² in one pregnancy, even in women of healthy weight,
400 doubled the risk of preeclampsia in a subsequent pregnancy, with that risk
401 disappearing if the excess pregnancy weight could be lost. The success of the
402 intervention in reducing gestational weight gain emphasises the fact that
403 severely obese women are open to the idea of changing their diet and behaviour
404 in order to achieve benefits for their health and the health of their babies, whilst
405 pregnant (Wilkinson *et al.* 2014). Wider use of interventions to target pregnancy
406 should be a priority for the future. To inform and optimise the development of
407 such interventions further work is required to determine which elements of the
408 intervention programme were most effective in achieving the outcomes, through
409 qualitative evaluation of the experience of the women. Gardner *et al.*, (2011)
410 reported that whilst interventions focused on dietary change and physical
411 activity can be effective in reducing gestational weight gain, too little emphasis
412 has been given to evaluation of the psychological determinants of behaviour
413 change. This makes it difficult to identify the processes by which weight change
414 can be achieved. It would also be of interest to determine what happens to

415 women in the post-partum period having completed an antenatal weight
416 management programme. The intervention described in this paper followed
417 women to 6 weeks post-partum, but as data was not available for the non-
418 intervention group it is not possible to assess whether differences seen in
419 pregnancy persisted.

420

421 The intervention has been shown to be highly effective in limiting the weight
422 gain of severely obese women during pregnancy, and was in fact most effective
423 in women whose BMI at booking was over 40 kg/m². Unfortunately the non-
424 intervention group in this study represents a large population of women, who
425 when given the advice that excessive weight gain may be detrimental to their
426 health during pregnancy and in terms of pregnancy outcome, chose not to
427 engage with the service. The reasons for non-engagement were not explored in
428 the current study but other work suggests that women decline to use antenatal
429 weight management services due to lack of motivation, not wanting to focus on
430 weight during pregnancy and a lack of time due to work commitments (Olander
431 and Atkinson, 2013; Patel *et al.*, 2013). These factors need to be considered in
432 designing intervention programmes based upon the model described in this
433 paper. Indeed, Heslehurst and colleagues (2014) suggest that the views of
434 women on antenatal weight management services should be incorporated into
435 the design of such services. Shaping the expectations of women at an early stage
436 may influence uptake of services. Where positive outcomes for mother and child
437 are given high emphasis over stressing the negative impact of not addressing
438 weight management, engagement may be stronger (Gardner *et al.*, 2012). In the

439 UPBEAT study, women who perceived the greatest benefits associated with
440 healthy eating patterns, were those most likely to reduce unhealthy eating.

441

442 The efficacy of the intervention in limiting weight gain was complemented by a
443 dramatic reduction in hypertensive disorders of pregnancy. If barriers to
444 participation can be overcome in the morbidly obese population, targeted,
445 personalised weight management intervention may therefore be a useful adjunct
446 to routine antenatal care. Greater use of this approach to obesity management in
447 pregnancy would be expected to have significant benefits for the health of
448 women and their babies.

449

450 **Acknowledgements and declaration of author interests**

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454

455 **References**

456

457 Brown, A. & Avery, A. (2012). Healthy weight management during pregnancy:
458 what advice and information is being provided. *J. Hum. Nutr. Diet.* **25**, 378-387.

459

460 Centre for Maternal and Child Enquiries (2010). *Maternal obesity in the UK:
461 Findings from a national project*. London: CMACE.

462

463 Dodd, J.M., Turnbull, D.A., McPhee, A.J., Wittert, G., Crowther, C.A. & Robinson, J.S.
464 (2011). Limiting weight gain in overweight and obese women during pregnancy
465 to improve health outcomes: the LIMIT randomised controlled trial. BMC
466 Pregnancy Childbirth. **11**, 79.

467

468 [Dodd, J.M., Turnbull, D., McPhee, A.J., Deussen, A.R., Grivell, R.M., Yelland, L.N.,
469 Crowther, C.A., Wittert, G., Owens, J.A., Robinson, J.S. \(2014\). Antenatal lifestyle
470 advice for women who are overweight or obese: LIMIT randomised trial. BMJ
471 **348**, g1285.](#)

472

473 Foresight (2007). Tackling Obesities: Future Choices – Modelling Future Trends
474 in Obesity & Their Impact on Health. London: The Stationery Office.

475

476 Gardner, B., Wardle, J., Poston, L. & Croker, H. (2011). Changing diet and physical
477 activity to reduce gestational weight gain: a meta-analysis. *Obes Rev.* **12**, e602-
478 20.

479

480 [Gardner, B., Croker, H., Barr, S., Briley, A., Poston, L. & Wardle, J. \(2012\).
481 Psychological predictors of dietary intentions in pregnancy; UPBEAT Trial. *J Hum
482 Nutr Diet.* **25**, 345-353.](#)

483

484 Guelinckx, I., Devlieger, R., Mullie, P., & Vansant, G. (2010). Effect of lifestyle
485 intervention on dietary habits, physical activity, and gestational weight gain in
486 obese pregnant women: a randomized controlled trial. *Am J Clin Nutr.* **91**, 373-
487 380.

488

489 Groth, S.W., Holland, M.L., Kitzman, H. & Meng, Y. (2013). Gestational weight gain
490 of pregnant African American adolescents affects body mass index 18 years later.
491 J Obstet Gynecol Neonatal Nurs. **42**, 541-550.

492

493 Herring, S.J., Platek, D.N., Elliott, P., Riley, L.E., Stuebe, A.M. & Oken, E. (2010).
494 Addressing obesity in pregnancy: what do obstetric providers recommend? J
495 Womens Health (Larchmt). **19**, 65-70.

496

497 Heslehurst, N., Russell, S., Brandon, H., Johnston, C., Summerbell, C., & Rankin, J.
498 (2013). Women's perspectives are required to inform the development of
499 maternal obesity services: a qualitative study of obese pregnant women's
500 experiences. Health Expect. **In press**

501

502 Hui, A., Back, L., Ludwig, S., Gardiner, P., Sevenhuysen, G., Dean, H., Sellers, E.,
503 McGavock, J., Morris, M., Bruce, S., Murray, R. & Shen, G.X. (2012). Lifestyle
504 intervention on diet and exercise reduced excessive gestational weight gain in
505 pregnant women under a randomised controlled trial. BJOG. **119**, 70-77.

506 Institute of Medicine (2009). *Weight Gain During Pregnancy: Reexamining the*
507 *Guidelines*. National Academies Press, USA.

508

509 Jensen, D.M., Damm, P., Sørensen, B., Mølsted-Pedersen, L., Westergaard, J.G.,
510 Ovesen, P. & Beck-Nielsen, H. (2003). Pregnancy outcome and prepregnancy
511 body mass index in 2459 glucose-tolerant Danish women. American Journal of
512 Obstetrics and Gynecology **189**, 239-244.

513

514 Langley-Evans, S.C. (2014). Nutrition in early life and the programming of adult
515 disease: a review. *Journal of Human Nutrition Dietetics* **In Press**

516

517 Li, N., Liu, E., Guo, J., Pan, L., Li, B., Wang, P., Liu, J., Wang, Y., Liu, G., Baccarelli,
518 A.A., Hou, L. & Hu, G. (2013). Maternal prepregnancy body mass index and
519 gestational weight gain on pregnancy outcomes. *PLoS One*. **8**, e82310.

520

521 Maconochie, N., Doyle, P., Prior, S. & Simmons, R. (2007). Risk factors for first
522 trimester miscarriage--results from a UK-population-based case-control study.
523 *BJOG*. **114**, 170-186.

524

525 May, L., Suminski, R., Berry, A., Linklater, E. & Jahnke, S. (2014). Diet and
526 pregnancy: health-care providers and patient behaviors. *J Perinat Educ*. **23**, 50-
527 56.

528

529 **Mission, J.F., Marshall, N.E. & Caughey, A.B. (2013). Obesity in pregnancy: a big
530 problem and getting bigger. *Obstet Gynecol Surv*. **68**, 389-399.**

531

532 National Institute for Health and Clinical Excellence; NICE (2010). Dietary
533 interventions and physical activity interventions for weight management before,
534 during and after pregnancy. Public Health Guidance PH27.

535 <http://publications.nice.org.uk/weight-management-before-during-and-after->

536 [pregnancy-ph27](http://publications.nice.org.uk/weight-management-before-during-and-after-pregnancy-ph27) Last accessed 16/3/2014.

537

538 National Obesity Observatory (2014). *Obesity trends in the UK*.
539 http://www.noo.org.uk/NOO_about_obesity/maternal_obesity/uk_trends Last
540 accessed January 28th 2014.

541

542 Normia, J., Laitinen, K., Isolauri, E., Poussa, T., Jaakkola, J & Ojala T. (2013).
543 Impact of intrauterine and post-natal nutritional determinants on blood
544 pressure at 4 years of age. *J. Human Nutr. Dietetics* **26**, 544-552.

545

546 Ogden, C.L., Carroll, M.D., Kit, B.K. & Flegal, K.M. (2013). Prevalence of obesity
547 among adults: United States, 2011–2012. NCHS data brief, no 131. Hyattsville,
548 MD, USA: National Center for Health Statistics.

549

550 Olander, E.K., & Atkinson, L. (2013). Obese women's reasons for not attending a
551 weight management service during pregnancy. *Acta Obstet. Gynecol. Scand.* **92**,
552 1227-1230.

553

554 Patel, C., Atkinson, L., & Olander, E.K. (2013). An exploration of obese pregnant
555 women's views of being referred by their midwife to a weight management
556 service. *Sex Reprod. Healthc.* **4**, 139-140.

557

558 Phelan, S., Phipps, M.G., Abrams, B., Darroch, F., Schaffner, A., & Wing, R.R. (2011).
559 Practitioner advice and gestational weight gain. *J Womens Health (Larchmt)*. **20**,
560 585-591.

561

562 Poston, L., Briley, A.L., Barr, S., Bell, R., Croker, H., Coxon, K., Essex, H.N., Hunt, C.,
563 Hayes, L., Howard, L.M., Khazaezadeh, N., Kinnunen, T., Nelson, S.M., Oteng-Ntim,

564 E., Robson, S.C., Sattar, N., Seed, P.T., Wardle, J., Sanders, T.A. & Sandall, J. (2013).
565 Developing a complex intervention for diet and activity behaviour change in
566 obese pregnant women (the UPBEAT trial); assessment of behavioural change
567 and process evaluation in a pilot randomised controlled trial. BMC Pregnancy
568 Childbirth. **13**, 148.

569

570 Public Health England (2014). The Eatwell Plate.
571 [https://www.gov.uk/government/uploads/system/uploads/attachment_data/fi](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/237283/Eatwell_plate_A5_postcard_052013_accessible.pdf)
572 [le/237283/Eatwell_plate_A5_postcard_052013_accessible.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/237283/Eatwell_plate_A5_postcard_052013_accessible.pdf)

573

574 Rae, A., Bond, D., Evans, S., North, F., Roberman, B. & Walters, B. (2000).
575 A randomised controlled trial of dietary energy restriction in the management of
576 obese women with gestational diabetes. Aust N Z J Obstet Gynaecol. **40**, 416-422.

577

578 Ritchie, L.D., Whaley, S.E., Spector, P., Gomez, J. & Crawford, P.B. (2010).
579 Favorable impact of nutrition education on California WIC families. J Nutr Educ
580 Behav. **42**, S2-10.

581

582 Sebire, N.J., Jolly, M., Harris, J.P., Wadsworth, J., Joffe, M., Beard, R.W., Regan, L. &
583 Robinson, S. (2001). Maternal obesity and pregnancy outcome: a study of
584 287,213 pregnancies in London. Int J Obes Relat Metab Disord. **25**, 1175-1182.

585

586 Shirazian, T., Monteith, S., Friedman, F. & Rebarber, A. (2010). Lifestyle
587 modification program decreases pregnancy weight gain in obese women. Am J
588 Perinatol. **27**, 411-414.

589

590 Sommer, C., Mørkrid, K., Jenum, A.K., Sletner, L., Mosdøl, A. & Birkeland, K.I.
591 (2014). Weight gain, total fat gain and regional fat gain during pregnancy and the
592 association with gestational diabetes: a population-based cohort study. *Int J Obes*
593 (Lond). **38**, 76-81.

594

595 Stengel, M.R., Kraschnewski, J.L., Hwang, S.W., Kjerulff, K.H. & Chuang, C.H.
596 (2012). "What my doctor didn't tell me": examining health care provider advice
597 to overweight and obese pregnant women on gestational weight gain and
598 physical activity. *Womens Health Issues* **22**, e535-540.

599

600 Taylor, P.D., Samuelsson, A.M. & Poston, L. (2014). Maternal Obesity and the
601 Developmental Programming of Hypertension: A role for leptin. *Acta Physiol*
602 (Oxf). **In Press**. doi: 10.1111/apha.12223.

603

604 Thangaratinam, S., Rogozinska, E., Jolly, K., Glinkowski, S., Roseboom, T.,
605 Tomlinson, J.W., Kunz, R., Mol, B.W., Coomarasamy, A. & Khan, K.S. (2012). Effects
606 of interventions in pregnancy on maternal weight and obstetric outcomes: meta-
607 analysis of randomised evidence. *BMJ*. **344**, e2088

608

609 Thornton, Y.S., Smarkola, C., Kopacz, S.M. & Ishaof, S.B. (2009). Perinatal
610 outcomes in nutritionally monitored obese pregnant women: a randomized
611 clinical trial. *J Natl Med Assoc*. **101**, 69-577.

612

613 von Ruesten, A., Brantsæter, A.L., Haugen, M., Meltzer, H.M., Mehlig, K., Winkvist,
614 A. & Lissner, L. (2014). Adherence of pregnant women to Nordic dietary
615 guidelines in relation to postpartum weight retention: results from the
616 Norwegian Mother and Child Cohort Study. *BMC Public Health*. **14**, 75.
617
618 Winter, E., Wang, J., Davies, M.J. & Norman, R. (2002). Early pregnancy loss
619 following assisted reproductive technology treatment. *Hum Reprod*. **17**,3220-
620 3223.
621
622 Wilkinson, S.A. & McIntyre, H.D. (2012). Evaluation of the 'healthy start to
623 pregnancy' early antenatal health promotion workshop: a randomized controlled
624 trial. *BMC Pregnancy Childbirth*. **12**,131.
625
626 Wilkinson, S.A., van der Pligt, P., Gibbons, K.S. & McIntyre, H.D. (2014). Trial for
627 Reducing Weight Retention in New Mums: a randomised controlled trial
628 evaluating a low intensity, postpartum weight management programme. *J Hum*
629 *Nutr Diet*. **In Press**. doi: 10.1111/jhn.12193.
630
631 WHO (2013). Obesity and overweight. WHO Factsheet 311. Available at
632 <http://www.who.int/mediacentre/factsheets/fs311/en/>. Last accessed 28th
633 January 2014.
634

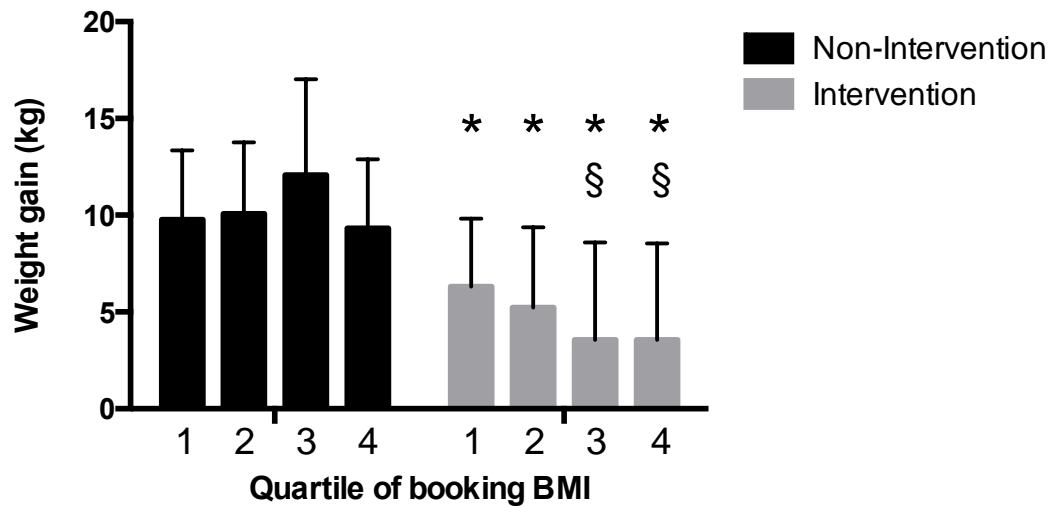
635 **Figure 1. Weight gain from booking to 36 weeks gestation, in groups**
636 **stratified by booking BMI.**
637 Data are shown as mean \pm standard deviation. * indicates significant difference
638 in weight gain comparing intervention group to non-intervention within same
639 quartile of booking BMI ($P < 0.05$). § indicates significantly different to quartile 1
640 within intervention group ($P < 0.05$). Q1 BMI 35-36.1 kg/m²; Q2 36.11-38.04
641 kg/m²; Q3 38.05-40.25 kg/m²; Q4 >40.25 kg/m².

642

643 **Figure 2. Weight gain in relation to complications in pregnancy and labour.**

644 The total population was stratified by quartiles of pregnancy weight gain. Q1
645 <3.66 kg; Q2 3.66-8.25 kg; Q3 8.25-11.1 kg; Q4 >11.1 kg. Data are shown as
646 unadjusted odds ratios. * indicates statistically significant (lowest quartile is
647 reference).

648 **Figure 1**



649

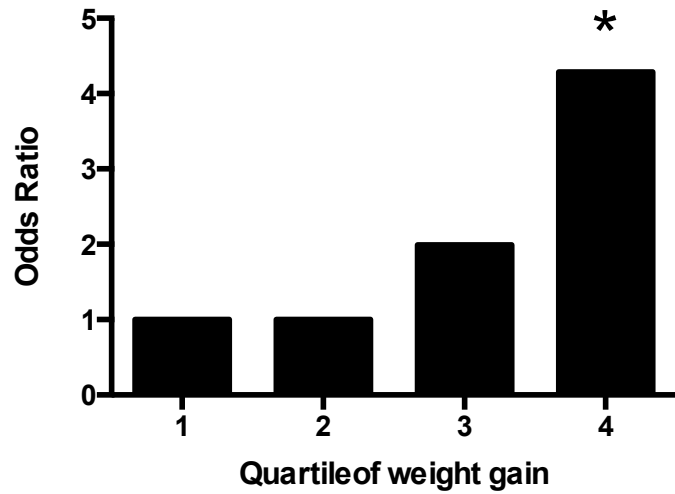
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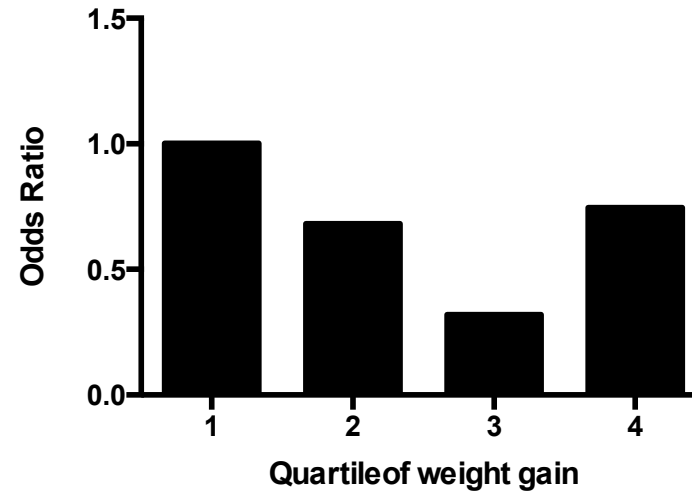
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653 **Figure 2**

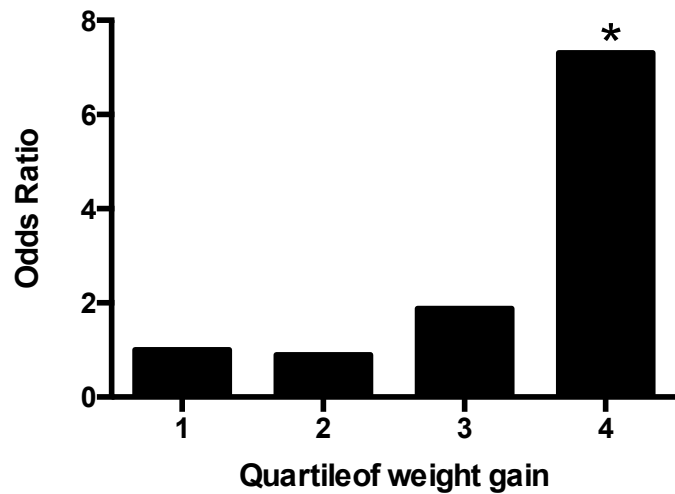
A. Pregnancy complications



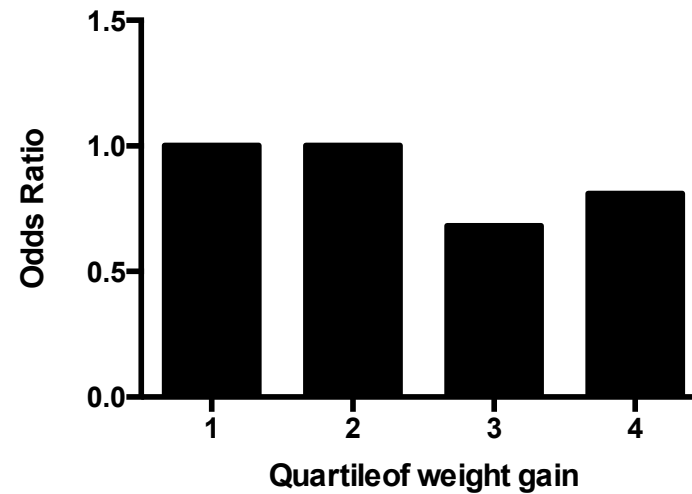
B. Labour complications



C. Hypertensive conditions



D. Gestational diabetes



655 **Table 1. Characteristics of the women**

656		Non-intervention	Intervention	<i>P</i>
657		Group (n=89)	Group (n=89)	
659				
660	Age (years)	27.3 ± 5.5	29.0 ± 5.8	0.042
661				
662	Height (m)	1.65 ± 0.08	1.65 ± 0.06	0.872
663				
664	Weight at booking	105.1 ± 11.5	107.8 ± 13.4	0.158
665	(kg)			
666				
667	BMI at booking	38.4 ± 3.2	39.4 ± 4.1	0.091
668	(kg/m ²)			
669				
670	Primigravidae	36 (40.4)	32 (34.8)	0.365
671	n (%)			
672				
673	Home owner n (%)	14 (15.7)	22 (24.7)	0.135
674				
675	White ethnicity	86 (96.6)	86 (96.6)	1.0
676	n (%)			
677				
678	Folate supplements	60 (67.4)	78 (84.7)	0.675
679	n (%)			
680				
681	Vit. D supplements	51 (57.3)	79 (88.8)	0.001
682	n (%)			
683				
684	Single mother	9 (12.0)	16 (17.4)	0.60
685	n (%)			
686				
687	Married	28 (31.5)	27 (30.3)	0.871
688	n (%)			

689 Frequency data were analysed by chi square test.

690

691 **Table 2. Weight and body mass index at 36 weeks gestation**

692

693

	Non-intervention	Intervention	<i>P</i>	
694				
695	Weight (kg)	115.6 ± 12.5	112.4 ± 13.4	0.113
696	BMI (kg/m ²)	42.1 ± 3.4	41.1 ± 4.2	0.072
697	Weight gain (kg)	10.3 ± 4.4	4.5 ± 4.6	<0.001 [§]

698

699 Data are shown as mean ± standard deviation. For n see Table 1. [§] indicates *P*
700 after adjustment for booking weight. Unadjusted *P*=0.012.

701

702 **Table 3. Impact of the intervention upon complications during pregnancy and labour**

703

704 Complications	Unadjusted OR (95% CI) ¹	Adjusted OR (95% CI) ^{1§}
705 Antenatal		
706 All complications	0.265 (0.142-0.497)	0.236 (0.121-0.461)
707 Gestational diabetes	1.139 (0.419-3.100)	1.082 (0.372-3.148)
708 Gestational hypertension	0.103 (0.034-0.307)	0.049 (0.011-0.220)
709 Pre-eclampsia	0.115 (0.014-0.940)	0.103 (0.011-0.901)
710 Musculo-skeletal disorders	1.0 (0.138-7.260)	1.183 (0.158-8.878)
711		
712 Labour		
713 All complications	1.112 (0.614-2.089)	1.115 (0.639-2.590)
714 Labour induction	1.219 (0.657-2.261)	1.018 (0.529-1.957)
715 Emergency CS	1.077 (0.519-2.209)	1.078 (0.529-2.219)
716 Instrumented delivery	1.265 (0.328-4.874)	1.598 (0.400-6.378)
717 Failure to progress	1.536 (0.418-5.641)	1.682 (0.877-25.125)
718 Post-partum haemorrhage	0.352 (0.279-1.094)	0.451 (0.211-0.963)
719		

720 ¹For all outcomes the non-intervention group is the reference group (OR=1.0). [§] adjusted for gravidae, parity, maternal age, ethnicity,

721 home ownership and marital status. NI- non-intervention; INT- intervention group.