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# BMJ Open

## Effect of introduction and withdrawal of a financial incentive on timing of attendance for antenatal care and incidence of small for gestational age: natural experimental evaluation using interrupted time series methods

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-017697
Article Type:	Research
Date Submitted by the Author:	11-May-2017
Complete List of Authors:	Adams, J; University of Cambridge, Centre for Diet and Activity Research, MRC Epidemiology Unit van der Waal, Zelda; Newcastle University Rushton, Steven; Newcastle University Rankin, Judith; Newcastle University, Institute of Health & Society
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Obstetrics and gynaecology
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, PUBLIC HEALTH, OBSTETRICS, PREVENTIVE MEDICINE, Community child health < PAEDIATRICS

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Manuscripts

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2 1 **Effect of introduction and withdrawal of a financial incentive on timing of attendance for antenatal**  
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4 2 **care and incidence of small for gestational age: natural experimental evaluation using interrupted**  
5  
6 3 **time series methods**  
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8

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33  
34 13 **Keywords:** reward, incentive, maternal, antenatal, prenatal, natural experiment  
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1  
2 **14 Abstract**

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5 **15 Objectives**

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8 To determine whether introduction or withdrawal of a government-provided incentive of £190 (\$235; €211)  
9  
10 made to UK pregnant women who attended antenatal care by the 25<sup>th</sup> week of pregnancy was associated  
11  
12 with changes in timing of first attendance for antenatal care, or incidence of small for gestational age.  
13  
14

15 **19 Design**

16  
17  
18 A natural experimental evaluation using an interrupted time series design.  
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21 **21 Setting**

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23  
24 One hospital-based maternity unit in the north of England.  
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27 **23 Participants**

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30 34,589 women (and their live-born babies) who delivered at the study hospital and were known to have  
31  
32 completed the 25<sup>th</sup> week of pregnancy in the 75 months before (January 2003–March 2009) introduction of  
33  
34 the incentives, 21 months during (April 2009–December 2010) availability of the incentives, and 36 months  
35  
36 after (January 2011–December 2013) withdrawal of the incentive.  
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38  
39

40 **28 Intervention**

41  
42  
43 The Health in Pregnancy Grant was a maternal financial incentive of £190 (\$235; €211) payable to pregnant  
44  
45 women in the UK from the 25<sup>th</sup> week of pregnancy, contingent on them receiving routine antenatal care.  
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47

48 **31 Primary and secondary outcome measures**

49  
50  
51 The primary outcome was mean gestational age at booking. Secondary outcomes were proportion of women  
52  
53 booking by 10, 18 and 25 weeks gestation; and proportion of babies that were small for gestational age.  
54  
55

56 **34 Results**

1  
2 35 By 21 months after introduction of the grant (i.e. immediately prior to withdrawal), compared to what was  
3  
4 36 predicted given prior trends, there was an reduction in mean gestational age at first antenatal care of 4·8  
5  
6 37 days (95% confidence intervals: 2·3 to 8·2). The comparable figure for 24 months after withdrawal was an  
7  
8 38 increase of 14·0 days (95%CI: 2·8 to 16·8). No changes in incidence of small for gestational age babies were  
9  
10 39 seen.

#### 13 40 *Conclusions*

16 41 Financial incentives can improve timing of first antenatal care attendance; effects do not translate into  
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18 42 changes in incidence of small for gestational age.  
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2 43 **Article summary**  
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5 44 *Strengths and limitations of this study*  
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7

- 8 45 • We used interrupted time series methods to evaluate this natural experiment; one of the strongest  
9  
10 46 quasi-experimental research designs available.  
11  
12 47 • By including substantial data before and after interventions, we took account of underlying secular  
13  
14 48 trends.  
15  
16 49 • However, interrupted time series designs are observational and we cannot categorically ascribe the  
17  
18 50 changes documented to the intervention.  
19  
20  
21 51 • Our primary outcomes was proportion of babies born small for gestational age - a substantial  
22  
23 52 improvement on previous studies that use a simple low birth weight cut-off.  
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25 53 • Differences between women included and excluded from the analyses may limit external validity, as may  
26  
27 54 our use of data from only one hospital.  
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**55 Introduction**

56 Financial incentives are increasingly used to encourage health promoting behaviours. However, few large,  
57 pragmatic, evaluations in high-income countries have been conducted.<sup>1,2</sup>

58 The Health in Pregnancy Grant (HiPG) was introduced in April 2009 as a one-off payment of £190 (\$235;  
59 €211) payable to pregnant women, normally resident in the UK, after the 25<sup>th</sup> week of pregnancy, but before  
60 delivery. Women submitted a claim form, signed by their doctor or midwife confirming their expected  
61 delivery date and that they had received usual antenatal care.<sup>3</sup> A key aim of the HiPG was to act as an  
62 "incentive to seek the recommended health advice at the appropriate time".<sup>3</sup> Following a general election in  
63 2010, the HiPG was withdrawn with women only able to claim if they reached the end of the 25<sup>th</sup> week of  
64 pregnancy before 1 January 2011.

65 England compares poorly to other European countries on perinatal outcomes.<sup>4</sup> One possible reason is poor  
66 attendance at antenatal care, which is associated with increased risk of small for gestational age (SGA),<sup>5,6</sup>  
67 and a range of adverse outcomes.<sup>7-9</sup> National guidance recommends that the first antenatal (or 'booking')  
68 visit should ideally take place by 10 weeks gestation and, at the latest, by 18 weeks.<sup>10</sup> Women living in more  
69 deprived circumstances tend to book later in pregnancy'.<sup>11</sup>

70 Health promoting financial incentives may be more effective in promoting one-off behaviours than complex  
71 behaviour change.<sup>12-15</sup> Antenatal care is a series of one-off behaviours and may be particularly responsive to  
72 incentives. However, a recent systematic review found only five trials of maternal incentives for antenatal  
73 care – three conducted in the USA and one each in Mexico and Honduras.<sup>16</sup> No effect on timing of antenatal  
74 care was found (although only one study investigated this).<sup>17</sup> No studies included birthweight or SGA as  
75 outcomes. A further observational study from the USA found no effect of an incentive on incidence of low  
76 birth weight.<sup>18</sup> One recent evaluation of the HiPG in Scotland reported no effect on birth weight, but a  
77 positive effect on the proportion of women booking by 25 weeks (other aspects of timing of attendance  
78 were not studied).<sup>19</sup>

1  
2 79 More deprived people may be more responsive to financial incentives.<sup>20 21</sup> Other personal characteristics,  
3  
4 80 such as age and previous experience of the behaviour incentivised, may also influence responsiveness.  
5  
6 81 However, differential responses to health promoting financial incentives have not been systematically  
7  
8 82 studied.<sup>1</sup>  
9

10  
11 83 The introduction and withdrawal of the HiPG provided a unique opportunity for a large-scale, pragmatic,  
12  
13 84 natural experimental evaluation of a health promoting financial incentive.<sup>22</sup> Our research questions were:  
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15 85 was the introduction or withdrawal of the HiPG associated with a change in the timing of booking, or  
16  
17 86 incidence of SGA? Did any effect of the HiPG vary according to maternal age, parity or deprivation?  
18  
19

## 20 21 87 **Methods**

22  
23  
24 88 We used an interrupted time series (ITS) design.

### 25 26 27 89 *Data and inclusion criteria*

28  
29  
30 90 We used routine data from a maternity unit in a tertiary hospital in northern England, extracted in May  
31  
32 91 2015. The study hospital is a general teaching hospital with over 1000 beds in a town with a population of  
33  
34 92 ~175,000 people. Both the town and surrounding areas are more deprived than the English average.  
35  
36  
37 93 Participants were women (and their live-born babies) who delivered at the study hospital and were known  
38  
39 94 to have completed the 25<sup>th</sup> week of pregnancy in the 75 months before (January 2003–March 2009)  
40  
41 95 introduction of the HiPG, 21 months during (April 2009–December 2010) availability of the HiPG, and 36  
42  
43 96 months after (January 2011–December 2013) withdrawal of the HiPG. The time periods included were  
44  
45 97 pragmatically arrived at based on when data was available from, and when the HiPG was introduced and  
46  
47 98 withdrawn. Our final data set of 120 monthly data points, substantially exceeds the minimum requirements  
48  
49 99 for ITS.<sup>23</sup> As calculation of when women reached the 25<sup>th</sup> week of pregnancy depended on knowing the date  
50  
51 100 of their last menstrual period (LMP), women for whom this date was missing were excluded.  
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1  
2 101 Women who had a termination or experienced a stillbirth were excluded, as were women with missing data  
3  
4 102 on any variable of interest. Women who delivered more than one live baby in any one pregnancy, or had  
5  
6 103 more than one pregnancy that resulted in a live birth during the study period, were included with each baby  
7  
8 104 counted as a separate 'case'.

9  
10  
11 105 *Outcome measures*

12  
13  
14 106 The primary outcome was mean gestational age at booking, calculated from dates of booking (recorded by  
15  
16 107 antenatal care staff) and LMP (self-reported). As national guidance recommends booking ideally before 10  
17  
18 108 weeks, and definitely before 18 weeks, and the HiPG was available to women from the 25<sup>th</sup> week, the  
19  
20 109 proportion of women booking by 10, 18 and 25 weeks gestation were secondary outcomes.<sup>10</sup>

21  
22  
23 110 The final secondary outcome was proportion of SGA babies, i.e. birth weight z-score below the 10<sup>th</sup>  
24  
25 111 percentile for sex-specific gestational age.<sup>24</sup> This was calculated using infant sex, birth weight and dates of  
26  
27 112 LMP and delivery (all except LMP recorded by antenatal care and delivery staff).

28  
29  
30  
31 113 *Other variables of interest*

32  
33  
34 114 We studied whether any effects of the HiPG on the outcomes varied according to maternal age at delivery  
35  
36 115 (in years, calculated from maternal date of birth and date of delivery and divided into three groups: <25, 25-  
37  
38 116 34, or 35+ years), parity (self-reported and considered as 0 or 1+ in analyses) and socio-economic position.  
39  
40 117 Socio-economic position was measured using the Index of Multiple Deprivation (IMD) 2007 rank assigned to  
41  
42 118 maternal address at delivery.<sup>25</sup> IMD ranks were divided into thirds for analysis based on the distribution  
43  
44 119 across England.

45  
46  
47 120 *Data preparation*

48  
49  
50 121 Data cleaning aimed to exclude data that were implausible. Date of LMP was recorded as month and year  
51  
52 122 only in around 20% of cases. To include these cases, day of month was set to the 1<sup>st</sup>. Gestational age at first  
53  
54 123 antenatal care of less than 28 days (4 weeks) or more than 308 days (44 weeks), gestational age at delivery

1  
2 124 of less than 24 weeks and more than 44 weeks, or birth weight z-scores of less than -3 or more than 3 were  
3  
4 125 recoded as missing.

#### 7 126 *Data analyses*

10 127 An uncontrolled, multiple time points, ITS design was used. The unit of analysis was the month in which  
11  
12 128 women entered the 25<sup>th</sup> week of pregnancy. ITS models estimate the change in 'level' and 'trend' of the  
13  
14 129 outcome of interest associated with the intervention. The change in level is the difference in intercepts  
15  
16 130 between regression lines estimated from observations before and after the intervention. The change in  
17  
18 131 trend is the difference in slopes. In the case of two 'interventions' (e.g. introduction and withdrawal of the  
19  
20 132 HiPG), two changes in level and trend are estimated.

23 133 General linear models were used allowing for autoregressive and moving average correlation structures as  
24  
25 134 appropriate. These allow any effect of seasonality to be taken into account. Firstly, associations between  
26  
27 135 introduction and withdrawal of the HiPG and the outcomes of interest were assessed in the whole cohort,  
28  
29 136 using separate models for each outcome. Final models were used to calculate estimated absolute and  
30  
31 137 relative effects on each outcome of the introduction of the HiPG at 21 months post-implementation  
32  
33 138 (immediately prior to withdrawal), and 24 months after withdrawal, with 95% confidence intervals.<sup>26</sup>  
34  
35 139 Interaction terms were then used to determine whether the effects of the introduction or withdrawal of the  
36  
37 140 HiPG varied by maternal age group, parity or IMD tertile.

41 141 Data preparation was conducted in StataSE v14; data analysis in R v3.3.1 and RStudio v0.99.903.

## 44 142 **Results**

### 47 143 *Sample description*

50 144 Of 39,571 women who delivered at the study hospital and were known to have reached the 25<sup>th</sup> week of  
51  
52 145 gestation between 1<sup>st</sup> January 2003 and 31<sup>st</sup> December 2013, full data were available for 34,589 (87.4%).  
53  
54 146 Characteristics of those for whom full data was and was not available during each study stage are described

1  
2 147 in Table 1. Most exclusions were due to missing information on birth weight. Typically, women included in  
3  
4 148 the analyses were aged 25-34 years, of parity 1 or more, lived in the most deprived third of areas in England,  
5  
6 149 and booked by 10 weeks gestation. Women excluded from the analyses tended to be younger, live in more  
7  
8 150 deprived areas, and booked later in their pregnancies than women included. Similar differences between  
9  
10 151 women included and excluded from the analyses were seen in each of the three study periods.

### 12 13 152 *Sample-wide effects of the intervention*

14  
15  
16 153 Final models for each outcome are summarised in Table 2 and plotted in Figure 1. Introduction of the HiPG  
17  
18 154 was associated with an immediate increase in mean gestational age at booking, and a decrease in the  
19  
20 155 proportion booking by 18 and 25 weeks. That is, the immediate effect was for these outcomes to get  
21  
22 156 clinically 'worse'. However, introduction of the HiPG was also associated with an improvement in the trend  
23  
24 157 in mean gestational age at booking and proportion booking by 10, 18 and 25 weeks. That is, the longer term  
25  
26 158 effect was a change in trend of these outcomes towards greater clinical improvement over time.

27  
28  
29  
30 159 Withdrawal of the HiPG was not associated with any level changes in outcomes. However, it was associated  
31  
32 160 with a change in trend in mean gestational age at booking and proportion booking by 18 and 25 weeks  
33  
34 161 towards less clinical improvement over time. The introduction or withdrawal of the HiPG was not associated  
35  
36 162 with any changes in the level or trend in the proportion of babies who were SGA.

37  
38  
39 163 Table 3 shows the absolute and relative impact of the introduction and withdrawal of the HiPG on each  
40  
41 164 outcome at 21 months post introduction and 24 months post withdrawal. By 21 months after introduction of  
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43 165 the HiPG, compared to the counterfactual of what was predicted given trends prior to the introduction of  
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45 166 the HiPG, there was a reduction in mean gestational age at booking of 4.8 days (95% confidence intervals:  
46  
47 167 2.3 to 8.2), an increase in the proportion of women booking by 18 weeks of 2.2% (95%CI: 1.2 to 3.9), and an  
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49 168 increase in the proportion of women booking by 25 weeks of 1.9% (95%CI: 0.6 to 3.5). Compared to the  
50  
51 169 counterfactual of what was predicted to occur given trends when the HiPG was available, by 24 months after  
52  
53 170 withdrawal, there was an increase in mean gestational age at booking of 14.0 days (95% CI: 2.8 to 16.8), a

1  
2 171 decrease in the proportion of women booking by 18 weeks of 7.6% (95% CI: 2.2 to 7.9), and a decrease in the  
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4 172 proportion of women booking by 25 weeks of 8.3% (95% CI: 3.1 to 8.6).  
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7 173 *Differential effects of the intervention across population sub-groups*  
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10 174 Models including interaction terms for maternal age, parity and IMD tertile are summarised in Tables 4-6.

11  
12 175 There were no interactions with parity. The effect of introduction and withdrawal of the HiPG on trend in  
13  
14 176 mean gestational age at booking varied by age group (Figure 2), with greater effects in older women.

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16  
17 177 The effect of introduction of the HiPG on mean gestational age at booking and proportion booking by 18 and  
18  
19 178 25 weeks varied by IMD group (Figure 3). The introduction of the HiPG was associated with a progressively  
20  
21 179 larger level change (towards older gestational age at booking, and lower proportion booking by 18 or 25  
22  
23 180 weeks) as deprivation decreased.  
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27 181 **Discussion**  
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30 182 *Statement of principal findings*  
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33 183 This is the first evaluation of the HiPG in England, the first evaluation of a financial incentive for attendance  
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35 184 at antenatal care on incidence of SGA, and one of the largest pragmatic evaluations of a health promoting  
36  
37 185 financial incentive in a high-income country. Introduction of the HiPG was associated with immediate  
38  
39 186 deteriorations in timing of booking, but longer term improvements over time. By 21 months after  
40  
41 187 introduction of the HiPG (immediately prior to its withdrawal), mean gestational age at booking had  
42  
43 188 decreased by 4.8 days compared to what would have been expected had it not been introduced. Withdrawal  
44  
45 189 of the HiPG was not associated with any immediate changes in timing of booking, but it was associated with  
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47 190 longer-term deteriorations in timing of booking over time. By 24 months after withdrawal, mean gestational  
48  
49 191 age at booking had increased by 14.0 days compared to what would have been expected had it not been  
50  
51 192 withdrawn. No effects of the HiPG on the incidence of SGA were found. The effect of the HiPG did not vary  
52  
53 193 by parity. The positive effects of the introduction of the HiPG on trends in gestational age at booking were  
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2 194 greater in older women. The immediate negative effect of the introduction of the HiPG on timing of booking  
3  
4 195 was more pronounced in less deprived groups.  
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6  
7 196 *Strengths and weaknesses of methods*  
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9  
10 197 The ITS approach is one of the strongest quasi-experimental research designs.<sup>23 27</sup> By including substantial  
11  
12 198 data before and after interventions, we took account of underlying secular trends. By studying outcomes at  
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14 199 the population-, rather than individual-, level confounding by individual-level variables was avoided. Our  
15  
16 200 large data set with 120 monthly data points, substantially exceeds the minimum requirements for ITS.<sup>23</sup> By  
17  
18 201 including auto-regressive and moving-average functions, any biases introduced by the serial nature of the  
19  
20 202 data (including seasonality) were accounted for. However, ITS designs are observational and we cannot  
21  
22 203 categorically ascribe the changes documented to the HiPG. Whilst we are not aware of any co-interventions  
23  
24 204 likely to have influenced the outcomes concurrent with the HiPG, it is difficult to absolutely exclude these.  
25  
26 205 A major strength of our study is the use of SGA. Unlike a simple cut-off for low birth weight, SGA allows sex  
27  
28 206 and gestational age differences in birth weight to be taken into account.  
29

30  
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32  
33 207 The data we used is likely to contain recording, reporting and transcription errors. Some of these may have  
34  
35 208 introduced bias. 'Feasibility' limits were used for some variables and may have led to misclassification.  
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37  
38 209 Cases included in the analytical cohort differed from those excluded. However, as differences between  
39  
40 210 women included and excluded from the analyses were similar in all three study periods, this is unlikely to  
41  
42 211 introduce bias and so we did impute missing data. Differences between women included and excluded from  
43  
44 212 the analyses may limit external validity, as may our use of data from only one hospital.  
45

46  
47 213 *Interpretation of findings*  
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49  
50 214 Our finding that the introduction of the HiPG was associated with an immediate deterioration in timing of  
51  
52 215 booking is not immediately explainable. It may reflect an implementation phase, where the process for  
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54 216 obtaining the HiPG was not yet fully understood. Whilst we could have conducted further analyses excluding  
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1  
2 217 an implementation period (e.g. four months after introduction of the HiPG), this would have been *post-hoc*  
3  
4 218 justified.

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6  
7 219 The longer-term associations of the introduction of the HiPG on markers of timing at booking are in line with  
8  
9 220 the intention of the intervention – that women should attend for antenatal care earlier in their pregnancies.  
10  
11 221 One previous study found no effect on timing of first attendance of providing a voucher for a taxi journey to  
12  
13 222 the antenatal clinic,<sup>17</sup> whilst a further evaluation of the HiPG found it was associated with a positive effect on  
14  
15 223 the proportion of women booking by 25 weeks that disappeared after withdrawal.<sup>19</sup> The substantial  
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17 224 difference in incentive value of the HiPG, compared to previous incentives, may explain these differences.

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20  
21 225 The finding that withdrawal of the HiPG was associated with deterioration of the benefits of its introduction  
22  
23 226 on timing of booking is also not unexpected. On the whole, different women would have been pregnant  
24  
25 227 when the HiPG was and was not available, meaning sustained effects would be highly unlikely.

26  
27  
28 228 Changes in timing of attendance for antenatal care associated with the introduction and withdrawal of the  
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30 229 HiPG did not translate into differences in the proportion of SGA babies. This may be because the effect size  
31  
32 230 (of 4.8 days at 21 months) was too small to impact on SGA. Two previous studies that examined the effect of  
33  
34 231 incentives for antenatal care on incidence of low birth weight (rather than SGA) also reported no effect.<sup>18 19</sup>

35  
36  
37 232 Although the HiPG was only available from the 25<sup>th</sup> week of pregnancy, we found that its introduction was  
38  
39 233 associated with changes in the proportion of women booking by both 10 and 18 weeks. This indicates that  
40  
41 234 the impact of health promoting financial incentives may not be as specific as previously thought.<sup>28</sup> The HiPG  
42  
43 235 may have been associated with a larger effect on timing of booking if it had been contingent on booking  
44  
45 236 earlier in pregnancy.

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48  
49 237 We did not find any evidence that the associations of the introduction or withdrawal of the HiPG with the  
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51 238 outcomes studied varied by parity. This suggests that prior experience of antenatal care did not diminish the  
52  
53 239 impact of the HiPG. However, the association of the introduction of the HiPG with improvements in  
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55 240 gestational age at booking over time were greater in older women. This suggests that age may be a

1  
2 241 determinant of responsiveness to financial incentives in this context. Our data are consistent with the  
3  
4 242 suggestion that those with fewer resources are particularly responsive to incentives.<sup>29</sup> Whilst introduction of  
5  
6 243 the HiPG was associated with an immediate negative change in timing of first antenatal care, this was least  
7  
8 244 pronounced in women living in the most deprived areas.

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11 245 *Implications of findings for policy, practice and research*

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14 246 It is possible that larger incentives, contingent on attendance earlier than 25 weeks, may have greater  
15  
16 247 impacts on timing of antenatal care and clinical outcomes than seen here. Future research could explore  
17  
18 248 how effects on antenatal care attendance vary with incentive value and timing.

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20  
21 249 As we used routine data in a retrospective analysis conducted more than two years after withdrawal of the  
22  
23 250 HiPG, we were unable to explore how women and other stakeholders responded to the HiPG. In particular,  
24  
25 251 we do not know what women spent the HiPG on, how doctors and midwives discussed it with women, or  
26  
27 252 how appropriate stakeholders thought it was. These factors may have influenced effectiveness and  
28  
29 253 variations in effectiveness between sub-groups.<sup>30</sup>

30  
31  
32  
33 254 **Conclusions**

34  
35  
36 255 The introduction of the HiPG was associated with an improvement in timing of first attendance for antenatal  
37  
38 256 care of almost five days by 21 months post-implementation. Withdrawal of the grant diminished this trend  
39  
40 257 towards greater improvement over time. Neither the introduction nor withdrawal of the HiPG was  
41  
42 258 associated with a change in proportion of babies who were SGA. Effects did not vary by parity. Introduction  
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44 259 of the HiPG was associated with greater long-term benefits on timing at booking in older women. Those  
45  
46 260 living in more deprived circumstances showing the most positive initial response.

**261 Funding**

262 This work is produced under the terms of a Career Development Fellowship research training fellowship  
263 issued by the National Institute of Health Research [grant number CDF-2011-04-001] to JA. The views  
264 expressed are those of the authors and not necessarily those of the NHS, The National Institute for Health  
265 Research or the Department of Health. JA is supported by the Centre for Diet and Activity Research (CEDAR),  
266 a UKCRC Public Health Research Centre of Excellence. Funding from the British Heart Foundation, Cancer  
267 Research UK, Economic and Social Research Council, Medical Research Council, the National Institute for  
268 Health Research, and the Wellcome Trust, under the auspices of the UK Clinical Research Collaboration, is  
269 gratefully acknowledged [grant number MR/K023187/1].

**270 Role of the funding sources**

271 The funders played no role in any aspect of study design, data analysis, writing or the decision to submit. All  
272 authors had full access to all the data and had final responsibility for the decision to submit. No authors were  
273 paid by a pharmaceutical company or other agency to write this article. All authors are independent from  
274 the funders.

**275 Competing interests**

276 All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and  
277 declare: JA had financial support from the National Institute for Health Research and the Centre for Diet and  
278 Activity Research (as described under 'funding') for the submitted work; no financial relationships with any  
279 organisations that might have an interest in the submitted work in the previous three years; no other  
280 relationships or activities that could appear to have influenced the submitted work.

**281 Contributions**

282 JA conducted the literature searches, obtained the data, conducted the data analysis and led writing. ZvdW,  
283 SR, and JR contributed to study design, development of the analysis plan, interpretation of the data and  
284 critically reviewed previous versions of the final manuscript. JA will act as guarantor.



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285 **Research ethics**

286 Ethics approval was granted by the East of England Norfolk NHS Research Ethics Committee (12/EE/0386).

287 The routine hospital data used in this study was anonymised before transfer to the research team and the  
288 ethics committee determined that explicit patient consent was not required.

289 **Data Sharing**

290 No additional data available.

For peer review only

291 **References**

- 292 1. Giles E, Robalino S, McColl E, et al. Systematic review, meta-analysis and meta-regression of the  
293 effectiveness of financial incentives for encouraging healthy behaviours. *PLoS ONE* 2014;9 doi:  
294 10.1371/journal.pone.0090347
- 295 2. Mantzari E, Vogt F, Shemilt I, et al. Personal financial incentives for changing habitual health-related  
296 behaviors: A systematic review and meta-analysis. *Prev Med* 2015;75:75-85. doi:  
297 10.1016/j.ypmed.2015.03.001 [published Online First: 2015/04/07]
- 298 3. HM Revenue & Customs, The Royal College of Midwives. Health in Pregnancy Grant: Frequently Asked  
299 Questions 2009 [Available from:  
300 [http://www.direct.gov.uk/en/groups/dg\\_digitalassets/@dg/@en/documents/digitalasset/dg\\_17340](http://www.direct.gov.uk/en/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_17340)  
301 [1.pdf](#) accessed 25 March 2010.
- 302 4. EURO-PERISTAT project, SCPE, EUROCAT, et al. European Perinatal Health Report. Paris, 2008.
- 303 5. VanderWeele TJ, Lantos JD, Siddique J, et al. A comparison of four prenatal care indices in birth outcome  
304 models: Comparable results for predicting small-for-gestational-age outcome but different results  
305 for preterm birth or infant mortality. *J Clin Epidemiol* 2009;62(4):438-45.
- 306 6. Heaman M, Newburn-Cook C, Green C, et al. Inadequate prenatal care and its association with adverse  
307 pregnancy outcomes: A comparison of indices. *BMC Pregnancy and Childbirth* 2008;8(1):15.
- 308 7. Lin C, Chen C, Chen P, et al. Risks and causes of mortality among low-birthweight infants in childhood and  
309 adolescence. *Paediatr Perinat Epidemiol* 2007;21(5):465-72.
- 310 8. Mikkola K, Ritari N, Tommiska V, et al. Neurodevelopmental outcome at 5 years of age of a national cohort  
311 of extremely low birth weight infants who were born in 1996-1997. *Pediatrics* 2005;116(6):1391-400.  
312 doi: 10.1542/peds.2005-0171 [published Online First: 2005/12/03]
- 313 9. Tommiska V, Heinonen K, Ikonen S, et al. A national short-term follow-up study of extremely low birth  
314 weight infants born in Finland in 1996-1997. *Pediatrics* 2001;107(1):E2. [published Online First:  
315 2001/01/03]
- 316 10. National Collaborating Centre for Women's and Children's Health. Antenatal care: Routine care for the  
317 healthy pregnant woman. London: National Institute for Health and Clinical Excellence, 2008.
- 318 11. Rowe RE, Garcia J. Social class, ethnicity and attendance for antenatal care in the United Kingdom: a  
319 systematic review. *J Public Health* 2003;25(2):113-19. doi: 10.1093/pubmed/fgd025
- 320 12. Sutherland K, Christianson JB, Leatherman S. Impact of Targeted Financial Incentives on Personal Health  
321 Behavior: A Review of the Literature. *Med Care Res Rev* 2008;65(6\_suppl):36S-78. doi:  
322 10.1177/1077558708324235
- 323 13. Marteau T, Ashcroft R, Oliver A. Using financial incentives to achieve healthy behaviour. *BMJ* 2009;338  
324 doi: 10.1136/bmj.b1415
- 325 14. Jochelson K. Paying the Patient: improving health using financial incentives. London: King's Fund, 2007.
- 326 15. Forde I, Zeuner D. Financial incentives to promote social mobility. *BMJ* 2009;339:b3219. doi:  
327 10.1136/bmj.b3219

- 1  
2 328 16. Till SR, Everetts D, Haas DM. Incentives for increasing prenatal care use by women in order to improve  
3 329 maternal and neonatal outcomes. *Cochrane Database Syst Rev* 2015(12) doi:  
4 330 10.1002/14651858.CD009916.pub2  
5  
6 331 17. Melnikow J, Paliescheskey M, Stewart G. Effect of a transportation incentive on compliance with the first  
7 332 prenatal appointment: a randomized trial. *Obstet Gynecol* 1997;89:1023-7.  
8  
9 333 18. Rosenthal M, Li Z, Robertson A, et al. Impact of financial incentive for prenatal care on birth outcomes  
10 334 and spending. *HSR: Health Services Research* 2009;44:1465-79.  
11  
12 335 19. Leyland A, Ouedraogo S, Gray R, et al. Evaluating health in pregnancy grants in Scotland: a natural  
13 336 experiment. *J Epidemiol Community Health* 2016;70(S1):A47-8.  
14  
15 337 20. Lorenc T, Petticrew M, Welch V, et al. What types of interventions generate inequalities? Evidence from  
16 338 systematic reviews. *J Epidemiol Community Health* 2012;67(2):190-3. doi: 10.1136/jech-2012-201257  
17  
18 339 21. White M, Adams J, Heywood P. How and why do interventions that increase health overall widen  
19 340 inequalities within populations? In: Babones S, ed. *Social inequality and public health*. Bristol: Policy  
20 341 Press 2009:65-82.  
21  
22 342 22. Craig P, Cooper C, Gunnell D, et al. Using natural experiments to evaluate population health  
23 343 interventions: guidance for producers and users of evidence: Medical Research Council, 2011.  
24  
25 344 23. Jandoc R, Burden AM, Mamdani M, et al. Interrupted time series analysis in drug utilization research is  
26 345 increasing: systematic review and recommendations. *J Clin Epidemiol* 2015;68(8):950-6. doi:  
27 346 10.1016/j.jclinepi.2014.12.018 [published Online First: 2015/04/22]  
28  
29 347 24. Bonellie S, Chalmers J, Gray R, et al. Centile charts for birthweight for gestational age for Scottish  
30 348 singleton births. *BMC Pregnancy & Childbirth* 2008;8:5. doi: 10.1186/1471-2393-8-5 [published  
31 349 Online First: 2008/02/27]  
32  
33 350 25. Department of Communities and Local Government. The English Indices of Deprivation 2010 2011  
34 351 [Available from: <http://www.communities.gov.uk/publications/corporate/statistics/indices201015>  
35 352 October 2012.  
36  
37 353 26. Zhang F, Wagner AK, Soumerai SB, et al. Methods for estimating confidence intervals in interrupted time  
38 354 series analyses of health interventions. *J Clin Epidemiol* 2009;62(2):10.1016/j.jclinepi.2008.08.007.  
39 355 doi: 10.1016/j.jclinepi.2008.08.007  
40  
41 356 27. Penfold RB, Zhang F. Use of interrupted time series analysis in evaluating health care quality  
42 357 improvements. *Academic Pediatrics* 2013;13(6 Suppl):S38-44. doi: 10.1016/j.acap.2013.08.002  
43 358 [published Online First: 2013/12/07]  
44  
45 359 28. Adams J, Giles E, McColl E, et al. Carrots, sticks, and health behaviours: a framework for documenting the  
46 360 complexity of financial incentive interventions to change health behaviours. *Health Psychology*  
47 361 *Review* 2014;8(3):286-95.  
48  
49 362 29. Giles E, Robalino S, Sniehotta F, et al. Acceptability of financial incentives for encouraging uptake of  
50 363 healthy behaviours: A critical review using systematic methods. *Prev Med* 2015;73 doi:  
51 364 10.1016/j.yjmed.2014.12.029  
52  
53 365 30. Giles EL, Adams JM. Capturing public opinion on public health topics: a comparison of experiences from a  
54 366 systematic review, focus group study, and analysis of online, user-generated content. *Frontiers in*  
55 367 *Public Health* 2015;3 doi: 10.3389/fpubh.2015.00200  
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## Evaluation of the "Health in Pregnancy Grant"

369 **Table 1. Characteristics of those included and excluded from the analytical cohort**

Variable	Level	Before HiPG availability (January 2003 – March 2009)		During HiPG availability (April 2009 – December 2010)		After HiPG availability (January 2011 – December 2013)		Full study period (January 2003 – December 2013)	
		Included <sup>1</sup>	Excluded <sup>2</sup>	Included <sup>1</sup>	Excluded <sup>2</sup>	Included <sup>1</sup>	Excluded <sup>2</sup>	Included <sup>1</sup>	Excluded <sup>2</sup>
N(%)		18 744	2816	6126	862	9719	1304	34 589	4982
Maternal age, n(%)	<25 years	6359 (33.9)	1327 (47.1)	2039 (33.3)	374 (43.4)	2836 (29.2)	523 (40.1)	11 234 (32.5)	2224 (44.6)
	25-34 years	9684 (51.7)	1208 (42.9)	3272 (53.4)	405 (47.0)	5577 (57.4)	651 (49.9)	18 533 (53.6)	2264 (45.4)
	35 years +	2701 (14.4)	281 (10.0)	815 (13.3)	83 (9.6)	1306 (13.4)	130 (10.0)	4822 (13.9)	494 (9.9)
	Data not available, n(%)	0	0 <sup>3</sup>	0	0 <sup>3</sup>	0	0 <sup>3</sup>	0	0 <sup>3</sup>
Parity, n(%)	0	8077 (43.1)	1288 (45.7)	2670 (43.6)	378 (43.9)	3944 (40.6)	585 (44.9)	14 691 (42.5)	2251 (45.2)
	1+	10 667 (56.9)	1528 (54.3)	3456 (56.4)	484 (56.2)	5775 (59.4)	719 (55.1)	19 898 (57.5)	2731 (54.8)
	Data not available, n(%)	0	0 <sup>3</sup>	0	0	0	0 <sup>3</sup>	0	0 <sup>3</sup>
Index of multiple deprivation group, n(%)	Most deprived	10 820 (57.7)	1777 (63.1)	3566 (58.2)	547 (63.5)	5821 (59.9)	794 (60.9)	20 207 (58.4)	3118 (62.6)
	Moderately deprived	4213 (22.5)	490 (17.4)	1330 (21.7)	160 (18.6)	2230 (22.9)	220 (16.9)	7773 (22.5)	870 (17.5)
	Least deprived	3711 (19.8)	361 (12.8)	1230 (20.1)	92 (10.7)	1668 (17.2)	128 (9.8)	6609 (19.1)	581 (11.7)
	Data not available, n(%)	0	188 (6.7) <sup>3</sup>	0	63 (7.3) <sup>3</sup>	0	162 (12.4) <sup>3</sup>	0	413 (8.3) <sup>3</sup>
Study outcomes	Mean (SD) gestational age at booking, days	76.7 (35.8)	106.2 (45.5) <sup>4</sup>	77.8 (41.3)	99.3 (39.8) <sup>4</sup>	71.8 (31.8)	95.0 (39.1) <sup>4</sup>	75.6 (35.8)	102.0 (43.2) <sup>4</sup>
	Booked by 10 weeks, n(%)	10 261 (54.7)	442 (17.0) <sup>4</sup>	3540 (57.8)	152 (18.8) <sup>4</sup>	6127 (63.0)	283 (23.9) <sup>4</sup>	19 928 (57.6)	877 (19.1) <sup>4</sup>
	Booked by 18 weeks, n(%)	17 579 (93.8)	2012 (77.7) <sup>4</sup>	5675 (92.6)	676 (83.7) <sup>4</sup>	9307 (95.8)	1022 (86.3) <sup>4</sup>	32 561 (94.1)	3719 (81.0) <sup>4</sup>
	Booked by 25 weeks, n(%)	18 098 (96.6)	2397 (92.1) <sup>4</sup>	5846 (95.4)	766 (94.8)	9477 (97.5)	1129 (95.4) <sup>4</sup>	33 421 (96.6)	4292 (93.4) <sup>4</sup>
	Small for gestational age, n(%)	2346 (12.5)	17 (8.3)	743 (12.1)	7 (11.5)	1163 (12.0)	25 (14.9)	4252 (12.3)	49 (11.3)
	Data not available on time at booking, n(%)	0	214 (7.6)	0	54 (6.3)	0	120 (9.2)	0	388 (7.8)
	Data not available on birth weight, n(%)	0	2611 (92.7)	0	801 (92.9)	0	1136 (87.1)	0	4548 (91.3)

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370 <sup>1</sup>Women who delivered at the study hospital, were known to have reached the 25<sup>th</sup> week of gestation between 1<sup>st</sup> January 2003 and 31<sup>st</sup> December 2013 and  
371 had available data on all variables of interest; <sup>2</sup>Women who delivered at the study hospital, were known to have reached the 25<sup>th</sup> week of gestation between 1<sup>st</sup>  
372 January 2003 and 31<sup>st</sup> December 2013 and did not have available data on all variables of interest; <sup>3</sup>chi-squared test indicates difference in distribution of levels  
373 between included and excluded at a level of p<0.01; <sup>4</sup>t-test indicates difference in means between included and excluded at a level of p<0.01

374 HiPG: Health in Pregnancy Grant

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375 **Table 2. Summary of interrupted time series models of the effect of the introduction and withdrawal of the Health in Pregnancy Grant, coefficients (95% CI)**

Model variable	Mean gestational age at booking (days)	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time	0.02 (-0.01 to 0.05)	0.00 <sup>1</sup> (-0.00 to 0.00)	<b>-0.00 (-0.00 to -0.00)</b> <sup>2</sup>	0.00 (-0.00 to 0.00)	0.00 (-0.00 to 0.00)
Level change at introduction	<b>5.29 (2.47 to 8.11)</b>	-0.04 (-0.10 to 0.01)	<b>-0.03 (-0.04 to -0.02)</b>	<b>-0.03 (-0.05 to -0.02)</b>	0.005 (-0.02 to 0.03)
Trend change at introduction	<b>-0.50 (-0.70 to -0.30)</b>	<b>0.005 (0.001 to 0.009)</b>	<b>0.003 (0.002 to 0.004)</b>	<b>0.003 (0.002 to 0.003)</b>	-0.001 (-0.002 to 0.001)
Level change at withdrawal	1.37 (-1.63 to 4.37)	-0.03 (-0.08 to 0.02)	0.001 (-0.01 to 0.02)	-0.01 (-0.02 to 0.004)	0.01 (-0.01 to 0.03)
Trend change at withdrawal	<b>0.35 (0.13 to 0.57)</b>	-0.003 (-0.008 to 0.002)	<b>-0.002 (-0.003 to -0.001)</b>	<b>-0.002 (-0.003 to -0.001)</b>	0.00 (-0.001 to 0.002)

376 <sup>1</sup>Values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001 are shown as 0.00; <sup>2</sup>Bold indicates where 95% confidence  
 377 intervals do not cross 0.

378 **Table 3. Predicted effects (95% CI) of introduction and withdrawal of the Health in Pregnancy Grant at 24 months after each event**

Outcome	21 months after introduction		24 months after withdrawal	
	Absolute change	Relative change (%)	Absolute change	Relative change (%)
Mean gestational age at booking (days)	<b>-4.8 (-8.2 to -2.3)<sup>1</sup></b>	<b>-6.2 (-10.5 to -3.0)</b>	<b>14.0 (2.8 to 16.8)</b>	<b>25.2 (2.1 to 33.2)</b>
Proportion booking by 10 weeks	0.06 (-0.02 to 12.5)	10.3 (-4.2 to 22.6)	-0.14 (-0.24 to 0.03)	-17.4 (-26.8 to 1.3)
Proportion booking by 18 weeks	<b>0.02 (0.01 to 0.04)</b>	<b>2.2 (1.2 to 3.9)</b>	<b>-0.08 (-0.08 to -0.02)</b>	<b>-7.6 (-7.9 to -2.2)</b>
Proportion booking by 25 weeks	<b>0.02 (0.01 to 0.03)</b>	<b>1.9 (0.6 to 3.5)</b>	<b>-0.09 (-0.09 to -0.03)</b>	<b>-8.3 (-8.6 to -3.1)</b>
Proportion of babies small for gestational age	-0.01 (-0.03 to 0.01)	-8.1 (-25.9 to 10.8)	0.03 (-0.03 to 0.08)	29.8 (-57.4 to 104.9)

379 <sup>1</sup>Bold indicates where 95% confidence intervals do not cross 0

380 **Table 4. Summary of interactions between parity and the effect of the introduction and withdrawal of the Health in Pregnancy Grant, model coefficients (95%**  
 381 **CI),**

Model variable	Mean gestational age booking	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time	0.03 (-0.01 to 0.08)	-0.00 (-0.00 to 0.00) <sup>1</sup>	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)
Parity >0 vs 0	0.09 (-2.54 to 2.72)	<b>-0.04 (-0.09 to -0.003)<sup>2</sup></b>	0.008 (-0.006 to 0.02)	0.01 (-0.001 to 0.02)	-0.004 (-0.02 to 0.02)
Parity * time	-0.02 (-0.08 to 0.04)	0.00 (-0.00 to 0.001)	0.00 (-0.00 to 0.00)	0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)
Level change at introduction	<b>5.57 (1.62 to 9.51)</b>	0.01 (-0.05 to 0.07)	<b>-0.04 (-0.06 to -0.01)</b>	<b>-0.04 (-0.05 to -0.02)</b>	0.01 (-0.02 to 0.04)
Trend change at introduction	<b>-0.50 (-0.78 to -0.21)</b>	0.003 (-0.001 to 0.008)	<b>0.002 (0.001 to 0.004)</b>	<b>0.003 (0.001 to 0.004)</b>	-0.001 (-0.004 to 0.001)
Parity * level change at introduction	-0.61 (-6.19 to 4.97)	-0.04 (-0.13 to 0.04)	0.007 (-0.02 to 0.04)	0.007 (-0.02 to 0.03)	-0.01 (-0.06 to 0.03)
Parity * trend change at introduction	0.01 (-0.39 to 0.41)	0.00 (-0.006 to 0.007)	-0.00 (-0.002 to 0.002)	-0.00 (-0.002 to 0.002)	0.002 (-0.002 to 0.005)
Level change at withdrawal	1.03 (-3.16 to 5.22)	-0.02 (-0.08 to 0.05)	0.005 (-0.02 to 0.03)	-0.01 (-0.03 to 0.001)	0.02 (-0.04 to 0.02)
Trend change at withdrawal	0.30 (-0.01 to 0.61)	-0.002 (-0.006 to 0.003)	<b>-0.002 (-0.003 to -0.00)</b>	-0.002 (-0.003 to 0.001)	0.001 (-0.002 to 0.003)
Parity * level change at withdrawal	-0.13 (-5.80 to 6.06)	0.006 (-0.09 to 0.10)	-0.003 (-0.04 to 0.03)	0.001 (-0.03 to 0.03)	-0.03 (-0.07 to 0.02)
Parity * trend change at withdrawal	0.08 (-0.36 to 0.52)	-0.00 (-0.008 to 0.006)	-0.00 (-0.003 to 0.002)	-0.00 (-0.002 to 0.002)	-0.001 (-0.004 to 0.003)

382 <sup>1</sup>Values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001 are shown as 0.00; <sup>2</sup>Bold indicates where 95% confidence  
 383 intervals do not cross 0.



384 **Table 5. Summary of interactions between maternal age and the effect of the introduction and withdrawal of the Health in Pregnancy Grant, model**  
 385 **coefficients (95% CI)**

	Mean gestational age booking	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time	-0.01 (-0.06 to 0.05)	0.00 <sup>1</sup> (-0.001 to 0.002)	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)
Age group	<b>-3.41 (-5.39 to -1.42)<sup>2</sup></b>	<b>0.05 (0.002 to 0.11)</b>	<b>0.01 (0.004 to 0.02)</b>	0.00 (-0.006 to 0.007)	<b>-0.04 (-0.05 to -0.03)</b>
Age * time	0.03 (-0.01 to 0.08)	-0.00 (-0.001 to 0.001)	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)	0.00 (-0.00 to 0.001)
Level change at introduction	3.02 (-0.87 to 6.90)	-0.04 (-0.10 to 0.02)	-0.03 (-0.05 to -0.001)	<b>-0.02 (-0.04 to -0.004)</b>	-0.002 (-0.04 to 0.03)
Trend change at introduction	-0.25 (-0.53 to 0.04)	0.002 (-0.003 to 0.008)	0.002 (-0.00 to 0.004)	<b>0.002 (0.00 to 0.003)</b>	0.00 (-0.002 to 0.003)
Age * level change at introduction	2.15 (-0.86 to 5.16)	-0.01 (-0.06 to 0.04)	-0.003 (-0.02 to 0.02)	-0.005 (-0.02 to 0.001)	0.005 (-0.02 to 0.03)
Age * trend change at introduction	<b>-0.26 (-0.48 to -0.04)</b>	0.001 (-0.003 to 0.005)	0.001 (-0.00 to 0.002)	0.001 (-0.00 to 0.002)	-0.001 (-0.003 to 0.001)
Level change at withdrawal	0.57 (-3.45 to 4.59)	-0.04 (-0.10 to 0.02)	0.01 (-0.02 to 0.04)	-0.006 (-0.03 to 0.02)	0.007 (-0.03 to 0.05)
Trend change at withdrawal	0.08 (-0.24 to 0.40)	-0.00 (-0.006 to 0.005)	-0.001 (-0.003 to 0.001)	-0.001 (-0.003 to 0.00)	-0.001 (-0.00 to 0.002)
Age * level change at withdrawal	1.23 (-1.88 to 4.34)	0.01 (-0.04 to 0.06)	-0.01 (-0.04 to 0.01)	-0.008 (-0.02 to 0.008)	0.002 (-0.03 to 0.03)
Age * trend change at withdrawal	<b>0.27 (0.02 to 0.52)</b>	-0.002 (-0.007 to 0.002)	-0.00 (-0.002 to 0.001)	-0.001 (-0.002 to 0.00)	0.001 (-0.001 to 0.003)

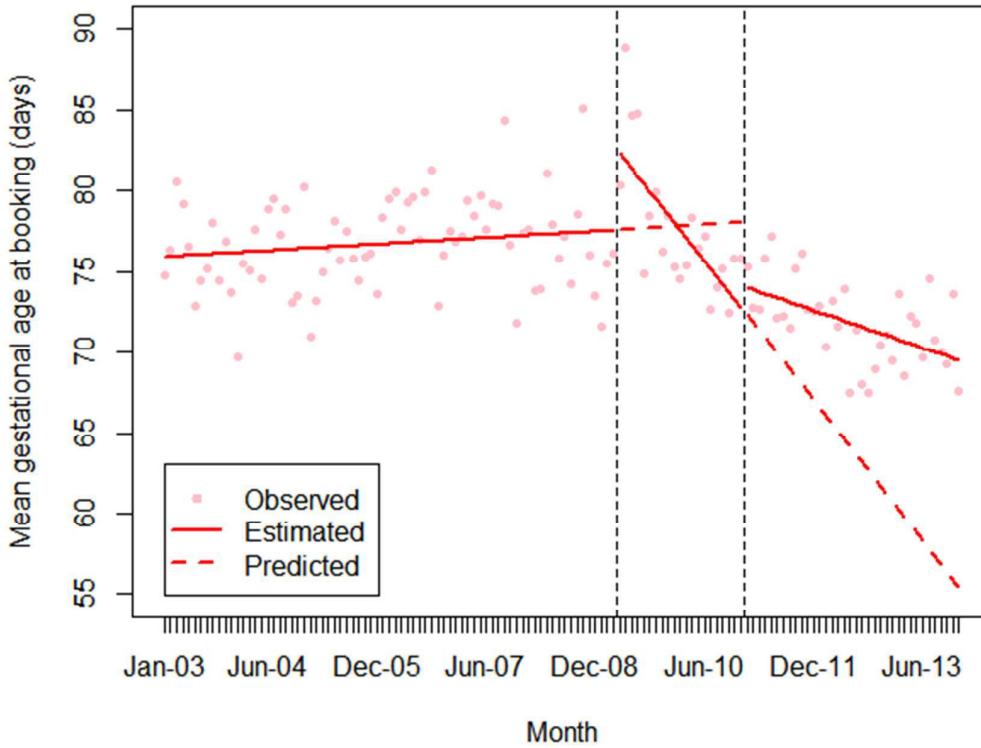
386 <sup>1</sup>Values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001 are shown as 0.00; <sup>2</sup>Bold indicates where 95% confidence  
 387 intervals do not cross 0.

388 **Table 6. Summary of interactions between Index of Multiple Deprivation group and the effect of the introduction and withdrawal of the Health in Pregnancy**  
 389 **Grant, model coefficients (95% CI)**

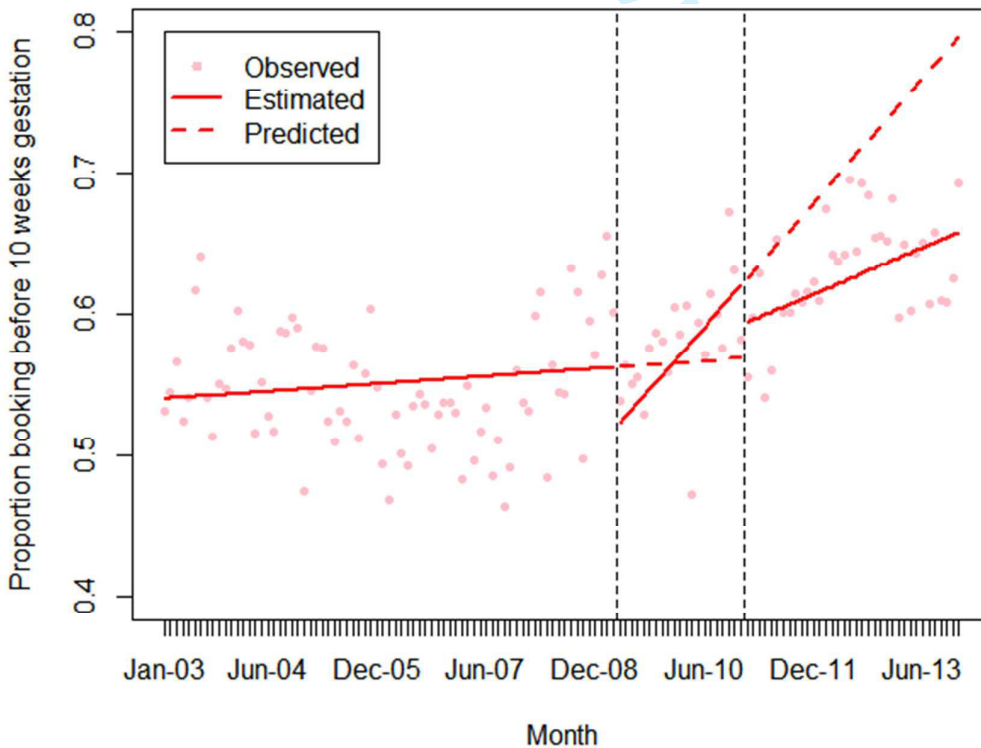
	Mean gestational age booking	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time	<b>0.11 (0.03 to 0.19)<sup>1</sup></b>	-0.001 (-0.003 to 0.001)	<b>-0.001 (-0.001 to -0.001)</b>	-0.00 (-0.00 to 0.00) <sup>2</sup>	0.00 (-0.00 to 0.00)
Deprivation tertile	<b>4.53 (2.90 to 6.15)</b>	<b>-0.09 (-0.13 to -0.05)</b>	<b>-0.02 (-0.03 to -0.001)</b>	-0.005 (-0.01 to 0.003)	<b>0.04 (0.03 to 0.05)</b>
Deprivation * time	<b>-0.04 (-0.07 to -0.00)</b>	0.00 (-0.00 to 0.001)	0.00 (-0.00 to 0.00)	0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)
Level change at introduction	<b>17.18 (9.55 to 24.81)</b>	-0.06 (-0.17 to 0.06)	<b>-0.09 (-0.14 to -0.05)</b>	<b>-0.10 (-0.13 to -0.06)</b>	0.01 (-0.05 to 0.07)
Trend change at introduction	<b>-1.04 (-1.59 to -0.49)</b>	0.005 (-0.003 to 0.01)	<b>0.004 (0.001 to 0.007)</b>	<b>0.005 (0.002 to 0.008)</b>	-0.00 (-0.005 to 0.003)
Deprivation * level change at introduction	<b>-5.02 (-8.56 to -1.49)</b>	0.007 (-0.05 to 0.06)	<b>0.03 (0.004 to 0.05)</b>	<b>0.03 (0.01 to 0.04)</b>	-0.001 (-0.03 to 0.03)
Deprivation * trend change at introduction	0.22 (-0.03 to 0.47)	-0.00 (-0.004 to 0.004)	-0.001 (-0.002 to 0.001)	-0.001 (-0.002 to -0.00)	0.00 (-0.002 to 0.002)
Level change at withdrawal	6.47 (-1.68 to 14.62)	-0.06 (-0.18 to 0.06)	-0.008 (-0.06 to 0.04)	-0.03 (-0.07 to 0.01)	0.02 (-0.04 to 0.08)
Trend change at withdrawal	0.59 (-0.005 to 1.18)	-0.002 (-0.01 to 0.01)	-0.002 (-0.006 to 0.001)	<b>-0.003 (-0.006 to -0.00)</b>	-0.001 (-0.006 to 0.003)
Deprivation * level change at withdrawal	-2.10 (-5.88 to 1.67)	0.01 (-0.04 to 0.07)	0.004 (-0.02 to 0.03)	0.008 (-0.01 to 0.03)	-0.003 (-0.03 to 0.03)
Deprivation * trend change at withdrawal	-0.10 (-0.37 to 0.18)	-0.00 (-0.005 to 0.005)	0.00 (-0.002 to 0.002)	0.00 (-0.001 to 0.002)	0.00 (-0.001 to 0.003)

390 <sup>1</sup>Bold indicates where 95% confidence intervals do not cross 0; <sup>2</sup>values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001  
 391 are shown as 0.00.

392 **Figure 1. Summary of interrupted time series models of the effect of the introduction and withdrawal of**  
393 **the Health in Pregnancy Grant**

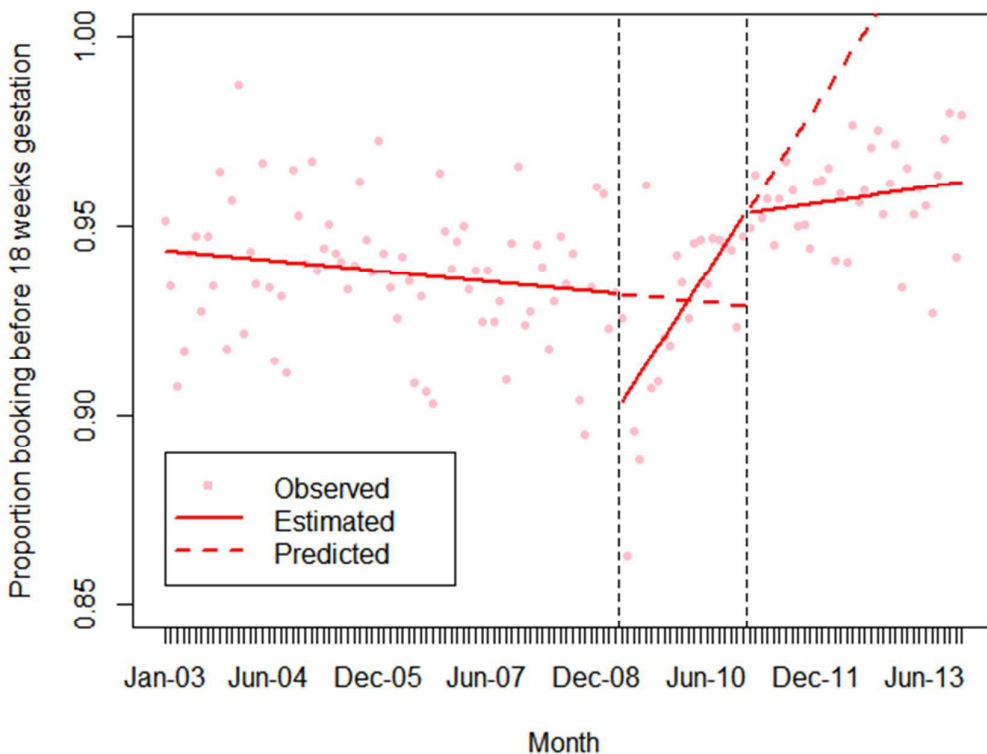


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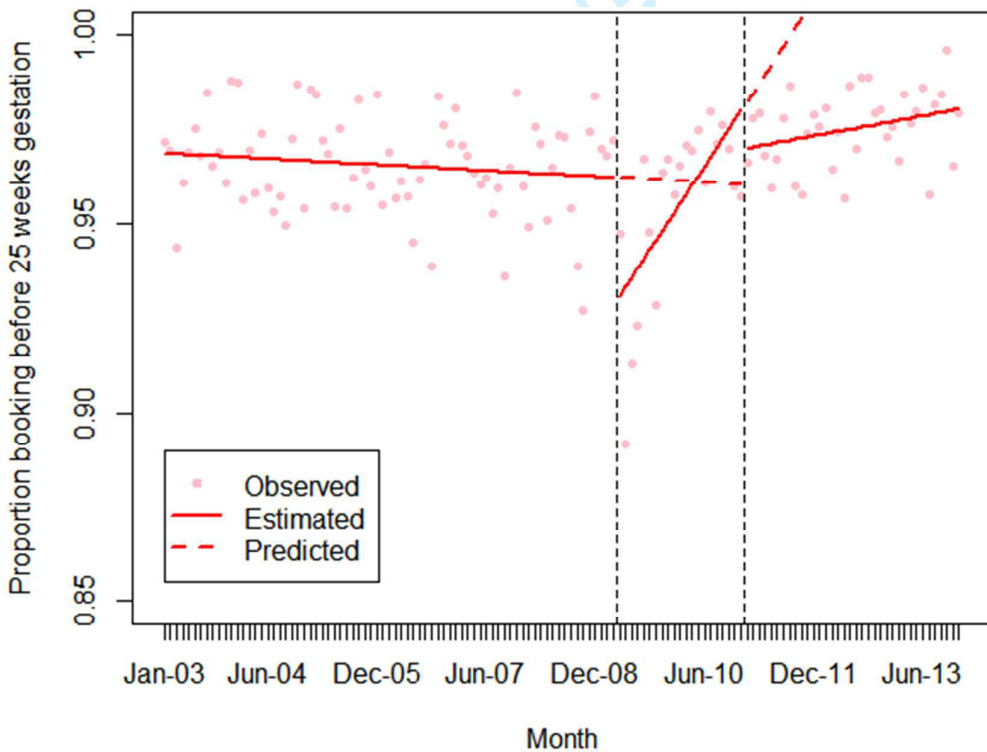


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396 Fig 1. cont.

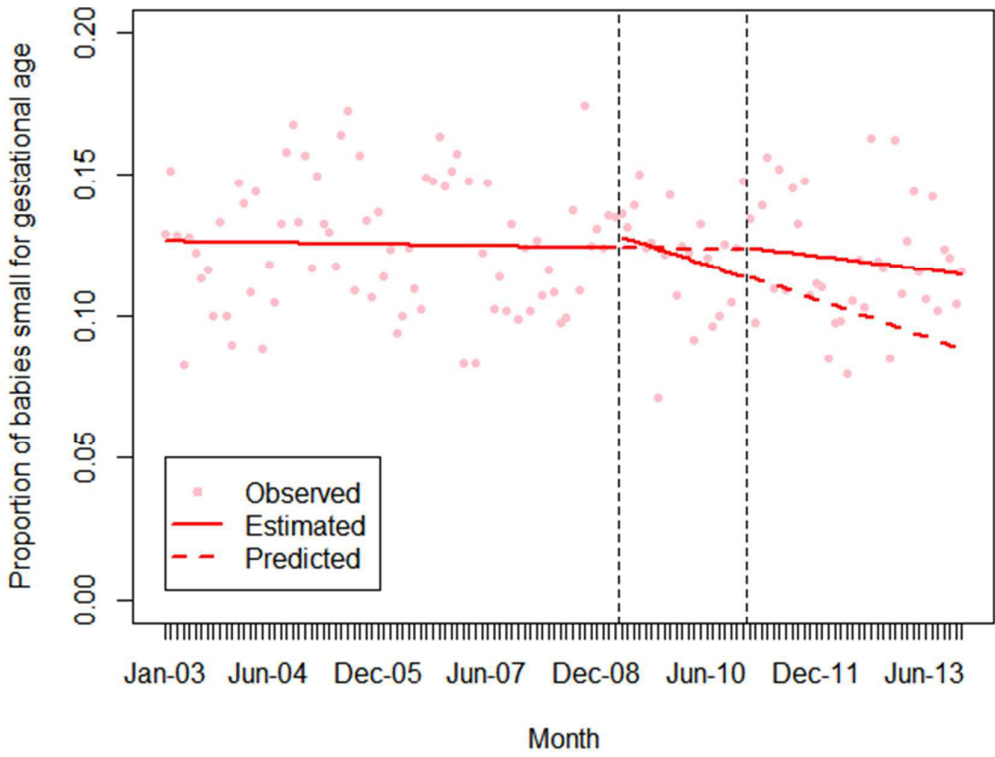


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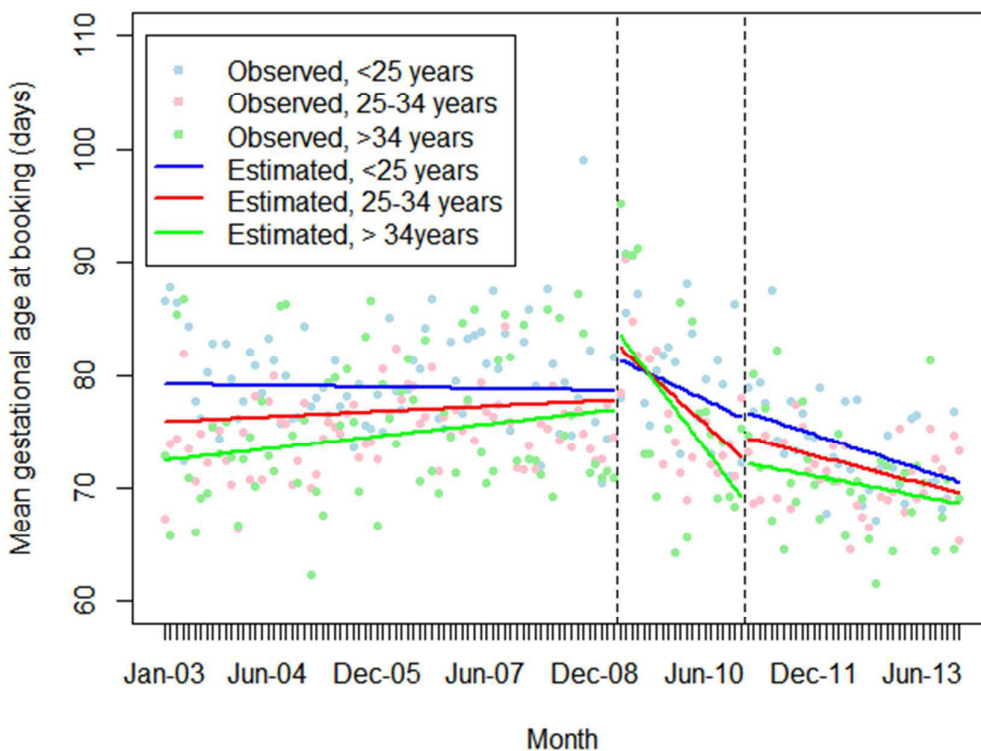
399 Fig 1. cont.



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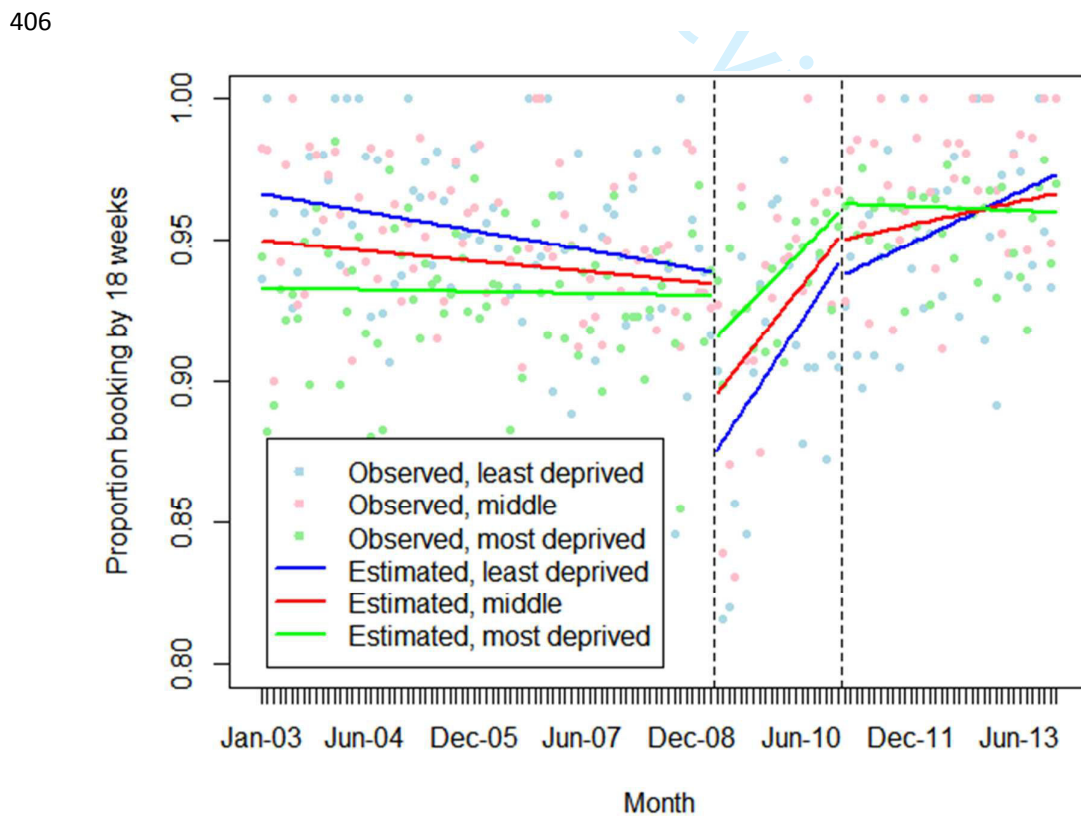
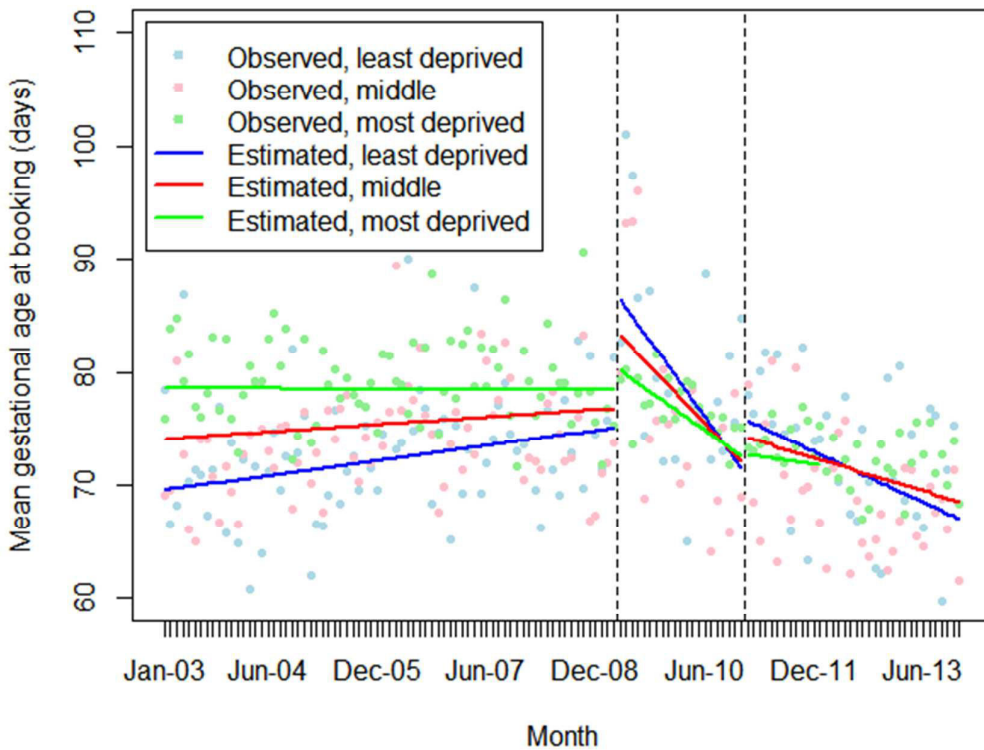
401 **Fig 2. Summary of interrupted time series models, interactions between maternal age group and the effect**  
 402 **of the introduction and withdrawal of the Health in Pregnancy Grant**



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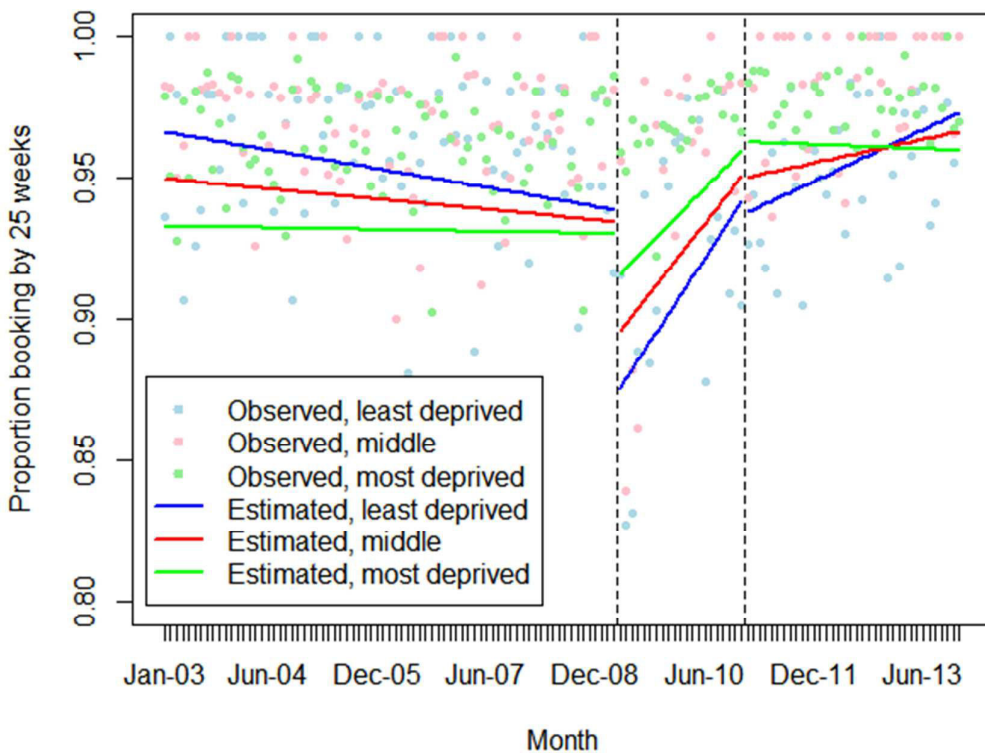
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404 **Fig 3. Summary of interrupted time series models, interactions between Index of Multiple Deprivation**  
405 **group and the effect of the introduction and withdrawal of the Health in Pregnancy Grant**



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408 Fig 3. Cont.



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## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page/line ref
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	p1, lines 2-3 p2, lines 17-37
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p4-5, lines 58-84
Objectives	3	State specific objectives, including any prespecified hypotheses	p5, lines 85-88
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	p5, line 90
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p5-6, lines 92-106
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	p5-6, lines 92-106 No matching
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Exposures – p5, lines 95-102 Outcomes – p6, lines 106-114 Potential effect modifiers – p6, lines 116-121
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p5-6, lines 92-121
Bias	9	Describe any efforts to address potential sources of bias	p6-7, lines 123-127; p10-11, lines 216-220
Study size	10	Explain how the study size was arrived at	p5, lines 95-101
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p6-7, lines 114-141

Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	p7, lines 127-141
		(b) Describe any methods used to examine subgroups and interactions	p7, lines 139-140
		(c) Explain how missing data were addressed	p6-7, lines 121-125
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	Not applicable
		<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	
		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	None – see p10-11, lines 214-218
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Table 1
		(b) Give reasons for non-participation at each stage	Table 1
		(c) Consider use of a flow diagram	Not considered helpful
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	Not applicable
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	Not applicable
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	Not applicable
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Table 1
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 2-6
		(b) Report category boundaries when continuous variables were categorized	Table 1
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Table 3
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Tables 4-6
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	p9-10, lines 183-195
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	p10, lines 197-212
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p10-12, lines 214-244
Generalisability	21	Discuss the generalisability (external validity) of the study results	p10, lines 211-212

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**Other information**

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Funding 22 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study p13-14, lines 276-288 on which the present article is based

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

For peer review only

# BMJ Open

## Associations between introduction and withdrawal of a financial incentive and timing of attendance for antenatal care and incidence of small for gestational age: natural experimental evaluation using interrupted time series methods

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-017697.R1
Article Type:	Research
Date Submitted by the Author:	21-Nov-2017
Complete List of Authors:	Adams, J; University of Cambridge, Centre for Diet and Activity Research, MRC Epidemiology Unit van der Waal, Zelda; Newcastle University Rushton, Steven; Newcastle University Rankin, Judith; Newcastle University, Institute of Health & Society
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Obstetrics and gynaecology, Health policy
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, PUBLIC HEALTH, OBSTETRICS, PREVENTIVE MEDICINE, Community child health < PAEDIATRICS

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Manuscripts

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1           **Associations between introduction and withdrawal of a financial incentive and timing of attendance**  
2           **for antenatal care and incidence of small for gestational age: natural experimental evaluation using**  
3           **interrupted time series methods**

4           Jean Adams, PhD;<sup>1\*</sup> Zeldia van der Waal, PhD;<sup>2</sup> Steve Rushton, PhD;<sup>2</sup> Judith Rankin, PhD<sup>3</sup>

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12  
13          **Keywords:** reward, incentive, maternal, antenatal, prenatal, natural experiment

1  
2 14 **Abstract**

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5 15 *Objectives*

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8 16 To determine whether introduction or withdrawal of a maternal financial incentive was associated with  
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10 17 changes in timing of first attendance for antenatal care ('booking'), or incidence of small for gestational age.  
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13 18 *Design*

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16 19 A natural experimental evaluation using interrupted time series analysis.  
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19 20 *Setting*

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22 21 A hospital-based maternity unit.  
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25 22 *Participants*

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28 23 34,589 women (and their live-born babies) who delivered at the study hospital and completed the 25<sup>th</sup> week  
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30 24 of pregnancy in the 75 months before (January 2003–March 2009), 21 months during (April 2009–December  
31  
32 25 2010), and 36 months after (January 2011–December 2013) the incentive was available.  
33  
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35 26 *Intervention*

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38 27 The Health in Pregnancy Grant was a financial incentive of £190 (\$235; €211) payable to pregnant women in  
39  
40 28 the UK from the 25th week of pregnancy, contingent on them receiving routine antenatal care.  
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43

44 29 *Primary and secondary outcome measures*

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46  
47 30 The primary outcome was mean gestational age at booking. Secondary outcomes were proportion of women  
48  
49 31 booking by 10, 18 and 25 weeks gestation; and proportion of babies that were small for gestational age.  
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2 32 *Results*  
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5 33 By 21 months after introduction of the grant (i.e. immediately prior to withdrawal), compared to what was  
6  
7 34 predicted given prior trends, there was an reduction in mean gestational age at booking of 4.8 days (95%  
8  
9 35 confidence intervals: 2.3 to 8.2). The comparable figure for 24 months after withdrawal was an increase of  
10  
11 36 14.0 days (95%CI: 2.8 to 16.8). No changes in incidence of small for gestational age babies were seen.  
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14 37 *Conclusions*  
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17 38 The introduction of a universal financial incentive for timely attendance at antenatal care was associated  
18  
19 39 with a reduction in mean gestational age at first attendance, but not proportion of babies that were small for  
20  
21 40 gestational age. Future research should explore the effects of incentives offered at different times and of  
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23 41 differing values; and how stakeholders view such incentives.  
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2 42 **Article summary**  
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5 43 *Strengths and limitations of this study*  
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- 8 44 • We used interrupted time series methods to evaluate this natural experiment; one of the strongest  
9  
10 45 quasi-experimental research designs available.  
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12 46 • By including substantial data before and after interventions, we took account of underlying secular  
13  
14 47 trends.  
15  
16 48 • However, interrupted time series designs are observational and we cannot categorically ascribe the  
17  
18 49 changes documented to the intervention.  
19  
20  
21 50 • One of our secondary outcomes was proportion of babies born small for gestational age - a substantial  
22  
23 51 improvement on previous studies that use a simple low birth weight cut-off.  
24  
25 52 • Differences between women included and excluded from the analyses may limit external validity, as may  
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27 53 our use of data from only one hospital.  
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## 54 Introduction

55 Financial incentives are increasingly used to encourage health promoting behaviours. However, few large,  
56 pragmatic, evaluations in high-income countries have been conducted.<sup>1,2</sup>

57 The Health in Pregnancy Grant (HiPG) was introduced in April 2009 as a one-off payment of £190 (\$235;  
58 €211) payable to all pregnant women, normally resident in the UK, after the 25<sup>th</sup> week of pregnancy, but  
59 before delivery. Women submitted a claim form, signed by their doctor or midwife confirming their expected  
60 delivery date and that they had received usual antenatal care.<sup>3</sup> A key aim of the HiPG was to act as an  
61 "incentive to seek the recommended health advice at the appropriate time".<sup>3</sup> Following a general election in  
62 2010, the HiPG was withdrawn with women only able to claim if they reached the end of the 25<sup>th</sup> week of  
63 pregnancy before 1 January 2011.

64 England compares poorly to other European countries on perinatal outcomes.<sup>4</sup> One possible reason is poor  
65 attendance at antenatal care, which is associated with increased risk of small for gestational age (SGA),<sup>5,6</sup>  
66 and a range of adverse outcomes.<sup>7-9</sup> National guidance recommends that the first antenatal (or 'booking')  
67 visit should ideally take place by 10 weeks gestation and, at the latest, by 18 weeks.<sup>10</sup> Women living in more  
68 deprived circumstances tend to book later in pregnancy'.<sup>11</sup>

69 Health promoting financial incentives may be more effective in promoting one-off behaviours than complex  
70 behaviour change.<sup>12-15</sup> Antenatal care is a series of one-off behaviours and may be particularly responsive to  
71 incentives. However, a recent systematic review found only five trials of maternal incentives for antenatal  
72 care – three conducted in the USA and one each in Mexico and Honduras.<sup>16</sup> No effect on timing of antenatal  
73 care was found (although only one study investigated this).<sup>17</sup> No studies included birthweight or SGA as  
74 outcomes. A further observational study from the USA found no effect of an incentive on incidence of low  
75 birth weight.<sup>18</sup> One recent evaluation of the HiPG in Scotland reported no effect on birth weight, but a  
76 positive effect on the proportion of women booking by 25 weeks (other aspects of timing of attendance  
77 were not studied).<sup>19</sup>

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2 78 UK public health policy makers and members of the public think that it may be appropriate to target financial  
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4 79 incentives at people living in more deprived circumstances – perhaps because those living in more deprived  
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6 80 circumstances are more in need of financial support.<sup>20 21</sup> There is some systematic review evidence that  
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8 81 people living in more deprived circumstances may be more responsive to fiscal interventions in general.  
9  
10 82 Other personal characteristics, such as age and previous experience of the behaviour incentivised, may also  
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12 83 influence responsiveness. However, differential responses to health promoting financial incentives between  
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14 84 population groups have not been systematically studied.<sup>1</sup>

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17 85 The introduction and withdrawal of the HiPG provided a unique opportunity for a large-scale, pragmatic,  
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19 86 natural experimental evaluation of a health promoting financial incentive.<sup>23</sup> Our research questions were:  
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21 87 was the introduction or withdrawal of the HiPG associated with a change in the timing of booking, or  
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23 88 incidence of SGA? Did any effect of the HiPG vary according to maternal age, parity or deprivation?  
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## 26 27 89 **Methods**

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30 90 We used an interrupted time series (ITS) design.

### 31 32 33 91 *Data and inclusion criteria*

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36 92 We used routine data from a maternity unit in a tertiary hospital in northern England, extracted in May  
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38 93 2015. The study hospital is a general teaching hospital with over 1000 beds in a town with a population of  
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40 94 ~175,000 people. Both the town and surrounding areas are more deprived than the English average.  
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43 95 Participants were women (and their live-born babies) who delivered at the study hospital and were known  
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45 96 to have completed the 25<sup>th</sup> week of pregnancy in the 75 months before (January 2003–March 2009)  
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47 97 introduction of the HiPG, 21 months during (April 2009–December 2010) availability of the HiPG, and 36  
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49 98 months after (January 2011–December 2013) withdrawal of the HiPG. The time periods included were  
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51 99 pragmatically arrived at based on when data was available from, and when the HiPG was introduced and  
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53 100 withdrawn. Our final data set of 132 monthly data points (and a mean of 262 cases per data point – see  
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55 101 results section), substantially exceeds the minimum requirements for ITS (of at least 8 data points per  
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2 102 intervention phase and 100 individual observations per data point).<sup>24</sup> Aggregating to the weekly, rather than  
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4 103 monthly, level would not have achieved these requirements – with a mean of 60 cases in each of 572 weekly  
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6 104 data points. As calculation of when women reached the 25<sup>th</sup> week of pregnancy depended on knowing the  
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8 105 date of their last menstrual period (LMP), women for whom this date was missing were excluded.

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11 106 Women who had a termination or experienced a stillbirth were excluded, as were women with missing data  
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13 107 on any variable of interest. Women who delivered more than one live baby in any one pregnancy, or had  
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15 108 more than one pregnancy that resulted in a live birth during the study period, were included with each baby  
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17 109 counted as a separate 'case'. As we did not have access to any identifiable data on women, we were not able  
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19 110 to determine on how many occasions this occurred or to take it into account in modelling.

#### 21 22 23 111 *Outcome measures*

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26 112 Our outcome measures focus on the stated aim of the HiPG – to encourage women to “seek the  
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28 113 recommended health advice at the appropriate time”.<sup>3</sup> The primary outcome was mean gestational age at  
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30 114 booking, calculated from dates of booking (recorded by antenatal care staff) and LMP (self-reported). As  
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32 115 national guidance recommends booking ideally before 10 weeks, and definitely before 18 weeks, and the  
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34 116 HiPG was available to women from the 25<sup>th</sup> week, the proportion of women booking by 10, 18 and 25 weeks  
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36 117 gestation were secondary outcomes.<sup>10</sup>

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39 118 As timely attendance for antenatal care is thought to improve perinatal outcomes, we included a final  
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41 119 secondary outcome: proportion of babies that were SGA. It should be noted that there is likely to be a long  
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43 120 and complicated chain of causation, if any, between receiving the HiPG and changes in gestational weight for  
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45 121 age. We defined SGA as birth weight z-score below the 10<sup>th</sup> percentile for sex-specific gestational age.<sup>25</sup> This  
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47 122 was calculated using infant sex, birth weight and dates of LMP and delivery (all except LMP recorded by  
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49 123 antenatal care and delivery staff).

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2 124 *Other variables of interest*  
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5 125 We studied whether any effects of the HiPG on the outcomes varied according to maternal age at delivery  
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7 126 (in years, calculated from maternal date of birth and date of delivery and divided into three groups: <25, 25-  
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9 127 34, or 35+ years), parity (self-reported and considered as 0 or 1+ in analyses) and socio-economic position.  
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11 128 The main age group (age 25-34 years) was coded using mid-decade to mid-decade as the convention  
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13 129 recommended to increase comparability between studies. We did not further sub-divide the other age  
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15 130 groups as only 8 women in the included sample were aged less than 15 years and only 27 were aged more  
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17 131 than 44 years. Socio-economic position was measured using the Index of Multiple Deprivation (IMD) 2007  
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19 132 rank assigned to maternal address at delivery.<sup>26</sup> IMD is an area-based measure of deprivation and ranks were  
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21 133 divided into thirds for analysis based on the distribution across England.  
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25 134 *Data preparation*  
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28 135 Data cleaning aimed to exclude data that were implausible. Date of LMP was recorded as month and year  
29  
30 136 only in around 20% of cases. To include these cases, day of month was set to the 1<sup>st</sup>. Gestational age at first  
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32 137 antenatal care of less than 28 days (4 weeks) or more than 308 days (44 weeks), gestational age at delivery  
33  
34 138 of less than 24 weeks or more than 44 weeks, or birth weight z-scores of less than -3 or more than 3 were  
35  
36 139 recoded as missing as these are likely to represent recording or transcriptions errors.<sup>25</sup>  
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39 140 *Data analyses*  
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42 141 We first compared women in the dataset who did and did not meet the inclusion criteria using  $\chi^2$  and t-tests.  
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45 142 For the main analysis, an uncontrolled, multiple time points, ITS design was used. The unit of analysis was  
46  
47 143 the month in which women entered the 25<sup>th</sup> week of pregnancy. ITS models estimate the change in 'level'  
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49 144 and 'trend' of the outcome of interest associated with the intervention. The change in level is the difference  
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51 145 in intercepts between regression lines estimated from observations before and after the intervention. The  
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53 146 change in trend is the difference in slopes. In the case of two 'interventions' (e.g. introduction and  
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55 147 withdrawal of the HiPG), two changes in level and trend are estimated.  
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2 148 Generalised least squares models were used allowing for autoregressive and moving average correlation  
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4 149 structures as appropriate. These allow any effect of periodicity to be taken into account. Firstly, associations  
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6 150 between introduction and withdrawal of the HiPG and the outcomes of interest were assessed in the whole  
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8 151 cohort, using separate models for each outcome. Final models were used to calculate estimated absolute  
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10 152 and relative effects on each outcome of the introduction of the HiPG at 21 months post-implementation  
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12 153 (immediately prior to withdrawal), and 24 months after withdrawal, with 95% confidence intervals.<sup>27</sup>  
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14 154 Interaction terms were then used to determine whether the effects of the introduction or withdrawal of the  
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16 155 HiPG varied by maternal age group, parity or IMD tertile.  
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20 156 Data preparation was conducted in StataSE v14; data analysis in R v3.3.1 and RStudio v0.99.903. We used  
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22 157 95% confidence intervals and a p-value of <0.05 to indicate statistical significance throughout.  
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## 25 158 **Results**

### 26 159 *Sample description*

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31 160 Of 39,571 women who delivered at the study hospital and were known to have reached the 25<sup>th</sup> week of  
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33 161 gestation between 1<sup>st</sup> January 2003 and 31<sup>st</sup> December 2013, full data were available for 34,589 (87.4%).  
34  
35 162 Characteristics of those for did and did not meet the inclusion criteria and hence were included or excluded  
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37 163 from the analysis are described in Table 1. Most exclusions were due to missing information on birth weight.  
38  
39 164 Typically, women included in the analyses were aged 25-34 years, of parity 1 or more, lived in the most  
40  
41 165 deprived third of areas in England, and booked by 10 weeks gestation. Women excluded from the analyses  
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43 166 tended to be younger, live in more deprived areas, and booked later in their pregnancies than women  
44  
45 167 included. Similar differences between women included and excluded from the analyses were seen in each of  
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47 168 the three study periods.  
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### 50 169 *Sample-wide changes in outcomes associated with introduction and withdrawal of the HiPG*

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54 170 Final models for each outcome are summarised in Table 2 and plotted in Figure 1, Figure 2, Figure 3, Figure 4  
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56 171 and Figure 5. Introduction of the HiPG was associated with an immediate increase in mean gestational age at  
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2 172 booking, and a decrease in the proportion booking by 18 and 25 weeks. That is, the immediate effect was for  
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4 173 these outcomes to get clinically 'worse'. However, introduction of the HiPG was also associated with an  
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6 174 improvement in the trend in mean gestational age at booking and proportion booking by 10, 18 and 25  
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8 175 weeks. That is, the longer term effect was a change in trend of these outcomes towards greater clinical  
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10 176 improvement over time.

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12  
13 177 Withdrawal of the HiPG was not associated with any level changes in outcomes. However, it was associated  
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15 178 with a change in trend in mean gestational age at booking and proportion booking by 18 and 25 weeks  
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17 179 towards less clinical improvement over time. The introduction or withdrawal of the HiPG was not associated  
18  
19 180 with any changes in the level or trend in the proportion of babies who were SGA.

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22  
23 181 Table 3 shows the absolute and relative impact of the introduction and withdrawal of the HiPG on each  
24  
25 182 outcome at 21 months post introduction and 24 months post withdrawal. By 21 months after introduction of  
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27 183 the HiPG, compared to the counterfactual of what was predicted given trends prior to the introduction of  
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29 184 the HiPG, there was a reduction in mean gestational age at booking of 4.8 days (95% confidence intervals:  
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31 185 2.3 to 8.2), an increase in the proportion of women booking by 18 weeks of 2.2% (95%CI: 1.2 to 3.9), and an  
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33 186 increase in the proportion of women booking by 25 weeks of 1.9% (95%CI: 0.6 to 3.5). Compared to the  
34  
35 187 counterfactual of what was predicted to occur given trends when the HiPG was available, by 24 months after  
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37 188 withdrawal, there was an increase in mean gestational age at booking of 14.0 days (95% CI: 2.8 to 16.8), a  
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39 189 decrease in the proportion of women booking by 18 weeks of 7.6% (95% CI: 2.2 to 7.9), and a decrease in the  
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41 190 proportion of women booking by 25 weeks of 8.3% (95% CI: 3.1 to 8.6).

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45 191 *Differential changes in outcomes associated with introduction and withdrawal of the HiPG across population*  
46  
47 192 *sub-groups*

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50 193 Models including interaction terms for maternal age, parity and IMD tertile are summarised in Tables 4-6.  
51  
52 194 There were no interactions with parity. The associations between introduction and withdrawal of the HiPG  
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54 195 and trend in mean gestational age at booking varied by age group (Figure 6), with greater changes in trend in  
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56 196 older women.

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2 197 The association between introduction of the HiPG and mean gestational age at booking and proportion  
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4 198 booking by 18 and 25 weeks varied by IMD group (Figure 7, Figure 8 and Figure 9). The introduction of the  
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6 199 HiPG was associated with a progressively larger level change (towards older gestational age at booking, and  
7  
8 200 lower proportion booking by 18 or 25 weeks) as deprivation decreased.  
9

## 11 201 **Discussion**

### 14 202 *Statement of principal findings*

17 203 This is the first evaluation of the HiPG in England, the first evaluation of a financial incentive for attendance  
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19 204 at antenatal care on incidence of SGA, and one of the largest pragmatic evaluations of a health promoting  
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21 205 financial incentive in a high-income country. Introduction of the HiPG was associated with immediate  
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23 206 deteriorations in timing of booking, but longer term improvements over time. By 21 months after  
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25 207 introduction of the HiPG (immediately prior to its withdrawal), mean gestational age at booking had  
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27 208 decreased by 4.8 days compared to what would have been expected had it not been introduced. Withdrawal  
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29 209 of the HiPG was not associated with any immediate changes in timing of booking, but it was associated with  
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31 210 longer-term deteriorations in timing of booking over time. By 24 months after withdrawal, mean gestational  
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33 211 age at booking had increased by 14.0 days compared to what would have been expected had it not been  
34  
35 212 withdrawn. We found no association between introduction or withdrawal of the HiPG and incidence of SGA.  
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37 213 Trends in outcomes associated with the HiPG did not vary by parity. The positive association between  
38  
39 214 introduction of the HiPG and gestational age at booking was greater in older women. The negative  
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41 215 association between introduction of the HiPG and timing of booking was more pronounced in less deprived  
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43 216 groups.  
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### 48 217 *Strengths and weaknesses of methods*

51 218 The ITS approach is one of the strongest quasi-experimental research designs.<sup>24 28</sup> By including substantial  
52  
53 219 data before and after interventions, we took account of underlying secular trends. By studying outcomes at  
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55 220 the population-, rather than individual-, level confounding by individual-level variables was avoided. Our  
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2 221 large data set with 132 monthly data points, substantially exceeds the minimum requirements for ITS.<sup>28</sup> By  
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4 222 including auto-regressive and moving-average functions, any biases introduced by the serial nature of the  
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6 223 data (including seasonality and other periodicities) were accounted for. However, ITS designs are  
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8 224 observational and we cannot categorically ascribe the changes documented to the HiPG. Whilst we are not  
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10 225 aware of any co-interventions likely to have influenced the outcomes concurrent with the HiPG, it is difficult  
11  
12 226 to absolutely exclude these.

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15 227 A major strength of our study is the use of SGA. Unlike a simple cut-off for low birth weight, SGA allows sex  
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17 228 and gestational age differences in birth weight to be taken into account.

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20 229 The data we used is likely to contain recording, reporting and transcription errors. Some of these may have  
21  
22 230 introduced bias. ‘Feasibility’ limits were used for some variables and may have led to misclassification.

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25 231 Cases included in the analytical cohort differed from those excluded. However, as differences between  
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27 232 women included and excluded from the analyses were similar in all three study periods, this is unlikely to  
28  
29 233 introduce bias and so we did impute missing data. Differences between women included and excluded from  
30  
31 234 the analyses may limit external validity, as may our use of data from only one hospital.

### 32 33 34 35 235 *Interpretation of findings*

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38 236 Our finding that the introduction of the HiPG was associated with an immediate deterioration in timing of  
39  
40 237 booking may reflect an implementation phase, where the process for obtaining the HiPG was not yet fully  
41  
42 238 understood. For instance, women may have thought that they were only entitled to the HiPG if they delayed  
43  
44 239 attending until after the 25<sup>th</sup> week of pregnancy. In fact this was not the case – although women could not  
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46 240 claim the grant until after the 25<sup>th</sup> week of pregnancy, whether they had first attended before this had no  
47  
48 241 impact on their entitlement. Whilst we could have conducted further analyses excluding an implementation  
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50 242 period (e.g. four months after introduction of the HiPG), this would have been *post-hoc* justified.

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54 243 The longer-term associations of the introduction of the HiPG on markers of timing at booking are in line with  
55  
56 244 the intention of the intervention – that women should attend for antenatal care earlier in their pregnancies.



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2 245 One previous study found no effect on timing of first attendance of providing a voucher for a taxi journey to  
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4 246 the antenatal clinic,<sup>17</sup> whilst a further evaluation of the HiPG found it was associated with a positive effect on  
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6 247 the proportion of women booking by 25 weeks that disappeared after withdrawal.<sup>19</sup> The substantial  
7  
8 248 difference in incentive value of the HiPG, compared to previous incentives, may explain these differences.  
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10  
11 249 The finding that withdrawal of the HiPG was associated with deterioration of the benefits of its introduction  
12  
13 250 on timing of booking is also not unexpected. On the whole, different women would have been pregnant  
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15 251 when the HiPG was and was not available, meaning sustained effects would be highly unlikely.  
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18 252 Changes in timing of attendance for antenatal care associated with the introduction and withdrawal of the  
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20 253 HiPG did not translate into differences in the proportion of SGA babies. This may be because the effect size  
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22 254 (of 4.8 days at 21 months) was too small to impact on SGA. Two previous studies that examined the effect of  
23  
24 255 incentives for antenatal care on incidence of low birth weight (rather than SGA) also reported no effect.<sup>18 19</sup>  
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28 256 Although the HiPG was only available from the 25<sup>th</sup> week of pregnancy, we found that its introduction was  
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30 257 associated with changes in the proportion of women booking by both 10 and 18 weeks. This indicates that  
31  
32 258 the impact of health promoting financial incentives may not be as specific as previously thought.<sup>29</sup> The HiPG  
33  
34 259 may have been associated with a larger effect on timing of booking if it had been contingent on booking  
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36 260 earlier in pregnancy.  
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38  
39 261 We did not find any evidence that the associations of the introduction or withdrawal of the HiPG with the  
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41 262 outcomes studied varied by parity. This suggests that prior experience of antenatal care did not diminish the  
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43 263 impact of the HiPG. However, the association of the introduction of the HiPG with improvements in  
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45 264 gestational age at booking over time were greater in older women. This suggests that age may be a  
46  
47 265 determinant of responsiveness to financial incentives in this context, with older women being more  
48  
49 266 responsive to the intervention. Our data are consistent with the suggestion that those with fewer resources  
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51 267 are particularly responsive to incentives.<sup>30</sup> Whilst introduction of the HiPG was associated with an immediate  
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53 268 negative change in timing of first antenatal care, this was least pronounced in women living in the most  
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55 269 deprived areas.  
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2 270 *Implications of findings for policy, practice and research*  
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5 271 It is possible that larger incentives, contingent on attendance earlier than 25 weeks, may have greater  
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7 272 impacts on timing of antenatal care and clinical outcomes than seen here. Future research could explore  
8  
9 273 how effects on antenatal care attendance vary with incentive value and timing.  
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11  
12 274 As we used routine data in a retrospective analysis conducted more than two years after withdrawal of the  
13  
14 275 HiPG, we were unable to explore how women and other stakeholders responded to the HiPG. In particular,  
15  
16 276 we do not know what women spent the HiPG on, how doctors and midwives discussed it with women, or  
17  
18 277 how appropriate stakeholders thought it was. These factors may have influenced effectiveness and  
19  
20 278 variations in effectiveness between sub-groups.<sup>31</sup>  
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22

23  
24 279 **Conclusions**  
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27 280 Although the introduction of the HiPG was associated with an immediate clinical deterioration in timing of  
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29 281 attendance for first antenatal care, it was also associated with a longer term trend towards improvement in  
30  
31 282 timing. By 21 months post-implementation, there was a decrease in almost five days in mean gestational age  
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33 283 at booking compared to what would have been expected without implementation. Withdrawal of the HiPG  
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35 284 was associated with deteriorations in timing of booking. By 24 months post-withdrawal there was an  
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37 285 increase in 14 days in mean gestational age at booking compared to what would have been expected  
38  
39 286 without withdrawal. Neither the introduction nor withdrawal of the HiPG was associated with a change in  
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41 287 proportion of babies who were SGA. There was no evidence that associations between introduction or  
42  
43 288 withdrawal of the HiPG and outcomes varied by maternal parity. Introduction of the HiPG was associated  
44  
45 289 with greater long-term benefits on timing at booking in older women suggesting older women were most  
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47 290 responsive to the intervention. The initial deterioration in timing of attendance for first antenatal care was  
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49 291 least pronounced in those living in the most deprived circumstances suggesting those living in the most  
50  
51 292 deprived circumstances were most responsive to the intervention. Future research should explore the  
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53 293 effects of incentives offered at different times in pregnancy and of differing values; and how stakeholders  
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55 294 view such incentives.  
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For peer review only

**296 Funding**

297 This work is produced under the terms of a Career Development Fellowship research training fellowship  
298 issued by the National Institute of Health Research [grant number CDF-2011-04-001] to JA. The views  
299 expressed are those of the authors and not necessarily those of the NHS, The National Institute for Health  
300 Research or the Department of Health. JA is supported by the Centre for Diet and Activity Research (CEDAR),  
301 a UKCRC Public Health Research Centre of Excellence. Funding from the British Heart Foundation, Cancer  
302 Research UK, Economic and Social Research Council, Medical Research Council, the National Institute for  
303 Health Research, and the Wellcome Trust, under the auspices of the UK Clinical Research Collaboration, is  
304 gratefully acknowledged [grant number MR/K023187/1].

**305 Role of the funding sources**

306 The funders played no role in any aspect of study design, data analysis, writing or the decision to submit. All  
307 authors had full access to all the data and had final responsibility for the decision to submit. No authors were  
308 paid by a pharmaceutical company or other agency to write this article. All authors are independent from  
309 the funders.

**310 Competing interests**

311 All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and  
312 declare: JA had financial support from the National Institute for Health Research and the Centre for Diet and  
313 Activity Research (as described under 'funding') for the submitted work; no financial relationships with any  
314 organisations that might have an interest in the submitted work in the previous three years; no other  
315 relationships or activities that could appear to have influenced the submitted work.

**316 Contributions**

317 JA conducted the literature searches, obtained the data, conducted the data analysis and led writing. ZvdW,  
318 SR, and JR contributed to study design, development of the analysis plan, interpretation of the data and  
319 critically reviewed previous versions of the final manuscript. JA will act as guarantor.

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320 **Research ethics**

321 Ethics approval was granted by the East of England Norfolk NHS Research Ethics Committee (12/EE/0386).

322 The routine hospital data used in this study was anonymised before transfer to the research team and the

323 ethics committee determined that explicit patient consent was not required.

324 **Data Sharing**

325 No additional data available.

For peer review only

326 **References**

- 327 1. Giles E, Robalino S, McColl E, et al. Systematic review, meta-analysis and meta-regression of the  
328 effectiveness of financial incentives for encouraging healthy behaviours. *PLoS ONE* 2014;9 doi:  
329 10.1371/journal.pone.0090347
- 330 2. Mantzari E, Vogt F, Shemilt I, et al. Personal financial incentives for changing habitual health-related  
331 behaviors: A systematic review and meta-analysis. *Prev Med* 2015;75:75-85. doi:  
332 10.1016/j.ypmed.2015.03.001 [published Online First: 2015/04/07]
- 333 3. HM Revenue & Customs, The Royal College of Midwives. Health in Pregnancy Grant: Frequently Asked  
334 Questions 2009 [Available from:  
335 [http://www.direct.gov.uk/en/groups/dg\\_digitalassets/@dg/@en/documents/digitalasset/dg\\_17340](http://www.direct.gov.uk/en/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_17340)  
336 [1.pdf](#) accessed 25 March 2010.
- 337 4. EURO-PERISTAT project, SCPE, EUROCAT, et al. European Perinatal Health Report. Paris, 2008.
- 338 5. VanderWeele TJ, Lantos JD, Siddique J, et al. A comparison of four prenatal care indices in birth outcome  
339 models: Comparable results for predicting small-for-gestational-age outcome but different results  
340 for preterm birth or infant mortality. *J Clin Epidemiol* 2009;62(4):438-45.
- 341 6. Heaman M, Newburn-Cook C, Green C, et al. Inadequate prenatal care and its association with adverse  
342 pregnancy outcomes: A comparison of indices. *BMC Pregnancy and Childbirth* 2008;8(1):15.
- 343 7. Lin C, Chen C, Chen P, et al. Risks and causes of mortality among low-birthweight infants in childhood and  
344 adolescence. *Paediatr Perinat Epidemiol* 2007;21(5):465-72.
- 345 8. Mikkola K, Ritari N, Tommiska V, et al. Neurodevelopmental outcome at 5 years of age of a national cohort  
346 of extremely low birth weight infants who were born in 1996-1997. *Pediatrics* 2005;116(6):1391-400.  
347 doi: 10.1542/peds.2005-0171 [published Online First: 2005/12/03]
- 348 9. Tommiska V, Heinonen K, Ikonen S, et al. A national short-term follow-up study of extremely low birth  
349 weight infants born in Finland in 1996-1997. *Pediatrics* 2001;107(1):E2. [published Online First:  
350 2001/01/03]
- 351 10. National Collaborating Centre for Women's and Children's Health. Antenatal care: Routine care for the  
352 healthy pregnant woman. London: National Institute for Health and Clinical Excellence, 2008.
- 353 11. Rowe RE, Garcia J. Social class, ethnicity and attendance for antenatal care in the United Kingdom: a  
354 systematic review. *J Public Health* 2003;25(2):113-19. doi: 10.1093/pubmed/fgd025
- 355 12. Sutherland K, Christianson JB, Leatherman S. Impact of Targeted Financial Incentives on Personal Health  
356 Behavior: A Review of the Literature. *Med Care Res Rev* 2008;65(6\_suppl):36S-78. doi:  
357 10.1177/1077558708324235
- 358 13. Marteau T, Ashcroft R, Oliver A. Using financial incentives to achieve healthy behaviour. *BMJ* 2009;338  
359 doi: 10.1136/bmj.b1415
- 360 14. Jochelson K. Paying the Patient: improving health using financial incentives. London: King's Fund, 2007.
- 361 15. Forde I, Zeuner D. Financial incentives to promote social mobility. *BMJ* 2009;339:b3219. doi:  
362 10.1136/bmj.b3219

- 1  
2 363 16. Till SR, Everetts D, Haas DM. Incentives for increasing prenatal care use by women in order to improve  
3 364 maternal and neonatal outcomes. *Cochrane Database Syst Rev* 2015(12) doi:  
4 365 10.1002/14651858.CD009916.pub2  
5  
6 366 17. Melnikow J, Paliescheskey M, Stewart G. Effect of a transportation incentive on compliance with the first  
7 367 prenatal appointment: a randomized trial. *Obstet Gynecol* 1997;89:1023-7.  
8  
9 368 18. Rosenthal M, Li Z, Robertson A, et al. Impact of financial incentive for prenatal care on birth outcomes  
10 369 and spending. *HSR: Health Services Research* 2009;44:1465-79.  
11  
12 370 19. Leyland A, Ouedraogo S, Gray R, et al. Evaluating health in pregnancy grants in Scotland: a natural  
13 371 experiment. *J Epidemiol Community Health* 2016;70(S1):A47-8.  
14  
15 372 20. Giles E, McColl E, Sniehotta F, et al. Acceptability of financial incentives and penalties for encouraging  
16 373 uptake of healthy behaviours: focus groups. *BMC Public Health* 2015;15 doi: 10.1186/s12889-015-  
17 374 1409-y  
18  
19 375 21. Giles EL, Sniehotta FF, McColl E, et al. Acceptability of financial incentives for health behaviour change to  
20 376 public health policymakers: a qualitative study. *BMC Public Health* 2016;16:989. doi:  
21 377 10.1186/s12889-016-3646-0 [published Online First: 2016/09/17]  
22  
23 378 22. Lorenc T, Petticrew M, Welch V, et al. What types of interventions generate inequalities? Evidence from  
24 379 systematic reviews. *J Epidemiol Community Health* 2012;67(2):190-3. doi: 10.1136/jech-2012-201257  
25  
26 380 23. Craig P, Cooper C, Gunnell D, et al. Using natural experiments to evaluate population health  
27 381 interventions: guidance for producers and users of evidence: Medical Research Council, 2011.  
28  
29 382 24. Penfold RB, Zhang F. Use of interrupted time series analysis in evaluating health care quality  
30 383 improvements. *Academic Pediatrics* 2013;13(6 Suppl):S38-44. doi: 10.1016/j.acap.2013.08.002  
31 384 [published Online First: 2013/12/07]  
32  
33 385 25. Bonellie S, Chalmers J, Gray R, et al. Centile charts for birthweight for gestational age for Scottish  
34 386 singleton births. *BMC Pregnancy & Childbirth* 2008;8:5. doi: 10.1186/1471-2393-8-5 [published  
35 387 Online First: 2008/02/27]  
36  
37 388 26. Department of Communities and Local Government. The English Indices of Deprivation 2010 2011  
38 389 [Available from: <http://www.communities.gov.uk/publications/corporate/statistics/indices201015>  
39 390 October 2012.  
40  
41 391 27. Zhang F, Wagner AK, Soumerai SB, et al. Methods for estimating confidence intervals in interrupted time  
42 392 series analyses of health interventions. *J Clin Epidemiol* 2009;62(2):10.1016/j.jclinepi.2008.08.007.  
43 393 doi: 10.1016/j.jclinepi.2008.08.007  
44  
45 394 28. Jandoc R, Burden AM, Mamdani M, et al. Interrupted time series analysis in drug utilization research is  
46 395 increasing: systematic review and recommendations. *J Clin Epidemiol* 2015;68(8):950-6. doi:  
47 396 10.1016/j.jclinepi.2014.12.018 [published Online First: 2015/04/22]  
48  
49 397 29. Adams J, Giles E, McColl E, et al. Carrots, sticks, and health behaviours: a framework for documenting the  
50 398 complexity of financial incentive interventions to change health behaviours. *Health Psychology*  
51 399 *Review* 2014;8(3):286-95.  
52  
53 400 30. Giles E, Robalino S, Sniehotta F, et al. Acceptability of financial incentives for encouraging uptake of  
54 401 healthy behaviours: A critical review using systematic methods. *Prev Med* 2015;73 doi:  
55 402 10.1016/j.ypmed.2014.12.029  
56  
57  
58  
59  
60

- 1  
2 403 31. Giles EL, Adams JM. Capturing public opinion on public health topics: a comparison of experiences from a  
3 404 systematic review, focus group study, and analysis of online, user-generated content. *Frontiers in*  
4 405 *Public Health* 2015;3 doi: 10.3389/fpubh.2015.00200  
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6 406  
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407 **Table 1. Characteristics of those included and excluded from the analytical cohort**

Variable	Level	Before HiPG availability (January 2003 – March 2009)		During HiPG availability (April 2009 – December 2010)		After HiPG availability (January 2011 – December 2013)		Full study period (January 2003 – December 2013)	
		Included <sup>1</sup>	Excluded <sup>2</sup>	Included <sup>1</sup>	Excluded <sup>2</sup>	Included <sup>1</sup>	Excluded <sup>2</sup>	Included <sup>1</sup>	Excluded <sup>2</sup>
N(%)		18 744	2816	6126	862	9719	1304	34 589	4982
Maternal age, n(%)	<25 years	6359 (33.9)	1327 (47.1)	2039 (33.3)	374 (43.4)	2836 (29.2)	523 (40.1)	11 234 (32.5)	2224 (44.6)
	25-34 years	9684 (51.7)	1208 (42.9)	3272 (53.4)	405 (47.0)	5577 (57.4)	651 (49.9)	18 533 (53.6)	2264 (45.4)
	35 years +	2701 (14.4)	281 (10.0)	815 (13.3)	83 (9.6)	1306 (13.4)	130 (10.0)	4822 (13.9)	494 (9.9)
	Data not available, n(%)	0	0 <sup>3</sup>	0	0 <sup>3</sup>	0	0 <sup>3</sup>	0	0 <sup>3</sup>
Parity, n(%)	0	8077 (43.1)	1288 (45.7)	2670 (43.6)	378 (43.9)	3944 (40.6)	585 (44.9)	14 691 (42.5)	2251 (45.2)
	1+	10 667 (56.9)	1528 (54.3)	3456 (56.4)	484 (56.2)	5775 (59.4)	719 (55.1)	19 898 (57.5)	2731 (54.8)
	Data not available, n(%)	0	0 <sup>3</sup>	0	0	0	0 <sup>3</sup>	0	0 <sup>3</sup>
Index of multiple deprivation group, n(%)	Most deprived	10 820 (57.7)	1777 (63.1)	3566 (58.2)	547 (63.5)	5821 (59.9)	794 (60.9)	20 207 (58.4)	3118 (62.6)
	Moderately deprived	4213 (22.5)	490 (17.4)	1330 (21.7)	160 (18.6)	2230 (22.9)	220 (16.9)	7773 (22.5)	870 (17.5)
	Least deprived	3711 (19.8)	361 (12.8)	1230 (20.1)	92 (10.7)	1668 (17.2)	128 (9.8)	6609 (19.1)	581 (11.7)
	Data not available, n(%)	0	188 (6.7) <sup>3</sup>	0	63 (7.3) <sup>3</sup>	0	162 (12.4) <sup>3</sup>	0	413 (8.3) <sup>3</sup>
Study outcomes	Mean (SD) gestational age at booking, days	76.7 (35.8)	106.2 (45.5) <sup>4</sup>	77.8 (41.3)	99.3 (39.8) <sup>4</sup>	71.8 (31.8)	95.0 (39.1) <sup>4</sup>	75.6 (35.8)	102.0 (43.2) <sup>4</sup>
	Booked by 10 weeks, n(%)	10 261 (54.7)	442 (17.0) <sup>3</sup>	3540 (57.8)	152 (18.8) <sup>3</sup>	6127 (63.0)	283 (23.9) <sup>3</sup>	19 928 (57.6)	877 (19.1) <sup>3</sup>
	Booked by 18 weeks, n(%)	17 579 (93.8)	2012 (77.7) <sup>3</sup>	5675 (92.6)	676 (83.7) <sup>3</sup>	9307 (95.8)	1022 (86.3) <sup>3</sup>	32 561 (94.1)	3719 (81.0) <sup>3</sup>
	Booked by 25 weeks, n(%)	18 098 (96.6)	2397 (92.1) <sup>3</sup>	5846 (95.4)	766 (94.8)	9477 (97.5)	1129 (95.4) <sup>3</sup>	33 421 (96.6)	4292 (93.4) <sup>4=3</sup>
	Small for gestational age, n(%)	2346 (12.5)	17 (8.3)	743 (12.1)	7 (11.5)	1163 (12.0)	25 (14.9)	4252 (12.3)	49 (11.3)
	Data not available on time at booking, n(%)	0	214 (7.6)	0	54 (6.3)	0	120 (9.2)	0	388 (7.8)
	Data not available on birth weight, n(%)	0	2611 (92.7)	0	801 (92.9)	0	1136 (87.1)	0	4548 (91.3)

## Evaluation of the "Health in Pregnancy Grant"

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4 408 <sup>1</sup>Women who delivered at the study hospital, were known to have reached the 25<sup>th</sup> week of gestation between 1<sup>st</sup> January 2003 and 31<sup>st</sup> December 2013 and  
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6 409 had available data on all variables of interest; <sup>2</sup>Women who delivered at the study hospital, were known to have reached the 25<sup>th</sup> week of gestation between 1<sup>st</sup>  
7  
8 410 January 2003 and 31<sup>st</sup> December 2013 and did not have available data on all variables of interest; <sup>3</sup>chi-squared test indicates difference in distribution of levels  
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10 411 between included and excluded at a level of  $p < 0.05$ ; <sup>4</sup>t-test indicates difference in means between included and excluded at a level of  $p < 0.05$   
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413 **Table 2. Summary of interrupted time series models of the associations between the introduction and withdrawal of the Health in Pregnancy Grant and**  
 414 **outcomes of interest, coefficients (95% CI)**

Model variable	Mean gestational age at booking (days)	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time (months)	0.02 (-0.01 to 0.05)	0.0003 <sup>1</sup> (-0.005 to 0.007)	<b>-0.0002 (-0.0003 to -0.00003)</b> <sup>2</sup>	-0.0001 (-0.0002 to 0.00005)	-0.00003 (-0.0003 to 0.0002)
Level change at introduction	<b>5.29 (2.47 to 8.11)</b>	-0.04 (-0.10 to 0.01)	<b>-0.03 (-0.04 to -0.02)</b>	<b>-0.03 (-0.05 to -0.02)</b>	0.005 (-0.02 to 0.03)
Trend change at introduction	<b>-0.50 (-0.70 to -0.30)</b>	<b>0.005 (0.001 to 0.009)</b>	<b>0.003 (0.002 to 0.004)</b>	<b>0.003 (0.002 to 0.003)</b>	-0.001 (-0.002 to 0.001)
Level change at withdrawal	1.37 (-1.63 to 4.37)	-0.03 (-0.08 to 0.02)	0.001 (-0.01 to 0.02)	-0.01 (-0.02 to 0.004)	0.01 (-0.01 to 0.03)
Trend change at withdrawal	<b>0.35 (0.13 to 0.57)</b>	-0.003 (-0.008 to 0.002)	<b>-0.002 (-0.003 to -0.001)</b>	<b>-0.002 (-0.003 to -0.001)</b>	0.00 (-0.001 to 0.002)

415 <sup>1</sup>Values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001 are shown as 0.00; <sup>2</sup>Bold indicates where 95% confidence  
 416 intervals do not cross 0.

417 **Table 3. Predicted effects (95% CI) of introduction and withdrawal of the Health in Pregnancy Grant at 24 months after each event**

Outcome	21 months after introduction		24 months after withdrawal	
	Absolute change	Relative change (%)	Absolute change	Relative change (%)
Mean gestational age at booking (days)	<b>-4.8 (-8.2 to -2.3)<sup>1</sup></b>	<b>-6.2 (-10.5 to -3.0)</b>	<b>14.0 (2.8 to 16.8)</b>	<b>25.2 (2.1 to 33.2)</b>
Proportion booking by 10 weeks	0.06 (-0.02 to 12.5)	10.3 (-4.2 to 22.6)	-0.14 (-0.24 to 0.03)	-17.4 (-26.8 to 1.3)
Proportion booking by 18 weeks	<b>0.02 (0.01 to 0.04)</b>	<b>2.2 (1.2 to 3.9)</b>	<b>-0.08 (-0.08 to -0.02)</b>	<b>-7.6 (-7.9 to -2.2)</b>
Proportion booking by 25 weeks	<b>0.02 (0.01 to 0.03)</b>	<b>1.9 (0.6 to 3.5)</b>	<b>-0.09 (-0.09 to -0.03)</b>	<b>-8.3 (-8.6 to -3.1)</b>
Proportion of babies small for gestational age	-0.01 (-0.03 to 0.01)	-8.1 (-25.9 to 10.8)	0.03 (-0.03 to 0.08)	29.8 (-57.4 to 104.9)

418 <sup>1</sup>Bold indicates where 95% confidence intervals do not cross 0

419 **Table 4. Summary of interactions between parity and the introduction and withdrawal of the Health in Pregnancy Grant, model coefficients (95% CI),**

Model variable	Mean gestational age booking	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time	0.03 (-0.01 to 0.08)	-0.0002 (-0.001 to 0.0004) <sup>1</sup>	-0.0002 (-0.0004 to 0.00001)	-0.0001 (-0.0003 to 0.00007)	-0.00002 (-0.0003 to 0.0003)
Parity >0 vs 0	0.09 (-2.54 to 2.72)	<b>-0.04 (-0.09 to -0.003)<sup>2</sup></b>	0.008 (-0.006 to 0.02)	0.01 (-0.001 to 0.02)	-0.004 (-0.02 to 0.02)
Parity * time	-0.02 (-0.08 to 0.04)	0.0005 (-0.0005 to 0.001)	0.0002 (-0.002 to 0.002)	0.00005 (-0.0002 to 0.0003)	-0.00002 (-0.0005 to 0.0004)
Level change at introduction	<b>5.57 (1.62 to 9.51)</b>	0.01 (-0.05 to 0.07)	<b>-0.04 (-0.06 to -0.01)</b>	<b>-0.04 (-0.05 to -0.02)</b>	0.01 (-0.02 to 0.04)
Trend change at introduction	<b>-0.50 (-0.78 to -0.21)</b>	0.003 (-0.001 to 0.008)	<b>0.002 (0.001 to 0.004)</b>	<b>0.003 (0.001 to 0.004)</b>	-0.001 (-0.004 to 0.001)
Parity * level change at introduction	-0.61 (-6.19 to 4.97)	-0.04 (-0.13 to 0.04)	0.007 (-0.02 to 0.04)	0.007 (-0.02 to 0.03)	-0.01 (-0.06 to 0.03)
Parity * trend change at introduction	0.01 (-0.39 to 0.41)	0.0006 (-0.006 to 0.007)	-0.001 (-0.002 to 0.002)	-0.0002 (-0.002 to 0.002)	0.002 (-0.002 to 0.005)
Level change at withdrawal	1.03 (-3.16 to 5.22)	-0.02 (-0.08 to 0.05)	0.005 (-0.02 to 0.03)	-0.01 (-0.03 to 0.001)	0.02 (-0.04 to 0.02)
Trend change at withdrawal	0.30 (-0.01 to 0.61)	-0.002 (-0.006 to 0.003)	<b>-0.002 (-0.003 to -0.00)</b>	-0.002 (-0.003 to 0.001)	0.001 (-0.002 to 0.003)
Parity * level change at withdrawal	-0.13 (-5.80 to 6.06)	0.006 (-0.09 to 0.10)	-0.003 (-0.04 to 0.03)	0.001 (-0.03 to 0.03)	-0.03 (-0.07 to 0.02)
Parity * trend change at withdrawal	0.08 (-0.36 to 0.52)	-0.001 (-0.008 to 0.006)	-0.001 (-0.003 to 0.002)	-0.00 (-0.002 to 0.002)	-0.001 (-0.004 to 0.003)

420 <sup>1</sup>Values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001 are shown as 0.00; <sup>2</sup>Bold indicates where 95% confidence  
 421 intervals do not cross 0.

422 **Table 5. Summary of interactions between maternal age and the introduction and withdrawal of the Health in Pregnancy Grant, model coefficients (95% CI)**

	Mean gestational age booking	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time	-0.01 (-0.06 to 0.05)	0.00 <sup>1</sup> (-0.001 to 0.002)	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)
Age group	<b>-3.41 (-5.39 to -1.42)<sup>2</sup></b>	<b>0.05 (0.002 to 0.11)</b>	<b>0.01 (0.004 to 0.02)</b>	0.00 (-0.006 to 0.007)	<b>-0.04 (-0.05 to -0.03)</b>
Age * time	0.03 (-0.01 to 0.08)	-0.00 (-0.001 to 0.001)	-0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)	0.00 (-0.00 to 0.001)
Level change at introduction	3.02 (-0.87 to 6.90)	-0.04 (-0.10 to 0.02)	-0.03 (-0.05 to -0.001)	<b>-0.02 (-0.04 to -0.004)</b>	-0.002 (-0.04 to 0.03)
Trend change at introduction	-0.25 (-0.53 to 0.04)	0.002 (-0.003 to 0.008)	0.002 (-0.00 to 0.004)	<b>0.002 (0.00 to 0.003)</b>	0.00 (-0.002 to 0.003)
Age * level change at introduction	2.15 (-0.86 to 5.16)	-0.01 (-0.06 to 0.04)	-0.003 (-0.02 to 0.02)	-0.005 (-0.02 to 0.001)	0.005 (-0.02 to 0.03)
Age * trend change at introduction	<b>-0.26 (-0.48 to -0.04)</b>	0.001 (-0.003 to 0.005)	0.001 (-0.00 to 0.002)	0.001 (-0.00 to 0.002)	-0.001 (-0.003 to 0.001)
Level change at withdrawal	0.57 (-3.45 to 4.59)	-0.04 (-0.10 to 0.02)	0.01 (-0.02 to 0.04)	-0.006 (-0.03 to 0.02)	0.007 (-0.03 to 0.05)
Trend change at withdrawal	0.08 (-0.24 to 0.40)	-0.00 (-0.006 to 0.005)	-0.001 (-0.003 to 0.001)	-0.001 (-0.003 to 0.00)	-0.001 (-0.00 to 0.002)
Age * level change at withdrawal	1.23 (-1.88 to 4.34)	0.01 (-0.04 to 0.06)	-0.01 (-0.04 to 0.01)	-0.008 (-0.02 to 0.008)	0.002 (-0.03 to 0.03)
Age * trend change at withdrawal	<b>0.27 (0.02 to 0.52)</b>	-0.002 (-0.007 to 0.002)	-0.00 (-0.002 to 0.001)	-0.001 (-0.002 to 0.00)	0.001 (-0.001 to 0.003)

423 <sup>1</sup>Values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001 are shown as 0.00; <sup>2</sup>Bold indicates where 95% confidence  
424 intervals do not cross 0.

425 **Table 6. Summary of interactions between Index of Multiple Deprivation group and the introduction and withdrawal of the Health in Pregnancy Grant, model**  
 426 **coefficients (95% CI)**

	Mean gestational age booking	Proportion booking by 10 weeks	Proportion booking by 18 weeks	Proportion booking by 25 weeks	Proportion of babies SGA
Time	<b>0.11 (0.03 to 0.19)<sup>1</sup></b>	-0.001 (-0.003 to 0.001)	<b>-0.001 (-0.001 to -0.001)</b>	-0.00 (-0.00 to 0.00) <sup>2</sup>	0.00 (-0.00 to 0.00)
Deprivation tertile	<b>4.53 (2.90 to 6.15)</b>	<b>-0.09 (-0.13 to -0.05)</b>	<b>-0.02 (-0.03 to -0.001)</b>	-0.005 (-0.01 to 0.003)	<b>0.04 (0.03 to 0.05)</b>
Deprivation * time	<b>-0.04 (-0.07 to -0.00)</b>	0.00 (-0.00 to 0.001)	0.00 (-0.00 to 0.00)	0.00 (-0.00 to 0.00)	-0.00 (-0.00 to 0.00)
Level change at introduction	<b>17.18 (9.55 to 24.81)</b>	-0.06 (-0.17 to 0.06)	<b>-0.09 (-0.14 to -0.05)</b>	<b>-0.10 (-0.13 to -0.06)</b>	0.01 (-0.05 to 0.07)
Trend change at introduction	<b>-1.04 (-1.59 to -0.49)</b>	0.005 (-0.003 to 0.01)	<b>0.004 (0.001 to 0.007)</b>	<b>0.005 (0.002 to 0.008)</b>	-0.00 (-0.005 to 0.003)
Deprivation * level change at introduction	<b>-5.02 (-8.56 to -1.49)</b>	0.007 (-0.05 to 0.06)	<b>0.03 (0.004 to 0.05)</b>	<b>0.03 (0.01 to 0.04)</b>	-0.001 (-0.03 to 0.03)
Deprivation * trend change at introduction	0.22 (-0.03 to 0.47)	-0.00 (-0.004 to 0.004)	-0.001 (-0.002 to 0.001)	-0.001 (-0.002 to -0.00)	0.00 (-0.002 to 0.002)
Level change at withdrawal	6.47 (-1.68 to 14.62)	-0.06 (-0.18 to 0.06)	-0.008 (-0.06 to 0.04)	-0.03 (-0.07 to 0.01)	0.02 (-0.04 to 0.08)
Trend change at withdrawal	0.59 (-0.005 to 1.18)	-0.002 (-0.01 to 0.01)	-0.002 (-0.006 to 0.001)	<b>-0.003 (-0.006 to -0.00)</b>	-0.001 (-0.006 to 0.003)
Deprivation * level change at withdrawal	-2.10 (-5.88 to 1.67)	0.01 (-0.04 to 0.07)	0.004 (-0.02 to 0.03)	0.008 (-0.01 to 0.03)	-0.003 (-0.03 to 0.03)
Deprivation * trend change at withdrawal	-0.10 (-0.37 to 0.18)	-0.00 (-0.005 to 0.005)	0.00 (-0.002 to 0.002)	0.00 (-0.001 to 0.002)	0.00 (-0.001 to 0.003)

427 <sup>1</sup>Bold indicates where 95% confidence intervals do not cross 0; <sup>2</sup>values are given to two decimal places or, for values <0.1, one significant figure. Values <0.001  
 428 are shown as 0.00.

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2 429 **Figure legends**

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4 430 **Figure 1. Summary of interrupted time series model of the introduction and withdrawal of the Health in**  
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6 431 **Pregnancy Grant on mean gestational age at booking (days)**

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8 432 **Figure 2. Summary of interrupted time series model of the introduction and withdrawal of the Health in**  
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10 433 **Pregnancy Grant on proportion booking before 10 weeks gestation**

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12 434 **Figure 3. Summary of interrupted time series model of the introduction and withdrawal of the Health in**  
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14 435 **Pregnancy Grant on proportion booking before 18 weeks gestation**

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16 436 **Figure 4. Summary of interrupted time series model of the introduction and withdrawal of the Health in**  
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18 437 **Pregnancy Grant on proportion booking before 25 weeks gestation**

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20 438 **Figure 5. Summary of interrupted time series model of the introduction and withdrawal of the Health in**  
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22 439 **Pregnancy Grant on proportion of babies small for gestational age**

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24 440 **Figure 6. Summary of interrupted time series model, interaction between maternal age group and the**  
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26 441 **introduction and withdrawal of the Health in Pregnancy Grant on mean gestational age at booking (days)**

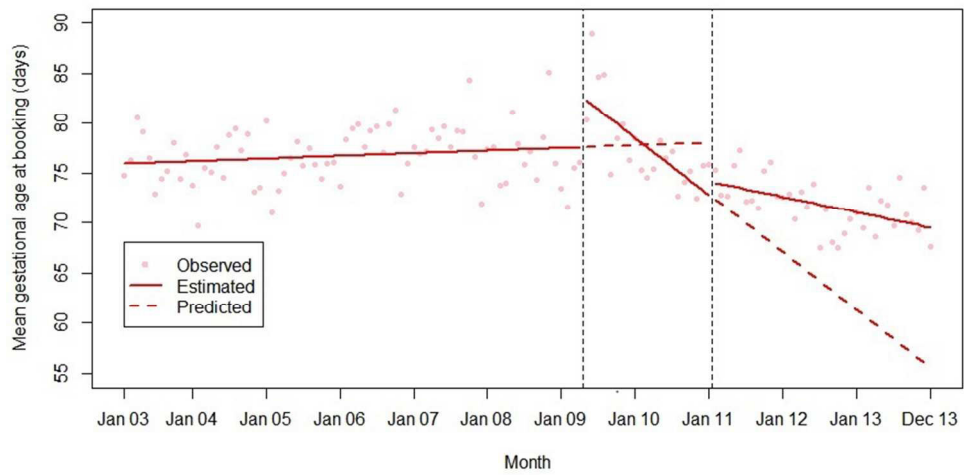
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28 442 **Figure 7. Summary of interrupted time series model, interactions between Index of Multiple Deprivation**  
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30 443 **group and the introduction and withdrawal of the Health in Pregnancy Grant on mean gestational age at**  
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32 444 **booking (days)**

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34 445 **Figure 8. Summary of interrupted time series model, interactions between Index of Multiple Deprivation**  
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36 446 **group and the introduction and withdrawal of the Health in Pregnancy Grant on proportion booking**  
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38 447 **before 18 weeks gestation**

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40 448 **Figure 9. Summary of interrupted time series model, interactions between Index of Multiple Deprivation**  
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42 449 **group and the introduction and withdrawal of the Health in Pregnancy Grant on proportion booking**  
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44 450 **before 25 weeks gestation**



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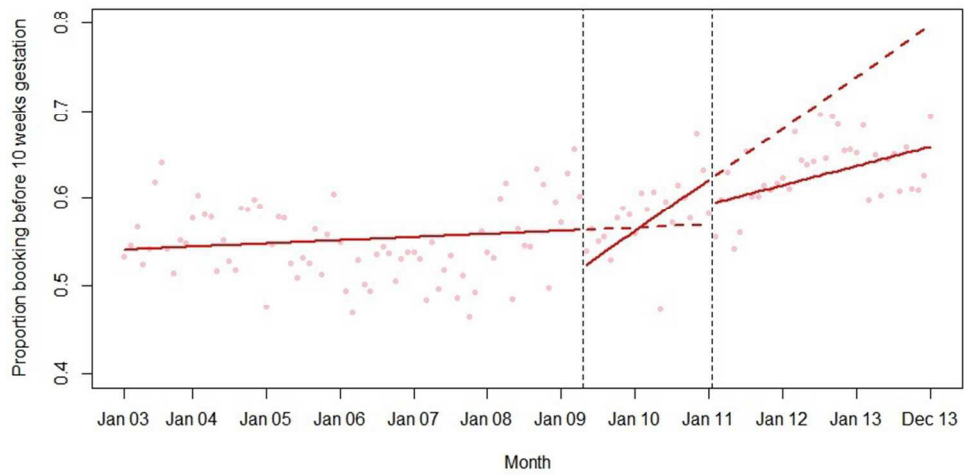


Summary of interrupted time series model of the introduction and withdrawal of the Health in Pregnancy Grant on mean gestational age at booking (days)

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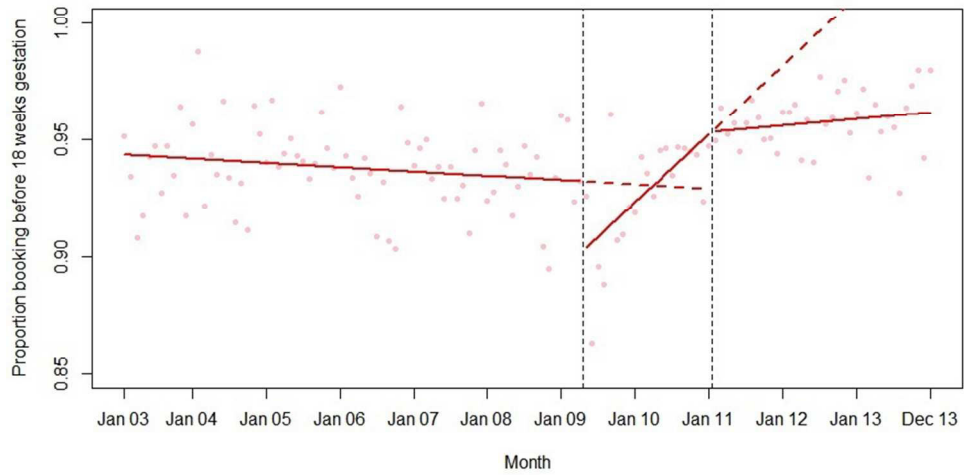


Summary of interrupted time series model of the introduction and withdrawal of the Health in Pregnancy Grant on proportion booking before 10 weeks gestation

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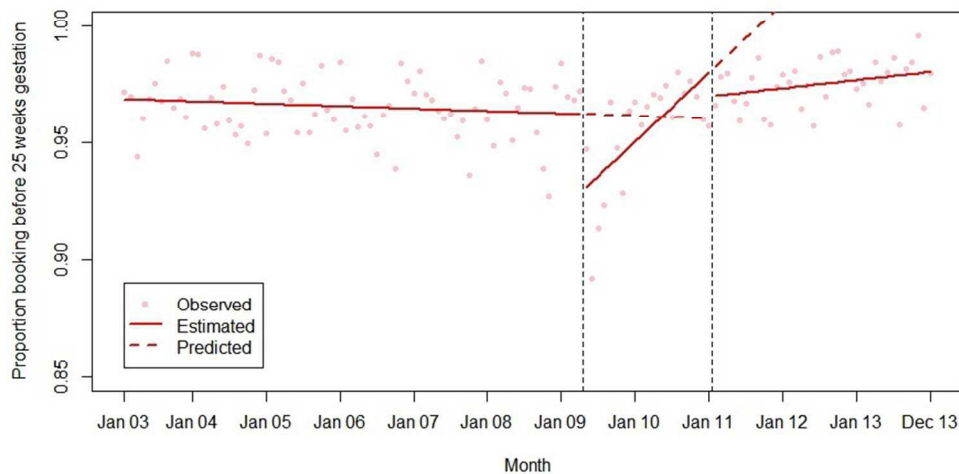


Summary of interrupted time series model of the introduction and withdrawal of the Health in Pregnancy Grant on proportion booking before 18 weeks gestation

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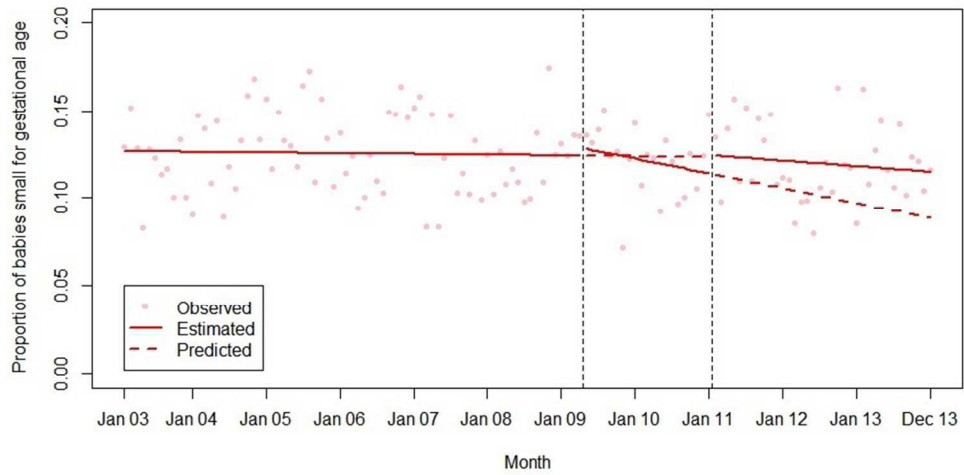


Summary of interrupted time series model of the introduction and withdrawal of the Health in Pregnancy Grant on proportion booking before 25 weeks gestation

76x44mm (300 x 300 DPI)

Review only

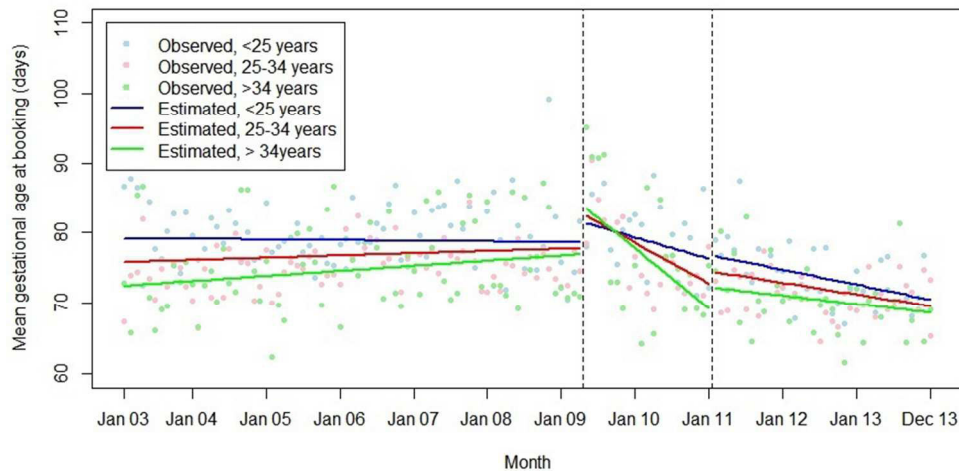
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Summary of interrupted time series model of the introduction and withdrawal of the Health in Pregnancy Grant on proportion of babies small for gestational age

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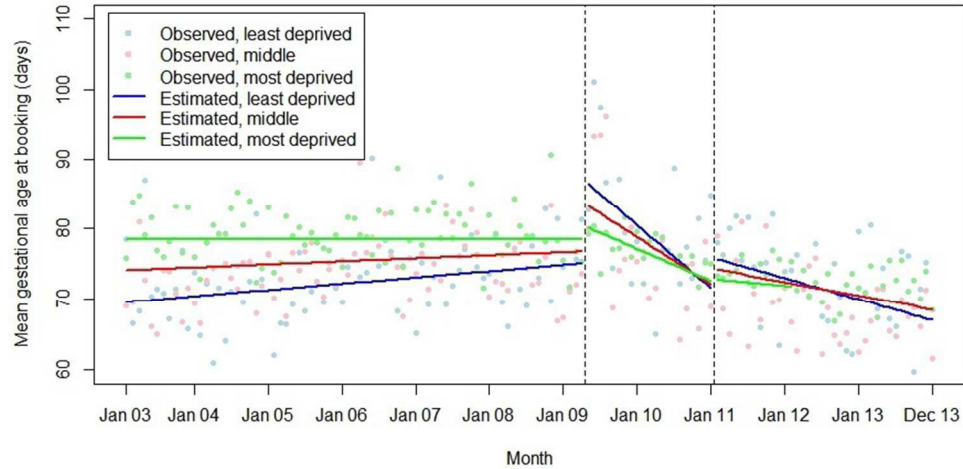
Review only



Summary of interrupted time series model, interaction between maternal age group and the introduction and withdrawal of the Health in Pregnancy Grant on mean gestational age at booking (days)

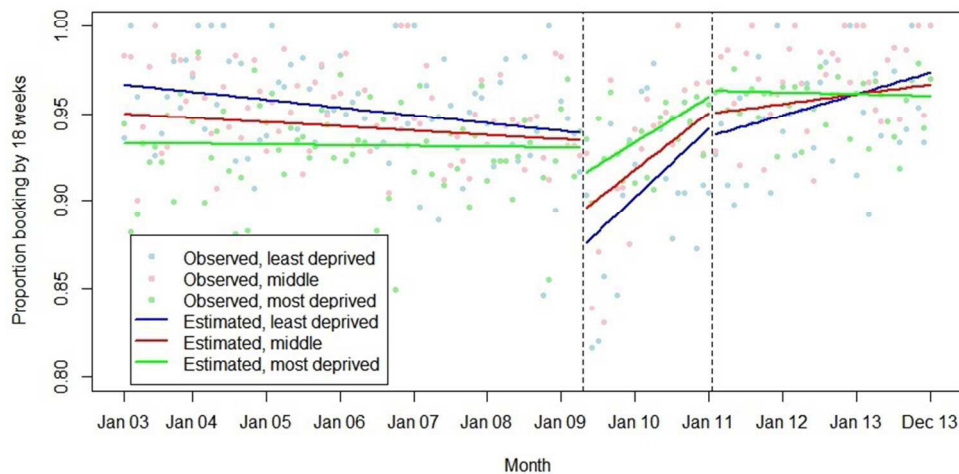
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Review only



Summary of interrupted time series model, interactions between Index of Multiple Deprivation group and the introduction and withdrawal of the Health in Pregnancy Grant on mean gestational age at booking (days)

76x44mm (300 x 300 DPI)

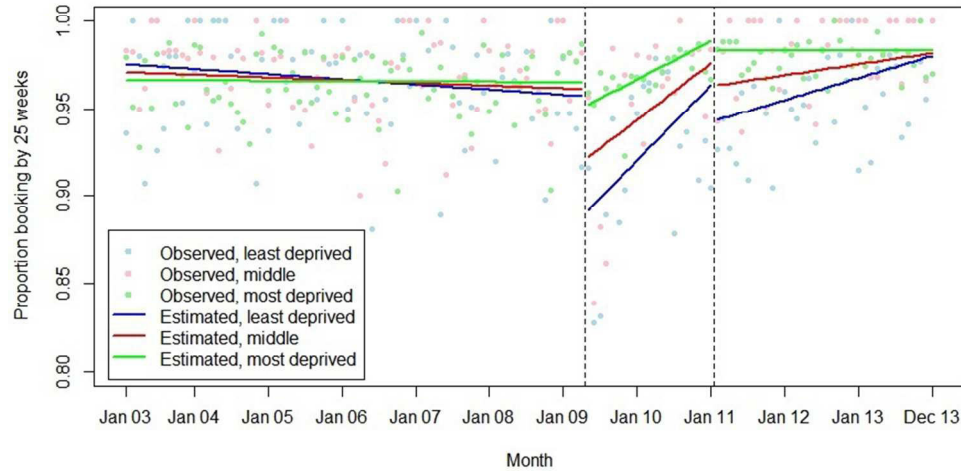


Summary of interrupted time series model, interactions between Index of Multiple Deprivation group and the introduction and withdrawal of the Health in Pregnancy Grant on proportion booking before 18 weeks gestation

76x44mm (300 x 300 DPI)

Review only





Summary of interrupted time series model, interactions between Index of Multiple Deprivation group and the introduction and withdrawal of the Health in Pregnancy Grant on proportion booking before 25 weeks gestation

76x44mm (300 x 300 DPI)

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page/line ref
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	p1, lines 2-3 p2, lines 17-37
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p4-5, lines 58-84
Objectives	3	State specific objectives, including any prespecified hypotheses	p5, lines 85-88
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	p5, line 90
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p5-6, lines 92-106
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	p5-6, lines 92-106 No matching
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Exposures – p5, lines 95-102 Outcomes – p6, lines 106-114 Potential effect modifiers – p6, lines 116-121
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p5-6, lines 92-121
Bias	9	Describe any efforts to address potential sources of bias	p6-7, lines 123-127; p10-11, lines 216-220
Study size	10	Explain how the study size was arrived at	p5, lines 95-101
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p6-7, lines 114-141

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4	Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
5			p7, lines 127-141
6			(b) Describe any methods used to examine subgroups and interactions
7			p7, lines 139-140
8			(c) Explain how missing data were addressed
9			p6-7, lines 121-125
10			(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed
11			Not applicable
12			<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed
13			<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy
14			(e) Describe any sensitivity analyses
15			None – see p10-11, lines 214-218
16	<b>Results</b>		
17	Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
18			Table 1
19			(b) Give reasons for non-participation at each stage
20			Table 1
21			(c) Consider use of a flow diagram
22			Not considered helpful
23	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
24			Table 1
25			(b) Indicate number of participants with missing data for each variable of interest
26			Table 1
27			(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
28			Not applicable
29	Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time
30			Not applicable
31			<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure
32			Not applicable
33			<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
34			Table 1
35	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
36			Tables 2-6
37			(b) Report category boundaries when continuous variables were categorized
38			Table 1
39			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
40			Table 3
41	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
42			Tables 4-6
43	<b>Discussion</b>		
44	Key results	18	Summarise key results with reference to study objectives
45			p9-10, lines 183-195
46	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
47			p10, lines 197-212
	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
			p10-12, lines 214-244
	Generalisability	21	Discuss the generalisability (external validity) of the study results
			p10, lines 211-212

**Other information**

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Funding 22 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study p13-14, lines 276-288 on which the present article is based

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).