BMJ open

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Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-004026
Article Type:	Research
Date Submitted by the Author:	13-Sep-2013
Complete List of Authors:	Li, Yangmei; University of Oxford, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Townend, John; University of Oxford, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Rowe, Rachel; University of Oxford, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Knight, Marian; University of Oxford, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Brocklehurst, Peter; University College London, Institute for Women's Health Hollowell, Jennifer; University of Oxford, National Perinatal Epidemiology Unit, Nuffield Department of Population Health
Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Epidemiology, Medical management, Evidence based practice, Health services research
Keywords:	OBSTETRICS, Midwifery led care, Maternal medicine < OBSTETRICS, Intrapartum care

The effect of maternal age and planned place of birth on intrapartum outcomes in healthy women with straightforward pregnancies: secondary analysis of the Birthplace national prospective cohort study

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Keywords

Maternal age, parity, birthing centre, home birth, augmentation, instrumental delivery, caesarean section, adverse maternal outcomes, adverse perinatal outcomes

Word count

Main text 4,277 words

Abstract

Objectives

To describe the relationship between maternal age and intrapartum outcomes in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth

Design

Prospective cohort study

Setting

Obstetric units, midwifery units and planned home births in England

Participants

63,371 women aged over 16 without any known medical or obstetric risk factors, with singleton pregnancies, planning a vaginal birth

Methods

Log Poisson regression was used to evaluate the association between maternal age, modelled as a continuous and categorical variable, and risk of intrapartum interventions and adverse maternal and perinatal outcomes.

Main Outcome Measures

Intrapartum caesarean section, instrumental delivery, syntocinon augmentation and a composite measure of maternal interventions/adverse outcomes requiring obstetric care encompassing augmentation, instrumental delivery, intrapartum caesarean section, general anaesthesia, maternal blood transfusion, 3rd/4th degree perineal tear, maternal admission for higher level care; adverse perinatal outcome (composite of neonatal unit admission or perinatal death).

Results

Interventions and adverse maternal outcomes requiring obstetric care generally increased with age, particularly in nulliparous women. For nulliparous women aged 16-40, the risk of experiencing an intervention or adverse outcome requiring obstetric care increased more steeply with age in planned non-obstetric unit births than in planned obstetric unit births (adjusted RR 1.21 per 5-year

increase in age, 95% CI 1.18-1.25 vs. adjusted RR 1.12, 95% CI 1.10-1.15) but absolute risks were lower in planned non-OU births at all ages. The risk of neonatal unit admission or perinatal death was significantly raised in nulliparous women aged 40+ relative to women aged 25-29 (adjusted RR 2.29, 95% CI 1.28-4.09).

Conclusions

Younger nulliparous women appear to benefit more than older nulliparous women from planned birth in a non-obstetric unit setting. Age 40 is an appropriate threshold for recommending individual assessment when planning place of birth.

Article summary

Article focus

- Does increasing age in women without known medical or obstetric risk factors increase the risk of intrapartum interventions and adverse outcomes that might affect their choice of planned place of birth?

Key messages

- Older women having a first baby appear to benefit less than younger women from planned birth in a non-obstetric unit setting.
- The chances of experiencing an intervention or outcome that requires obstetric care increase with age, even in women who do not have known risk factors.
- Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

Strengths and weaknesses

Strengths

- The study was based on a large, nationally representative cohort of 'low risk' women, with high quality data collected prospectively.

Weaknesses

- The number of women over 40 was relatively small so the study had limited power to explore effects in women over 40, particularly in non-obstetric unit settings.
- Planned births in non-obstetric unit settings were combined; graphical plots indicated that this was reasonable but important differences between settings cannot be ruled out.

Background

The proportion of births in women aged 35 and over has been steadily rising in recent years in the UK and elsewhere.[1, 2] Currently approximately 16% of births in England and Wales are to women aged 35-39 and 4% of births are to women aged 40 and over.[1]

Advanced maternal age is associated with an increased risk of pregnancy complications including gestational diabetes,[3] pregnancy induced hypertension and preeclampsia,[4, 5] twin or higher order pregnancies,[3] breech presentation,[6] placenta praevia,[3, 7-9] preterm birth,[5, 10] post-term birth,[11], severe maternal morbidity,[12] and adverse perinatal outcomes including antepartum stillbirth,[13] intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission.[5] Older women also have an increased risk of interventions such as induction and caesarean section.[16-20] However, many age-related pregnancy complications are known risk factors for intrapartum complications or adverse perinatal outcomes and women with these risk factors would normally be advised to give birth in an obstetric unit (OU). Relatively little is known about the incidence of intrapartum interventions and adverse maternal and perinatal outcomes in older women who do not have known risk factors.[21]

Current clinical guidelines[22] recommend that healthy women with straightforward pregnancies should be offered a choice of planned birth at home, in a midwife-led unit or in an obstetric unit, but also suggest individual assessment when planning place of birth for women over 40 at booking.[22] The evidence for 'low risk' women in general shows that planned birth in a non-OU setting is associated with a lower incidence of intrapartum interventions[22-28] and research has demonstrated that in 'low risk' women, after adjustment for maternal characteristics, planned birth in a midwifery unit and planned birth at home (multiparous women only) is not associated with an increased risk to the baby compared with planned birth in an OU.[25] However, the risks that might affect the choice of planned place of birth by healthy older women (and in particular nulliparous older women) are not well documented.

The aim of this study was to evaluate the association between maternal age and intrapartum interventions and adverse maternal and perinatal outcomes that may influence the choice of planned place of birth, in 'low risk' women with singleton, term pregnancies planning a vaginal birth.

The main objectives were to describe the relationship between maternal age and intrapartum interventions and adverse outcomes that indicate a need for obstetric or neonatal care in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth.

Methods

Settings and participants

The study used data from the Birthplace in England national prospective cohort study which was designed to compare perinatal and maternal outcomes and interventions by planned place of birth at the start of care in labour.

The cohort study methods are described in full elsewhere.[25, 26] Briefly, the Birthplace cohort included a total of 79,774 births between April 2008 and April 2010, including 32,257 planned OU births from a stratified random sample of 36 OUs, 11,666 planned births in 53 freestanding midwifery units (FMUs), 17,582 planned births in 43 alongside midwifery units (AMUs) and 18,269 planned home births from 142 NHS trusts across England. Births were eligible for inclusion if the woman was planning a vaginal birth and received some labour care from an NHS midwife in her planned birth setting. Women who had an elective caesarean section or caesarean section before the onset of labour, presented in preterm labour (<37 weeks' gestation), had a multiple pregnancy, an unplanned home birth, or who were "unbooked" (received no antenatal care) were excluded. Stillbirths occurring before the start of care in labour were excluded. Women in the cohort were classified as 'low risk' if before the start of labour they were not known to have any of the medical or obstetric risk factors listed in national guidelines on intrapartum care[22] as "indicating increased risk suggesting planned birth in an obstetric unit". The study had a high response rate and low levels of missing data.[25, 26]

The study population for the analyses reported here was 'low risk' women in the Birthplace cohort aged 16 years or over at the time of birth, with a term (gestational age 37^{+0} weeks to 42^{+0} weeks inclusive) pregnancy and parity less than 6. In the NICE intrapartum care guideline individual assessment is recommended when planning place of birth for women with parity of 6 or more and many midwifery units restrict admission to women of parity 5 or less.[29]

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee and did not require consent to be sought from participants as no personally identifiable data were collected.

Data

As described elsewhere,[25] maternal characteristics, and medical or obstetric risk factors known prior to the onset of labour were extracted from the woman's medical records by the midwife attending the birth. Complicating conditions identified by the midwife at the start of care in labour

(for example prolonged rupture of membranes), intrapartum interventions and adverse maternal and perinatal outcomes were recorded by the attending midwife using a data collection form started during labour and completed on or after the fifth postnatal day.

Planned place of birth (OU, AMU, FMU or home) was based on the intended place of birth at the start of care in labour. Women were included in the group in which they planned to give birth at the start of care in labour regardless of whether they were transferred during labour care or immediately after the birth.

Outcomes

We focused on outcome measures that reflected interventions and adverse outcomes that indicated a need for obstetric and/or neonatal care, that is, outcomes that would require the woman and/or baby to be transferred to an obstetric or neonatal unit if labour care or birth took place elsewhere. For women, we considered the following outcomes both separately and as a combined maternal composite outcome ('interventions/adverse outcomes requiring obstetric care'): augmentation with syntocinon, instrumental delivery (ventouse or forceps), intrapartum caesarean section, general anaesthesia, maternal blood transfusion, 3rd/4th degree perineal tear, maternal admission for higher level care. The use of epidural/spinal analgesia was also considered as a secondary outcome. The main outcomes considered for women were the maternal composite outcome, augmentation, instrumental delivery, and intrapartum caesarean section.

For babies, we considered a single composite outcome measure largely reflecting admission to a neonatal unit. This 'perinatal composite outcome' encompassed one or more of the following events: admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death.

Statistical analysis

Analyses were conducted separately by parity. We modelled age at the time of delivery both as a categorical and continuous variable, using log Poisson regression to estimate relative risks adjusted for the following potential confounders: ethnic group, understanding of English, marital or partner status, body mass index (BMI), index of multiple deprivation (IMD) score, gestational age at birth and, where appropriate, planned place of birth (see supplementary Table S1 for categorisation). We also carried out sensitivity analyses in which we additionally adjusted for the presence of complicating conditions identified at the start of care in labour (none, one or more) and for the use of epidural/spinal analgesia.

We fitted a series of models following a pre-specified, iterative strategy. In order to test our modelling assumptions regarding age and to determine whether it was appropriate to combine data for planned births in non-OU settings, we plotted outcomes by age and planned place of birth using polynomial smoothing.[30] Visual inspection of these plots (see Figure 1 for the main outcomes) indicated that it was reasonable to model age as a continuous variable within the age range 16-40 (inclusive) and further indicated that event rates were generally similar in the three non-OU settings, suggesting that it was reasonable to combine the non-OU settings for the purposes of exploring interactions between maternal age and planned place of birth. We did not model age as a continuous variable above the age of 40 because data were sparse, particularly for planned non-OU births to nulliparous women, and we could not be confident that the broadly linear trends seen at younger ages could be extrapolated above this age.

We initially modelled the effect of age on study outcomes separately by parity and for all planned places of birth combined. Models in which age was modelled as a continuous variable were restricted to the age range 16-40 inclusive. For each of the study outcomes, we tested for an interaction between age (as a continuous variable) and planned place of birth (OU vs. non-OU) using a Wald test, and where the interaction was significant at the 5% level, we modelled the effect of age on the outcome separately by planned place of birth.

In order to test whether the presence of complicating conditions at the start of care in labour (for example prolonged rupture of membranes) had an effect on the observed relationships, we fitted a further set of models in which we adjusted for both maternal characteristics and the presence of complicating conditions. Because previous analyses have shown that women planning birth in an OU have a higher prevalence of complicating conditions than in other settings[25] and this affects the magnitude of the difference in event rates between settings, we carried out further analyses of the main outcomes restricted to 'low risk' women without complicating conditions at the start of care in labour.

Robust variance estimation was used to allow for the clustered nature of the data and, as described elsewhere,[25, 26] probability weights were incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs. The weighting is such that, when applied to the pooled data for all four settings, the weighted event rates represent the estimated average event rates for England as a whole.

For each outcome, we calculated the number of events, the number of births, the weighted incidence and the unadjusted and adjusted relative risks. We assessed statistical significance at the 5% level.

Results

Description of the study sample

From the 79,774 women in the Birthplace cohort we excluded 15,553 women who had pre-existing medical and obstetric risk factors, 62 women who were aged <16, 682 women who had missing data on risk factors, parity or gestational age, and 106 whose age was missing . The study population consisted of 63,371 eligible 'low risk' women. The proportion (weighted) of women who were ineligible because of pre-existing medical or obstetric risk factors, increased from 31.9% in women aged 16-19 to 46.7% in women aged 40 and over.

Table 1 describes the characteristics of the sample by age. The percentages shown in the table are weighted so that they provide an estimate of the distribution of maternal characteristics that would apply to eligible 'low risk' births in England. Older women tended to be white, have a fluent understanding of English, and were more likely than younger women to live in a socioeconomically advantaged area. They were less likely than younger women to be nulliparous and more likely to have had multiple previous pregnancies. Planned home births were more common at older ages (Table 1 and supplementary Tables S2 and S3), particularly in multiparous women (supplementary Table S3). Older women were more likely to have complicating conditions, such as prolonged rupture of membranes, noted by the midwife at the start of care in labour (Table 1). Complicating conditions at start of care in labour were more common in nulliparous women (supplementary Tables S2 and S3).

[TABLE 1 HERE]

Maternal interventions and adverse outcomes

Descriptive plots of outcomes by age indicated that the incidence of most outcomes tended to increase steadily with age in the age range 16 to 40, and that incidence rates were generally lower in planned non-OU births (Figure 1 and supplementary Figure S1). Rates for planned OU and non-OU births tended to diverge above this age range, but rates were based on small numbers of older women (supplementary Table S4) particularly for planned AMU and FMU births and therefore these rates have wide confidence intervals.

For nulliparous women in the age range 16-40 (all PPOBs combined), the adjusted risk of having an intervention/ adverse outcome requiring obstetric care (maternal composite) increased significantly with age, as did the risk of augmentation with syntocinon, instrumental delivery, intrapartum caesarean section, 3rd/4th degree perineal tear, or maternal admission for higher level care (Table 2).

For augmentation with syntocinon and the maternal composite outcome, the effect of age differed by PPOB (Table 2). The risk of augmentation increased more steeply with age in non-OU settings (RR 1.23, 95% CI 1.18-1.28 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.07-1.17 for planned OU births). Nevertheless, the proportion of women receiving augmentation was lower in planned non-OU births at all ages (Table 3). For example, 42.2% (95% CI 36.4%-48.1%) of nulliparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 22.6% (95% CI 19.8%-25.7%) of nulliparous women of the same age who planned birth in a non-OU setting. A similar pattern was observed for the maternal composite outcome: the risk of an intervention/adverse outcome requiring obstetric care (maternal composite) increased slightly more steeply with age in the non-OU settings (RR 1.21, 95% CI 1.18-1.25 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.10-1.15 for planned OU births) but the absolute risk was lower in the planned non-OU birth (Table 3). For example, 65.5% (95% CI 61.8%-69.1%) of nulliparous women aged 35-39 who planned birth in an OU experienced an intervention/adverse outcome requiring obstetric care compared with 39.9% (95% CI 36.0%-43.9%) of nulliparous women of the same age who planned birth in a non-OU setting.

[TABLE 2 AND TABLE 3 HERE]

In nulliparous women, the risk of instrumental delivery and intrapartum caesarean section increased significantly with age (RR 1.18, 95% CI 1.12-1.25 and RR 1.27, 95% CI 1.23-1.32) across all settings. Again, absolute risks were substantially lower in planned non-OU births (Table 3).

For multiparous women aged 16-40 (all PPOBs combined), the combined risk of having an intervention or adverse outcome requiring obstetric care (maternal composite) or of instrumental delivery, intrapartum caesarean section, and maternal admission for higher level care increased with age (Table 2). Augmentation with syntocinon, general anaesthesia, blood transfusion, and 3rd/4th degree perineal tear were not associated with maternal age in multiparous women (Table 2). For all of the outcomes considered, the effect of age did not differ by PPOB in multiparous women (Table 2). Again, for the maternal composite outcome, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section, the absolute event rates were lower in planned non-OU births in most age categories (Table 4). For example, 9.8% (95% CI 8.2%-11.6%) of multiparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 1.8% (95% CI 1.3%-2.5%) of women of the same age who planned birth in a non-OU setting.

Up to age 40, other less common outcomes did not increase significantly with maternal age in nulliparous or multiparous women with the exception of maternal admission to higher level care (Table 2 and supplementary Tables S5 and S6).

[TABLE 4 HERE]

Adjustment for complicating conditions at the start of care in labour had a negligible effect on the relationship between age and the study outcomes (supplementary Table S7). Absolute event rates for the main outcomes (maternal composite, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section and perinatal composite) were reduced when the analysis was restricted to women without complicating conditions identified at start of labour care but absolute intervention rates remained substantially higher at all ages in planned OU births vs. planned births in other settings (supplementary Tables S8 and S9).

The use of epidural/spinal analgesia increased significantly with maternal age and lower rates of use were observed in planned non-OU births (supplementary Figure S2). Adjustment for use of epidural in the multivariable models attenuated but did not change the results materially (data not shown).

Perinatal outcome

The perinatal composite outcome (admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death) showed a modest but not statistically significant increase with age in nulliparous women in the age range 16-40 (Table 2). The risk increased significantly in nulliparous women aged 40+ compared with women aged 25-29 (RR 2.29, 95%CI 1.28-4.09, adjusted for maternal characteristics and planned place of birth, all settings combined). Maternal age was not significantly associated with the risk of the perinatal composite outcome in multiparous women in the age range 16-40 (Table 2) and the risk was not significantly increased in births to multiparous women aged 40+ compared with women aged 25-29 (RR 1.21, 95% CI 0.60-2.43, adjustment as before). Absolute event rates are shown in Table 5.

[TABLE 5 HERE]

Discussion

Principal findings

In women without known medical or obstetric risk factors prior to the onset of labour, interventions and adverse maternal outcomes requiring obstetric care generally increased with age, but there was no age at which there was a step-change in risk. For both nulliparous and multiparous women, maternal intervention rates were lower in births planned in non-OU settings compared with planned OU births, but for nulliparous women the overall risk of experiencing an intervention or adverse outcome requiring obstetric care, and in particular of augmentation with syntocinon, increased more steeply with age in planned non-OU births than in planned OU births. As a consequence, the benefit of planned non-OU birth was greatest at younger ages and reduced with increasing age.

In low risk women up to the age of 40, the risk of neonatal unit admission or intrapartum stillbirth/early neonatal death did not show a statistically significant upward trend with age in either nulliparous or multiparous women. In planned OU births, the risk of neonatal unit admission or perinatal death was significantly higher in nulliparous women aged 40+ relative to women aged 25-29.

Strengths and limitations

A strength of the study is that we were able to evaluate the effect of age on intrapartum outcomes by planned birth setting in a nationally representative sample of 'low risk' women. In order to strengthen the evidence supporting clinical guidelines on planned place of birth, the study specifically focused on outcomes that reflect need for obstetric or neonatal care in a sample of women who meet the current criteria for planned birth in a non-OU setting.[22] To our knowledge, this is the first study to investigate the effect of increasing maternal age in different birth settings with a focus on outcomes that would require transfer to an OU and hence may affect the choice of planned place of birth.

Despite the large overall sample size, the number of older women was relatively small, so we had limited ability to explore effects above age 40 or to separate results of individual non-OU birth settings. We combined data for the non-OU settings, having first explored the data to check that this was reasonable. This increased our statistical power to evaluate the association between maternal age and the study outcomes (maternal and perinatal), but we still lacked the statistical power to evaluate uncommon outcomes. It is important to note that previous analyses[25] have shown that planned home births are associated with a significantly increased risk of adverse perinatal outcomes in nulliparous women.

The risk of bias due to missing data and non-response was low: the study had a low level of missing data, a high response rate[25, 26] and, because consent was not required, there was no self-selection bias due to non-consent. We controlled for important potential confounders such as body mass index and, because the study focused on a relatively homogeneous population of women without known medical or obstetric risk factors, uncontrolled differences in clinical risks between groups seem unlikely to explain our findings. Nevertheless, women self-select their birth setting and it may be that some of the differences in outcomes that we observed between settings may have been due to unmeasured differences in the characteristics of women opting for OU and non-OU births, rather than to differences attributable to the birth setting.

Comparison with the existing literature

Older women have been shown to have an increased risk of intrapartum intervention,[6, 31] but many studies include women known to be at higher risk who would normally be advised to give birth in an obstetric unit. Evidence relating to 'low risk' women[17] or from studies that have controlled for pre-existing risk factors or complications[32] is more limited but is generally consistent with our finding that intervention rates increase with age in 'low risk' women.

There is extensive evidence that 'low risk' women who plan birth in a non-OU setting have a reduced risk of a range of intrapartum interventions, including augmentation, instrumental delivery and intrapartum caesarean section, and are more likely to have a spontaneous vaginal birth.[22-24, 27, 28] Our study found that, across the age range 16-40, women who plan birth in a non-OU setting experience substantially lower intervention rates and are less likely to experience an outcome requiring obstetric care than women of the same age who plan birth in an obstetric unit.

In nulliparous women we found that rates of augmentation of labour with syntocinon increased more steeply with maternal age in planned non-OU births compared with planned OU births. An age-related increase in augmentation is consistent with evidence of poorer uterine function at older ages,[33] longer labours[33] and an increased incidence of prolonged labour,[34, 35] but the reasons for a steeper increase in augmentation with age in non-OU settings is unclear. It has been suggested that labelling of older women as 'higher risk' and/or heightened concern about the safety of older nulliparous women, particularly those who have required fertility treatment, may result in increased rates of caesarean section for non-medical reasons,[20, 31, 32, 36] and it is possible that similar factors affect midwives' decision making regarding transfer for failure to progress, or for other reasons. Intrapartum transfers from midwifery units in the Birthplace study have been shown to increase significantly with age in nulliparous women[37] and, once transferred, women are 'exposed' to the higher intervention rates found in obstetric units.

It is also possible that age-related differences in women's expectations and expressed preferences may contribute to the pattern of intervention observed in our study. Older nulliparous women have been found to have a more positive attitude towards caesarean section,[38] for example, and also to have a higher perception of pregnancy risk, even in older women without known risk factors.[39] The significant positive association between maternal age and epidural use observed in our study (seen most strongly in nulliparous women planning a non-OU birth), would be consistent with a greater willingness of older women to consider interventions.

We found a significantly increased risk of maternal admission to higher level care at older ages in both nulliparous and multiparous women. The number of events was small and this could be a chance finding but an increase in serious obstetric complications at older ages observed in some studies[3, 6, 12] cannot be ruled out.

Although studies including women with known risk factors have reported increased risks in women aged over 35,[3, 6, 34] our analysis shows that up to the age of 40, risks tend to increase in a broadly linear manner in healthy women with straightforward pregnancies, with no evidence of a step-change in risk below the age of 40. Other studies have similarly concluded that the association of adverse outcomes with maternal age is a continuum,[3] with the increase in adverse perinatal outcomes possibly gaining momentum above the age of 40.[40] Because of the small number of births to mothers aged over 40 in our sample we had limited power to evaluate risks at older ages and other evidence relating to older 'low risk' women is sparse.[21]

There is some evidence that the babies of older women are at increased risk of serious adverse outcomes, including intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission,[5, 32] but these outcomes would be expected to be substantially reduced in 'low risk' women who, by definition, do not have medical or obstetric risk factors such as severe obesity, diabetes or previous caesarean section. Furthermore, the poorer outcomes associated with the increased risk of pre-term birth at older ages do not apply to women giving birth at term. In our 'low risk' cohort, we did not observe a significant increase with age in our composite measure of neonatal unit admission/perinatal death within the age range 16-40, but graphical plots for nulliparous women suggested a possible upturn in neonatal unit admission/perinatal death around the age of 40 in nulliparous women. Further research evaluating perinatal outcomes in 'low risk' women aged over 40 is needed.

Conclusions and policy implications

The incidence of intrapartum interventions and adverse outcomes requiring obstetric care increases with maternal age, but at all ages 'low risk' women who plan birth in a non-obstetric unit setting

tend to experience lower intervention rates than comparable women who plan birth in an OU. Younger nulliparous women appear to benefit more than older nulliparous women from planned birth in a non-OU setting. Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

The findings support the current threshold of age 40 for recommending individual assessment when planning place of birth. Healthy older nulliparous women with straightforward pregnancies planning birth in non-OU setting should be informed that they have an increased risk of interventions that require transfer to an OU. Further research is required to evaluate adverse perinatal outcomes in 'low risk' women aged over 40.

Acknowledgements

We thank Xiaosi Wang for conducting initial literature searches and statistical analysis.

Competing interests

None.

Contribution to authorship

JH conceived and developed the study outline with input from PB; YL developed the protocol and analysis plan with input from JH, JT and MK; YL conducted the analysis; JT provided statistical advice; YL and JH drafted the manuscript with input from RR, MK and PB. All authors were involved in interpretation of data, review and revision of the draft manuscript and approval of the final version.

Ethics Approval

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee (MREC ref 07/H0505/151).

Funding

This paper reports on an independent study which is funded by the Policy Research Programme in the Department of Health. The views expressed are not necessarily those of the Department.

Birthplace combines the Evaluation of Maternity Units in England study funded in 2006 by the National Institute for Health Research Service Delivery and Organisation (NIHR SDO) programme, and the Birth at Home in England study funded in 2007 by the Department of Health Policy Research Programme (DH PRP). From January 2012, the NIHR SDO programme merged with the NIHR Health Services Research programme to establish the new NIHR health Services and Delivery Research (NIHR HS&DR) programme. The views and opinions expressed by the authors do not necessarily reflect those of the HS&DR Programme, NIHR, NHS, DH PRP or the Department of Health.

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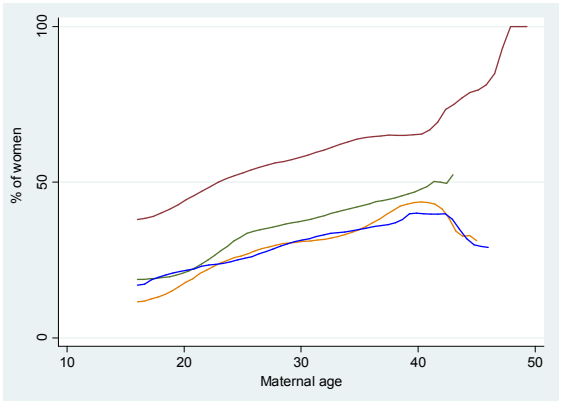
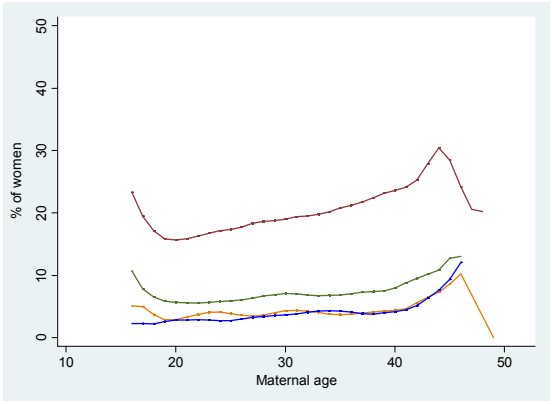


(a) Maternal composite, nulliparous women



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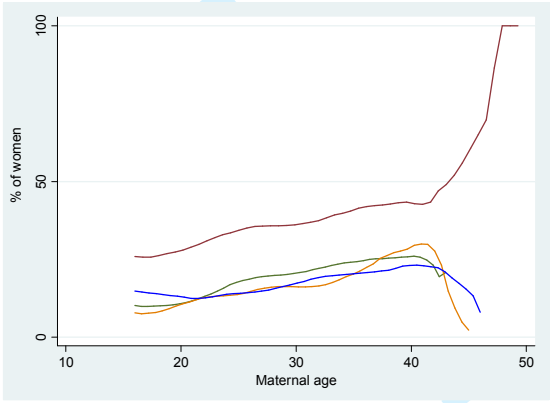

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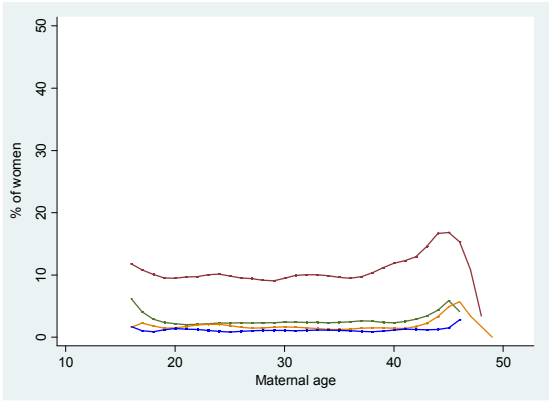

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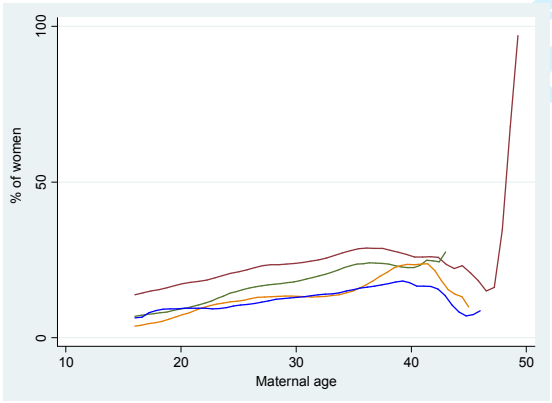
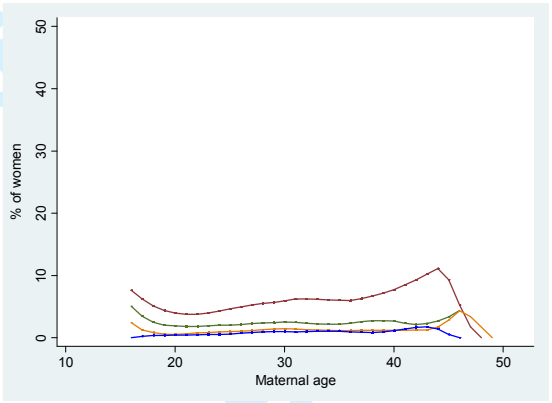
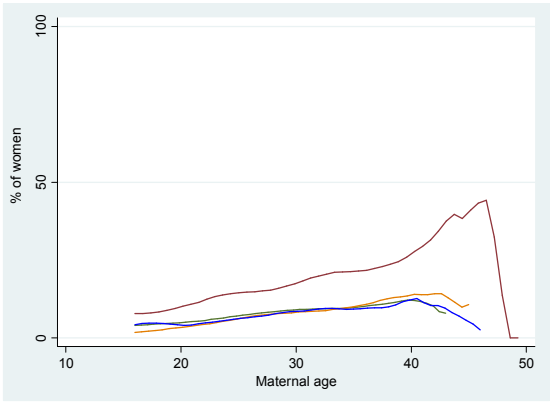


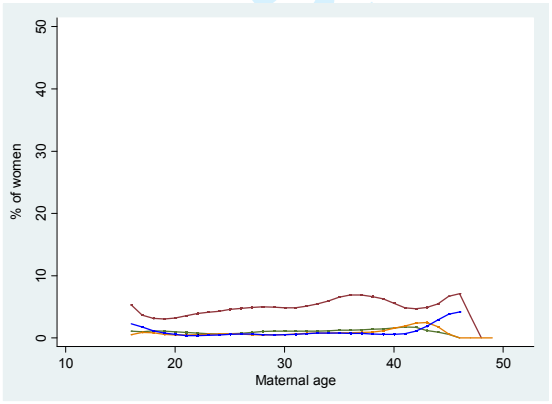
(c) Instrumental delivery, nulliparous women



(g) Instrumental delivery, multiparous women



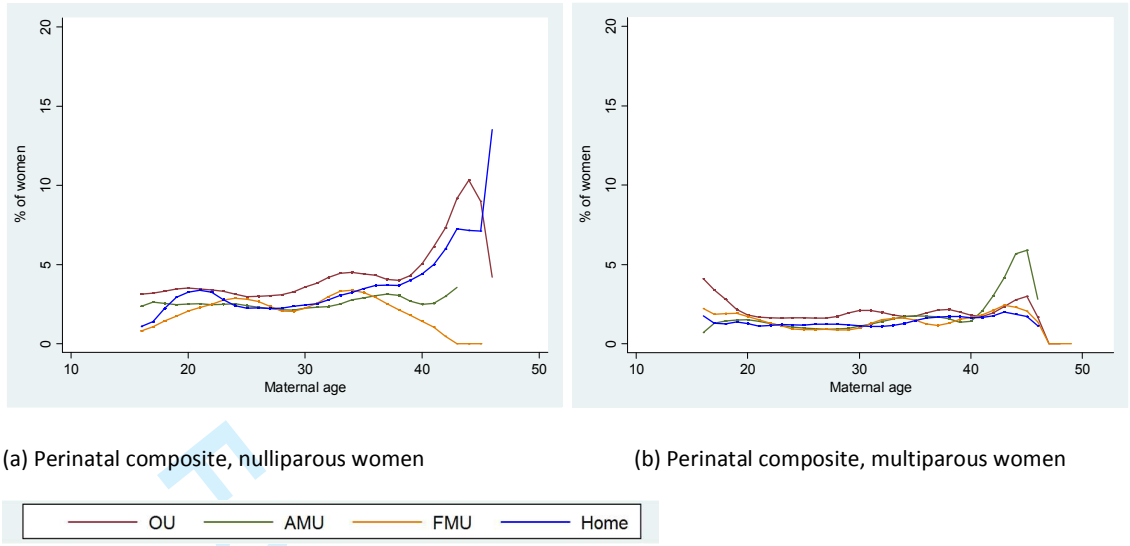
(d) Intrapartum caesarean section, nulliparous



(h) Intrapartum caesarean section, multiparous

Figure 1 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over[1]

[1] NOTE THAT scales for nulliparous women and multiparous women are different.



(a) Perinatal composite, nulliparous women

(b) Perinatal composite, multiparous women

Figure 2 Association between maternal age and perinatal composite outcome in low risk women aged 16 and over

Table 1 Characteristics of low risk women aged 16 and over by maternal age category

	16 - 19 years n=3354		20 - 24 years n=11395		25 - 29 years n=18091		30 - 34 years n=18453		35 - 39 years n=10397		≥ 40 years n=1681	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	3078	90.1	9685	81.2	15146	77.5	16052	80.7	9339	84.3	1527	86.6
Non-white	275	9.9	1697	18.8	2920	22.5	2375	19.3	1044	15.8	153	13.4
Missing	1		13		25		26		14		1	
Understanding of English												
Fluent	3254	96.7	10394	89.6	16757	90.0	17605	92.9	10155	96.3	1638	96.7
Not fluent	94	3.3	948	10.4	1251	10.0	776	7.1	214	3.7	36	3.4
Missing	6		53		83		72		28		7	
Marital/partner status												
Married/living with partner	1836	51.9	9550	81.8	16868	92.1	17782	96.1	10004	95.4	1591	94.4
Single/unsupported by partner	1440	48.1	1677	18.2	1010	7.9	493	3.9	293	4.7	68	5.7
Missing	78		168		213		178		100		22	
BMI in pregnancy (kg/m^2)												
< 18.5	184	6.2	426	4.2	413	2.6	337	2.1	156	1.5	18	0.2
18.5 - 24.9	1753	50.3	5316	45.6	8560	45.9	9059	46.7	4864	44.5	802	46.4
25.0 - 29.9	598	17.9	2558	21.7	4341	24.6	4206	23.2	2572	26.9	415	27.6
30.0 - 35.0	233	7.6	1096	10.0	1627	9.3	1399	8.8	769	8.9	109	8.1
Not recorded	581	18.1	1969	18.4	3091	17.6	3389	19.2	2000	18.3	329	17.7
Missing	5		30		59		63		36		8	
IMD quintile												
1st (Least deprived)	245	6.8	1102	8.5	2875	13.8	4255	20.5	2783	24.6	434	26.0
2nd	405	12.3	1521	13.3	3259	17.5	4114	21.7	2434	22.3	396	22.0
3rd	637	18.2	2115	18.0	3657	18.6	3759	19.7	2135	20.0	357	21.6
4th	827	25.3	2784	23.9	3957	22.7	3479	19.8	1765	17.9	291	16.9
5th (Most deprived)	1221	37.5	3821	36.2	4262	27.5	2759	18.4	1215	15.2	197	13.7
Missing	19		52		81		87		65		6	
Previous pregnancies ≥ 24 weeks												
0	2835	86.8	6341	62.0	8438	53.6	7307	46.7	2989	36.9	346	28.0

1	474	12.1	3772	29.4	5892	29.9	6963	33.9	3929	35.5	540	32.3
2	38	0.8	1006	6.8	2549	10.9	2779	12.2	2260	17.4	414	20.2
3-5	7	0.3	276	1.9	1212	5.6	1404	7.2	1219	10.2	381	19.5
Missing												
Gestation at delivery (completed weeks)												
37	119	4.1	351	3.5	530	3.6	534	3.5	275	3.1	52	3.2
38	305	11.0	1136	10.1	1743	9.9	1739	9.9	971	10.2	146	9.9
39	783	22.5	2788	24.4	4409	24.2	4439	23.5	2516	23.2	410	27.2
40	1292	36.7	4361	36.7	6970	36.2	7090	37.5	3933	35.9	639	35.0
41 - 42+0 days	855	25.7	2759	25.3	4439	26.1	4651	25.6	2702	27.7	434	24.7
Planned place of birth												
OU	1445	87.5	4150	84.9	5601	82.6	4946	80.7	2571	80.2	497	83.2
AMU	1038	8.5	3445	9.6	4958	10.1	4540	10.3	2212	9.6	294	7.9
FMU	661	3.2	2115	3.5	3242	3.8	3216	3.9	1674	3.8	249	3.0
Home	210	0.8	1685	2.0	4290	3.5	5751	5.1	3940	6.4	641	5.8
Birth weight (grams)												
< 2500	53	1.9	146	1.8	166	1.4	159	1.1	75	1.0	17	1.3
2500 - 2999	561	18.4	1728	16.4	2281	14.5	1924	12.7	1100	12.5	168	12.8
3000 - 3499	1502	44.6	4678	41.1	7171	39.3	6960	38.2	3644	36.5	596	37.1
3500 - 3999	977	28.4	3664	30.9	6256	33.4	6767	35.0	3888	35.3	617	36.9
4000 - 4499	233	6.0	1023	8.7	1926	10.0	2294	11.4	1432	12.5	239	9.9
≥ 4500	21	0.7	135	1.2	262	1.5	303	1.6	237	2.3	40	2.0
Missing	7		21		29		46		21		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	145	7.1	411	6.1	678	6.5	706	7.1	415	7.0	78	8.9
Meconium stained liquor	126	5.8	322	4.8	469	5.0	541	6.1	295	5.9	60	7.4
Proteinuria 1+ or more	79	2.3	203	1.7	261	1.9	226	1.6	109	1.7	20	1.6
Hypertension	55	2.6	160	2.2	232	2.4	207	2.0	102	2.1	17	2.0
Abnormal vaginal bleeding	16	0.7	57	0.9	79	0.9	119	1.5	77	2.1	16	2.1

Non-cephalic presentation	5	0.2	31	0.5	44	0.4	64	0.5	46	0.7	3	0.3
Abnormal fetal heart rate	41	1.5	106	1.7	162	1.8	143	1.7	82	1.7	27	3.0
Other complications	14	0.6	24	0.3	23	0.2	27	0.1	11	0.2	2	0.2
Any complicating condition	431	18.5	1175	16.1	1744	16.6	1829	18.0	1001	18.1	199	22.5

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 2 Association between maternal age (per 5-year increase) and maternal and perinatal outcomes in low risk women aged between 16 and 40 years old (inclusive)

	Nulliparous women				Multiparous women			
	Unadjusted[1]		Adjusted[1, 2]		Unadjusted[1]		Adjusted[1, 2]	
	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Maternal composite	1.13	(1.11-1.16)	1.13	(1.11-1.16)	1.07	(1.03-1.13)	1.08	(1.03-1.14)
OU	1.13	(1.11-1.16)	1.12	(1.10-1.15)				
Non-OU[1, 3]	1.22	(1.19-1.26)	1.21	(1.18-1.25)				
		Wald test for interaction	$P^{1,4}$ <0.001			Wald test for interaction	$P^{1,4}$ =0.34	
Augmentation	1.13	(1.09-1.16)	1.12	(1.08-1.17)	1.00	(0.92-1.08)	1.01	(0.92-1.11)
OU	1.13	(1.09-1.17)	1.12	(1.07-1.17)				
Non- OU[1, 3]	1.25	(1.20-1.31)	1.23	(1.18-1.28)				
		Wald test for interaction	$P^{1,4}$<0.001			Wald test for interaction	$P^{1,4}$ =0.24	
Instrumental delivery	1.20	(1.13-1.26)	1.18	(1.12-1.25)	1.14	(1.04-1.25)	1.15	(1.05-1.27)
		Wald test for interaction	$P^{1,4}$ =0.18			Wald test for interaction	$P^{1,4}$ =0.06	
Intrapartum caesarean section	1.27	(1.23-1.31)	1.27	(1.23-1.32)	1.16	(1.07-1.26)	1.16	(1.06-1.28)
		Wald test for interaction	$P^{1,4}$ =0.26			Wald test for interaction	$P^{1,4}$ =0.50	
General anaesthesia	1.06	(0.93-1.20)	1.06	(0.92-1.22)	1.05	(0.87-1.27)	1.09	(0.91-1.32)
		Wald test for interaction	$P^{1,4}$ =0.83			Wald test for interaction	$P^{1,4}$ =0.15	
Maternal blood transfusion	1.09	(0.97-1.23)	1.13	(0.95-1.34)	1.23	(0.95-1.60)	1.24	(0.94-1.62)
		Wald test for interaction	$P^{1,4}$ =0.38			Wald test for interaction	$P^{1,4}$ =0.44	
Third/fourth degree perineal tear	1.17	(1.09-1.27)	1.12	(1.02-1.23)	1.10	(0.98-1.23)	1.01	(0.89-1.15)
		Wald test for interaction	$P^{1,4}$ =0.43			Wald test for interaction	$P^{1,4}$ =0.29	
Maternal admission for higher level care	1.28	(1.03-1.58)	1.46	(1.07-1.99)	1.40	(1.01-1.92)	1.49	(1.06-2.10)
		Wald test for interaction	$P^{1,4}$ =0.41			Wald test for interaction	$P^{1,4}$ =0.15	
Perinatal composite	1.07	(0.97-1.17)	1.06	(0.95-1.17)	1.02	(0.87-1.19)	0.98	(0.84-1.15)
		Wald test for interaction	$P^{1,4}$ =0.92			Wald test for interaction	$P^{1,4}$ =0.66	

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. AMU vs. FMU vs. home).

[3] Results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[4] P for interaction, results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. non-OU).

Table 3 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	480/1239	39.4	(35.6-43.3)	252/1553	17.5	(15.2-20.1)
20-24	1229/2577	47.9	(44.7-51.1)	886/3679	24.2	(21.8-26.8)
25-29	1670/3003	55.6	(53.4-57.9)	1680/5354	32.3	(29.5-35.2)
30-34	1402/2322	61.1	(57.3-64.8)	1730/4897	36.6	(34.2-39.1)
35-39	622/957	65.5	(61.8-69.1)	792/1995	39.9	(36.0-43.9)
40+	108/148	71.9	(63.0-79.3)	83/196	44.8	(35.2-54.7)
Total	5511/10246	54.4	(51.9-56.9)	5423/17674	31.3	(29.3-33.4)
Augmentation						
16-19	317/1245	25.9	(22.5-29.7)	141/1564	8.6	(7.0-10.5)
20-24	790/2584	30.7	(26.9-34.7)	489/3706	12.9	(11.1-14.9)
25-29	1079/3011	35.7	(33.4-38.1)	918/5372	17.4	(15.6-19.3)
30-34	867/2318	37.5	(34.1-41.1)	964/4921	19.9	(18.3-21.7)
35-39	402/955	42.2	(36.4-48.1)	473/2015	22.6	(19.8-25.7)
40+	71/149	47.6	(37.0-58.4)	44/196	23.7	(15.7-34.1)
Total	3526/10262	34.6	(31.9-37.4)	3029/17774	16.9	(15.7-18.1)
Instrumental delivery						
16-19	191/1266	15.1	(12.5-18.2)	99/1568	7.9	(6.2-10.2)
20-24	469/2618	17.9	(15.9-20.0)	392/3717	10.6	(8.9-12.5)
25-29	707/3039	23.4	(21.3-25.6)	772/5391	15.0	(13.1-17.0)
30-34	591/2349	26.3	(21.3-32.1)	795/4950	17.0	(15.2-19.1)
35-39	275/968	29.5	(25.0-34.4)	401/2018	19.4	(15.9-23.6)
40+	41/149	30.4	(20.0-43.2)	37/197	21.0	(13.3-31.5)
Total	2274/10389	22.5	(19.9-25.3)	2496/17841	14.5	(13.0-16.0)
Intrapartum caesarean section						
16-19	101/1266	8.3	(6.5-10.5)	55/1568	3.3	(2.5-4.2)
20-24	313/2618	12.2	(10.4-14.2)	194/3717	5.2	(4.2-6.5)
25-29	461/3039	15.2	(13.3-17.2)	408/5391	8.0	(6.9-9.3)
30-34	466/2349	19.8	(17.5-22.3)	452/4950	9.0	(7.9-10.4)
35-39	223/968	23.0	(19.8-26.5)	212/2018	11.2	(9.0-13.9)
40+	47/149	29.2	(20.9-39.3)	22/197	9.7	(5.2-17.2)
Total	1611/10389	15.7	(14.1-17.5)	1343/17841	7.6	(6.8-8.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 4 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	35/177	20.2	(14.1-28.0)	20/338	6.6	(4.1-10.6)
20-24	242/1506	16.2	(13.8-19.0)	146/3486	4.6	(3.6-5.8)
25-29	468/2504	18.9	(16.9-20.9)	297/6989	4.8	(4.1-5.7)
30-34	492/2548	19.2	(16.8-21.8)	418/8440	5.4	(4.7-6.2)
35-39	344/1575	21.9	(19.4-24.7)	273/5737	5.6	(4.8-6.6)
40+	82/340	24.1	(20.7-28.0)	65/975	7.4	(5.6-9.7)
Total	1663/8650	19.3	(17.6-21.1)	1219/25965	5.3	(4.7-5.9)
Augmentation						
16-19	19/178	10.5	(5.9-17.9)	11/340	3.8	(2.0-7.1)
20-24	144/1516	9.4	(7.5-11.8)	62/3520	2.0	(1.4-2.7)
25-29	247/2529	9.9	(8.2-12.0)	109/7077	1.8	(1.4-2.3)
30-34	255/2572	9.7	(8.0-11.7)	132/8535	1.6	(1.3-2.0)
35-39	156/1592	9.8	(8.2-11.6)	89/5796	1.8	(1.3-2.5)
40+	42/345	12.2	(9.5-15.5)	18/985	1.8	(1.1-3.2)
Total	863/8732	9.8	(8.5-11.4)	421/26253	1.8	(1.5-2.1)
Instrumental delivery						
16-19	12/179	7.5	(3.6-14.9)	7/340	3.1	(1.3-7.1)
20-24	55/1530	3.6	(2.7-4.9)	38/3520	1.4	(1.0-2.0)
25-29	139/2557	5.5	(4.6-6.5)	102/7092	1.8	(1.4-2.3)
30-34	159/2594	6.1	(5.0-7.5)	124/8544	1.6	(1.2-2.0)
35-39	102/1600	6.6	(5.0-8.6)	82/5802	1.8	(1.4-2.4)
40+	30/347	8.8	(5.5-13.8)	17/987	2.5	(1.3-4.7)
Total	497/8807	5.7	(4.9-6.7)	370/26285	1.7	(1.4-2.1)
Intrapartum caesarean section						
16-19	6/179	3.4	(1.4-7.7)	4/340	0.9	(0.3-2.5)
20-24	62/1530	4.1	(2.6-6.3)	21/3520	0.6	(0.3-1.1)
25-29	121/2557	4.8	(3.8-6.1)	48/7092	0.7	(0.5-0.9)
30-34	134/2594	5.1	(4.0-6.5)	70/8544	0.9	(0.6-1.2)
35-39	110/1600	6.8	(5.1-9.1)	53/5802	1.1	(0.8-1.5)
40+	16/347	4.8	(3.1-7.4)	15/987	1.5	(0.8-2.7)
Total	449/8807	5.1	(4.2-6.3)	211/26285	0.8	(0.7-1.1)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 5 Perinatal outcomes by maternal age in low risk women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Nulliparous						
16-19	39/1260	3.2	(2.2-4.5)	31/1553	2.9	(1.9-4.4)
20-24	89/2610	3.5	(2.5-5.0)	94/3700	2.4	(1.9-3.2)
25-29	92/3026	3.3	(2.6-4.0)	123/5357	2.1	(1.7-2.8)
30-34	101/2340	4.2	(3.1-5.6)	128/4918	3.0	(2.2-4.0)
35-39	37/962	3.9	(2.8-5.4)	65/1999	3.0	(2.1-4.1)
40+	10/149	7.5	(3.4-15.7)	8/195	3.9	(1.0-14.0)
Total	368/10347	3.7	(2.9-4.6)	449/17722	2.6	(2.2-3.1)
Multiparous						
16-19	6/179	3.0	(1.4-6.4)	5/337	1.7	(0.6-4.6)
20-24	26/1519	1.8	(1.2-2.7)	43/3489	1.3	(0.8-2.0)
25-29	41/2547	1.6	(1.2-2.3)	73/7032	1.1	(0.8-1.6)
30-34	50/2578	2.0	(1.5-2.6)	111/8468	1.2	(1.0-1.5)
35-39	33/1594	2.1	(1.3-3.3)	88/5761	1.6	(1.2-2.2)
40+	7/345	2.1	(0.9-4.6)	20/978	2.3	(1.3-4.1)
Total	163/8762	1.9	(1.5-2.4)	340/26065	1.3	(1.1-1.6)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

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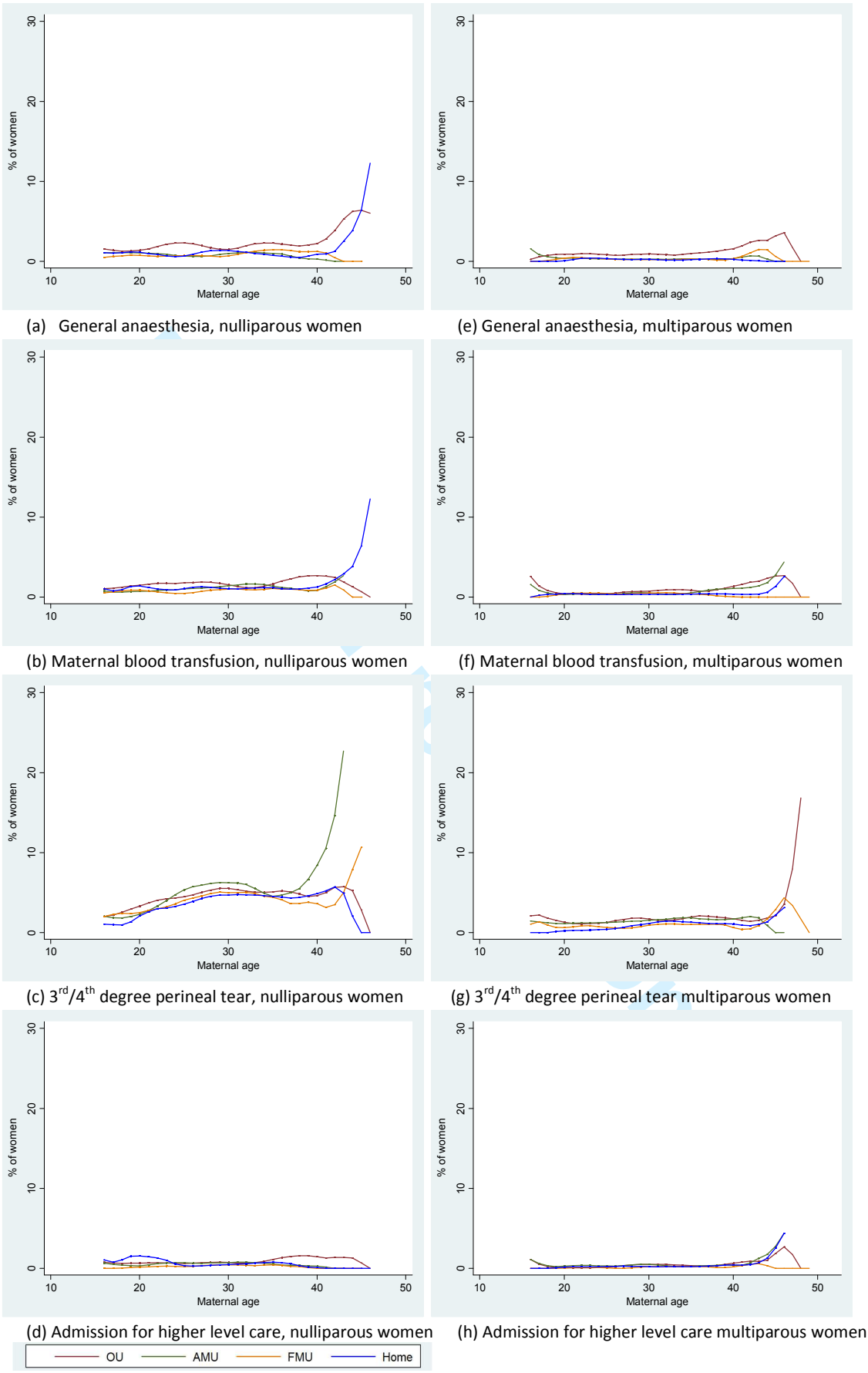

(a) General anaesthesia, nulliparous women

(e) General anaesthesia, multiparous women

(b) Maternal blood transfusion, nulliparous women

(f) Maternal blood transfusion, multiparous women

(c) 3rd/4th degree perineal tear, nulliparous women

(g) 3rd/4th degree perineal tear multiparous women

(d) Admission for higher level care, nulliparous women

(h) Admission for higher level care multiparous women

Figure S1 Association between maternal age and less common intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over

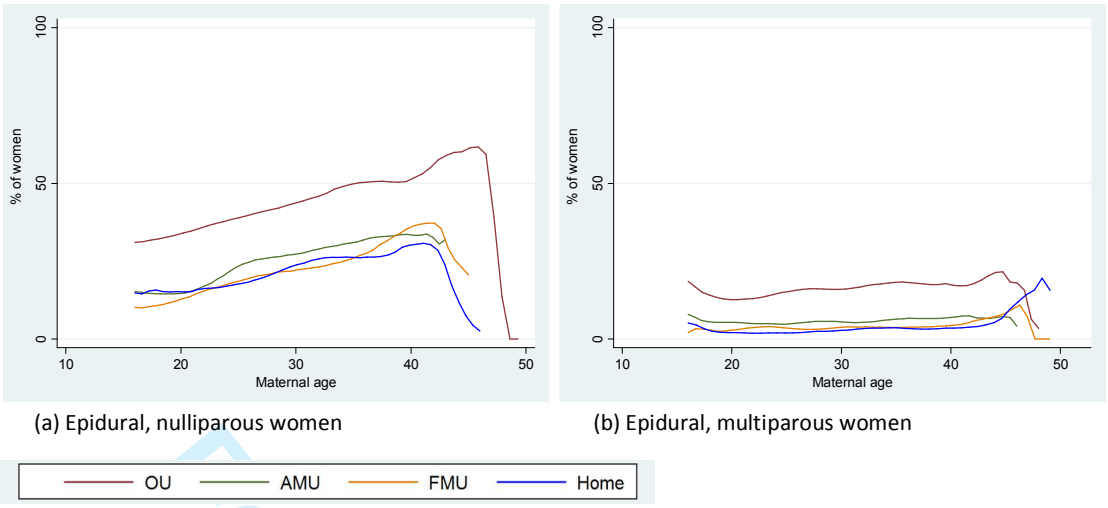

Figure S2 Association between maternal age and epidural in low risk women aged 16 and over

Table S1 Categorisation of potential confounders

Covariate	Response categories	Alternative categories in case of few events
Ethnic group	1 White 2 Non-white	
Understanding of English	1 Fluent 2 Not fluent (some/none)	
Marital/partner status	1 Married/living with partner 2 Single/unsupported by partner	
BMI in pregnancy (kg/m^2)	1 Less than 18.5 2 18.5 to 24.9 3 25.0 to 29.9 4 30.0 to 35.0 5 Not recorded	
Index of Multiple Deprivation (IMD) quintile	1 1st quintile (least deprived) 2 2nd quintile 3 3rd quintile 4 4th quintile 5 5th quintile (most deprived)	1 1st to 3rd quintile 2 4th to 5th quintile
Previous pregnancies ≥24 weeks	1 0 Nulliparous 2 1 previous 3 2 previous 4 3 or more previous	1 Nulliparous 2 Multiparous
Gestation at delivery (completed weeks)	1 37 weeks 2 38 weeks 3 39 weeks 4 40 weeks 5 41 weeks to 42 weeks+0 days	1 37 - 39 weeks 2 ≥ 40 weeks
Planned place of birth	1 Obstetric unit 2 Alongside midwifery unit 3 Freestanding midwifery unit 4 Home	
Complicating conditions identified at the start of care in labour	1 No complicating conditions 2 One or more complicating conditions	

Table S2 Characteristics of low risk nulliparous women aged 16 and over by maternal age category

	16 - 19 years n=2835		20 - 24 years n=6341		25 - 29 years n=8438		30 - 34 years n=7307		35 - 39 years n=2989		≥ 40 years n=346	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	2600	90.4	5329	80.6	7085	78.5	6434	82.7	2686	86.0	314	86.1
Non-white	234	9.6	1004	19.4	1340	21.5	859	17.3	298	14.0	31	13.9
Missing	1		8		13		14		5		1	
Understanding of English												
Fluent	2749	96.8	5709	88.6	7757	89.8	6999	94.4	2931	97.5	341	98.7
Not fluent	81	3.2	602	11.4	636	10.2	276	5.7	48	2.5	3	1.3
Missing	5		30		45		32		10		2	
Marital/partner status												
Married/living with partner	1484	50.2	5171	80.1	7869	92.2	7015	95.9	2854	94.9	320	92.8
Single/unsupported by partner	1284	49.8	1072	19.9	474	7.8	217	4.1	97	5.1	23	7.3
Missing	67		98		95		75		38		3	
BMI in pregnancy (kg/m^2)												
< 18.5	163	6.2	237	3.9	183	2.6	140	2.2	49	1.6	0	0.0
18.5 - 24.9	1510	51.0	3136	47.8	4216	47.2	3813	48.7	1441	46.0	170	44.8
25.0 - 29.9	494	18.1	1358	20.9	1897	23.6	1528	21.7	682	25.6	74	24.3
30.0 - 35.0	189	7.1	535	9.0	641	8.3	438	7.6	192	8.1	21	8.0
Not recorded	477	17.7	1059	18.4	1477	18.3	1363	19.9	616	18.8	80	22.9
Missing	2		16		24		25		9		1	
IMD quintile												
1st (Least deprived)	212	7.2	670	9.2	1475	14.5	1667	21.4	741	22.8	89	26.9
2nd	356	12.6	940	14.5	1690	19.7	1641	22.1	689	22.0	89	23.8
3rd	538	17.7	1239	18.9	1769	19.3	1544	20.7	633	21.1	69	20.0
4th	689	25.3	1525	23.6	1808	22.7	1455	20.7	558	20.3	56	16.9
5th (Most deprived)	1025	37.2	1932	33.8	1663	23.7	972	15.2	353	13.9	40	12.5
Missing	15		35		33		28		15		3	
Gestation at delivery (completed weeks)												
37	93	3.7	189	3.4	275	4.0	243	3.7	90	3.2	9	2.4
38	255	10.9	631	10.1	813	9.8	717	9.6	287	9.3	29	6.0
39	649	21.9	1462	23.5	1989	23.3	1652	22.2	700	23.3	76	23.6
40	1075	36.5	2393	36.3	3107	34.3	2688	36.6	1076	35.0	132	36.5
41 - 42+0 days	763	27.1	1666	26.8	2254	28.6	2007	27.9	836	29.2	100	31.6

Planned place of birth												
OU	1266	88.0	2620	86.6	3043	85.0	2351	83.5	968	84.4	149	89.2
AMU	882	8.4	2040	9.3	2535	9.7	1984	10.0	752	9.2	56	5.9
FMU	564	3.2	1235	3.3	1531	3.3	1302	3.4	456	2.7	47	2.0
Home	123	0.5	446	0.8	1329	2.0	1670	3.2	813	3.7	94	3.0
Birth weight (grams)												
< 2500	46	2.0	105	2.1	88	1.4	87	1.3	43	1.5	6	1.9
2500 - 2999	470	17.8	1053	17.4	1209	16.0	914	14.1	453	16.2	48	10.9
3000 - 3499	1286	44.7	2709	43.0	3536	41.1	3053	41.0	1167	38.8	139	43.0
3500 - 3999	826	28.8	1913	28.9	2782	31.8	2481	33.4	997	32.1	110	32.3
4000 - 4499	185	6.0	487	7.6	734	8.5	669	8.7	282	10.0	38	9.2
≥ 4500	15	0.7	64	0.9	77	1.1	82	1.5	40	1.5	5	2.7
Missing	7		10		12		21		7		0	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	130	7.2	293	7.4	457	8.7	466	10.6	209	10.8	34	14.7
Meconium stained liquor	112	5.9	220	5.6	285	6.0	286	7.4	127	7.6	16	6.1
Proteinuria 1+ or more	73	2.4	150	2.1	161	2.4	129	2.0	49	2.5	8	3.5
Hypertension	51	2.8	128	2.9	156	3.2	127	2.8	48	3.6	10	5.0
Abnormal vaginal bleeding	16	0.8	38	1.0	54	1.2	66	1.8	42	3.3	7	2.9
Non-cephalic presentation	5	0.2	20	0.5	29	0.4	38	0.7	18	0.7	1	0.5
Abnormal fetal heart rate	35	1.5	79	2.1	108	2.3	83	2.1	41	2.6	9	3.7
Other complications	14	0.6	15	0.3	16	0.2	14	0.2	5	0.3	0	0.0
Any complicating conditions	390	19.0	825	19.1	1112	21.0	1073	24.1	465	25.7	73	32.2

[1]Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S3 Characteristics of low risk multiparous women aged 16 and over by maternal age category

	16-19 years n=519		20 - 24 years n=5054		25 - 29 years n=9653		30 - 34 years n=11146		35 - 39 years n=7408		≥ 40 years n=1335	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	478	88.2	4356	82.1	8061	76.3	9618	78.9	6653	83.2	1213	86.8
Non-white	41	11.8	693	17.9	1580	23.7	1516	21.1	746	16.8	122	13.2
Missing	0		5		12		12		9		0	
Understanding of English												
Fluent	505	96.3	4685	91.3	9000	90.3	10606	91.7	7224	95.6	1297	95.9
Not fluent	13	3.8	346	8.8	615	9.7	500	8.3	166	4.5	33	4.1
Missing	1		23		38		40		18		5	
Marital/partner status												
Married/living with partner	352	63.0	4379	84.5	8999	92.0	10767	96.3	7150	95.6	1271	95.0
Single/unsupported by partner	156	37.1	605	15.5	536	8.0	276	3.7	196	4.4	45	5.0
Missing	11		70		118		103		62		19	
BMI in pregnancy (kg/m^2)												
< 18.5	21	5.9	189	4.6	230	2.6	197	2.0	107	1.5	18	0.3
18.5 - 24.9	243	45.8	2180	42.2	4344	44.4	5246	45.0	3423	43.7	632	47.0
25.0 - 29.9	104	17.2	1200	23.1	2444	25.7	2678	24.6	1890	27.6	341	28.9
30.0 - 35.0	44	10.4	561	11.7	986	10.5	961	10.0	577	9.3	88	8.1
Not recorded	104	20.7	910	18.5	1614	16.9	2026	18.5	1384	17.9	249	15.7
Missing	3		14		35		38		27		7	
IMD quintile												
1st (Least deprived)	33	3.6	432	7.4	1400	13.0	2588	19.6	2042	25.7	345	25.6
2nd	49	10.0	581	11.4	1569	15.0	2473	21.4	1745	22.4	307	21.3
3rd	99	21.2	876	16.4	1888	17.7	2215	19.0	1502	19.4	288	22.2
4th	138	25.6	1259	24.6	2149	22.6	2024	18.9	1207	16.5	235	16.8
5th (Most deprived)	196	39.6	1889	40.2	2599	31.7	1787	21.1	862	16.0	157	14.1
Missing	4		17		48		59		50		3	
Previous pregnancies ≥ 24 weeks												
1	474	91.6	3772	77.1	5892	64.5	6963	63.6	3929	56.3	540	44.9
2	38	6.3	1006	17.9	2549	23.4	2779	22.9	2260	27.5	414	28.0
3-5	7	2.2	276	5.0	1212	12.1	1404	13.5	1219	16.2	381	27.1

Gestation at delivery (completed weeks)												
37	26	6.9	162	3.8	255	3.2	291	3.4	185	3.0	43	3.6
38	50	12.3	505	10.0	930	10.0	1022	10.3	684	10.8	117	11.4
39	134	26.5	1326	26.0	2420	25.2	2787	24.5	1816	23.1	334	28.6
40	217	37.7	1968	37.4	3863	38.4	4402	38.2	2857	36.3	507	34.4
41 - 42+0 days	92	16.7	1093	22.8	2185	23.2	2644	23.6	1866	26.8	334	22.0
Planned place of birth												
OU	179	84.6	1530	82.2	2558	79.8	2595	78.3	1603	77.7	348	80.9
AMU	156	9.6	1405	10.0	2423	10.6	2556	10.5	1460	9.8	238	8.7
FMU	97	3.4	880	3.9	1711	4.4	1914	4.4	1218	4.5	202	3.4
Home	87	2.5	1239	3.9	2961	5.3	4081	6.7	3127	8.0	547	6.9
Birth weight (grams)												
< 2500	7	0.8	41	1.3	78	1.3	72	1.0	32	0.7	11	1.1
2500 - 2999	91	22.7	675	14.6	1072	12.7	1010	11.5	647	10.3	120	13.5
3000 - 3499	216	44.0	1969	37.9	3635	37.3	3907	35.8	2477	35.2	457	34.9
3500 - 3999	151	26.0	1751	34.0	3474	35.2	4286	36.3	2891	37.1	507	38.7
4000 - 4499	48	6.1	536	10.6	1192	11.6	1625	13.8	1150	14.0	201	10.1
≥ 4500	6	0.5	71	1.7	185	1.9	221	1.6	197	2.8	35	1.8
Missing	0		11		17		25		14		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	15	6.1	118	4.0	221	4.0	240	4.0	206	4.8	44	6.6
Meconium stained liquor	14	5.6	102	3.7	184	3.8	255	4.9	168	4.9	44	7.9
Proteinuria 1+ or more	6	1.9	53	0.9	100	1.3	97	1.2	60	1.2	12	0.9
Hypertension	4	1.6	32	0.9	76	1.5	80	1.4	54	1.2	7	0.8
Abnormal vaginal bleeding	0	0.0	19	0.8	25	0.5	53	1.2	35	1.4	9	1.8
Non-cephalic presentation	0	0.0	11	0.4	15	0.3	26	0.4	28	0.8	2	0.3
Abnormal fetal heart rate	6	1.9	27	1.0	54	1.2	60	1.3	41	1.2	18	2.8
Other complications	0	0.0	9	0.3	7	0.2	13	0.1	6	0.2	2	0.3
Any complicating conditions	41	15.5	350	11.2	632	11.5	756	12.7	536	13.6	126	18.7

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S4 Sample size of low risk women aged 40 and over by planned place of birth and parity

Age (years)	Nulliparous women				Multiparous women			
	OU	AMU	FMU	Home	OU	AMU	FMU	Home
40	64	32	24	38	157	103	93	242
41	31	17	11	26	86	63	47	147
42	24	6	3	13	53	39	25	83
43	12	1	2	10	29	18	22	37
44	14	0	4	4	12	10	10	23
45	2	0	3	2	4	4	2	9
46	1	0	0	1	5	1	1	5
47	0	0	0	0	1	0	1	0
48	0	0	0	0	1	0	0	0
49	0	0	0	0	0	0	1	0
50	1	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	1
Total	**149**	**56**	**47**	**94**	**348**	**238**	**202**	**547**

Table S5 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	17/1251	1.4	(0.8-2.4)	14/1562	0.8	(0.4-1.5)
20-24	47/2587	1.8	(1.4-2.4)	31/3698	0.9	(0.6-1.4)
25-29	58/2984	1.9	(1.5-2.5)	41/5349	0.8	(0.5-1.3)
30-34	44/2312	1.8	(1.3-2.7)	57/4900	1.3	(0.9-1.9)
35-39	20/949	2.0	(1.2-3.5)	16/2001	0.9	(0.4-1.9)
40+	5/143	3.0	(1.2-7.6)	2/195	0.6	(0.1-2.5)
Total	191/10226	1.9	(1.5-2.3)	161/17705	1.0	(0.8-1.2)
Maternal blood transfusion						
16-19	13/1260	1.1	(0.7-1.9)	10/1555	0.6	(0.3-1.2)
20-24	47/2606	1.8	(1.4-2.5)	29/3697	0.8	(0.6-1.2)
25-29	57/3024	1.8	(1.2-2.6)	54/5359	1.0	(0.8-1.3)
30-34	27/2335	1.2	(0.8-1.8)	64/4923	1.7	(1.2-2.5)
35-39	21/961	2.3	(1.3-3.9)	21/2002	1.2	(0.7-2.1)
40+	4/149	2.8	(1.1-6.8)	5/196	1.6	(0.5-4.6)
Total	169/10335	1.6	(1.3-2.0)	183/17732	1.1	(1.0-1.4)
3rd/4th degree perineal tear						
16-19	25/1259	2.0	(1.2-3.2)	30/1567	1.9	(1.2-2.8)
20-24	107/2609	4.1	(3.3-5.3)	118/3709	3.2	(2.5-4.1)
25-29	153/3030	4.8	(3.9-5.8)	274/5389	5.4	(4.7-6.3)
30-34	121/2343	5.1	(4.3-6.1)	267/4942	5.8	(5.0-6.7)
35-39	49/968	5.0	(3.4-7.2)	85/2007	4.1	(3.2-5.2)
40+	9/149	5.3	(2.9-9.6)	17/196	11.1	(5.0-22.7)
Total	464/10358	4.4	(3.8-5.1)	791/17810	4.6	(4.1-5.2)
Maternal admission for higher level care						
16-19	9/1266	0.7	(0.3-1.6)	5/1569	0.3	(0.1-0.8)
20-24	18/2620	0.7	(0.4-1.2)	22/3721	0.8	(0.4-1.5)
25-29	22/3043	0.7	(0.4-1.3)	24/5395	0.7	(0.4-1.3)
30-34	16/2351	0.7	(0.4-1.3)	31/4956	1.3	(0.5-3.1)
35-39	14/968	1.9	(0.7-4.8)	10/2021	0.5	(0.2-1.1)
40+	2/149	1.5	(0.3-6.8)	0/197	0	-
Total	81/10397	0.8	(0.5-1.4)	92/17859	0.8	(0.4-1.5)

[1]Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S6 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	1/177	0.7	(0.1-4.3)	1/339	0.5	(0.1-3.6)
20-24	15/1516	1.0	(0.6-1.7)	15/3518	0.4	(0.2-0.8)
25-29	19/2528	0.8	(0.5-1.2)	18/7072	0.3	(0.1-0.5)
30-34	21/2569	0.8	(0.5-1.3)	17/8526	0.2	(0.1-0.4)
35-39	19/1584	1.1	(0.7-1.7)	16/5790	0.3	(0.1-0.5)
40+	9/343	2.6	(1.5-4.6)	5/985	0.5	(0.2-1.6)
Total	84/8717	0.9	(0.7-1.2)	72/26230	0.3	(0.2-0.4)
Maternal blood transfusion						
16-19	3/179	1.7	(0.4-6.4)	1/339	0.5	(0.1-3.6)
20-24	6/1519	0.4	(0.2-0.9)	15/3495	0.5	(0.2-0.9)
25-29	16/2544	0.6	(0.3-1.0)	26/7024	0.4	(0.3-0.6)
30-34	23/2575	0.9	(0.5-1.6)	35/8478	0.4	(0.3-0.5)
35-39	11/1593	0.6	(0.3-1.1)	30/5759	0.6	(0.4-1.0)
40+	7/345	2.2	(1.1-4.3)	6/979	0.8	(0.3-1.8)
Total	66/8755	0.7	(0.6-1.0)	113/26074	0.5	(0.4-0.6)
3rd/4th degree perineal tear						
16-19	5/179	2.7	(1.2-5.9)	4/340	0.9	(0.3-2.4)
20-24	15/1529	1.1	(0.6-1.8)	29/3518	1.0	(0.7-1.4)
25-29	44/2550	1.8	(1.3-2.3)	60/7075	1.0	(0.7-1.3)
30-34	42/2588	1.6	(1.1-2.3)	123/8531	1.6	(1.3-2.1)
35-39	32/1600	2.0	(1.3-3.1)	71/5792	1.3	(1.0-1.7)
40+	5/345	1.4	(0.6-3.3)	12/985	1.2	(0.6-2.2)
Total	143/8791	1.7	(1.3-2.1)	299/26241	1.3	(1.1-1.5)
Maternal admission for higher level care						
16-19	1/179	0.5	(0.1-3.6)	1/340	0.5	(0.1-3.6)
20-24	1/1530	0.1	(0.0-0.5)	8/3524	0.2	(0.1-0.5)
25-29	9/2558	0.3	(0.2-0.7)	17/7095	0.3	(0.2-0.5)
30-34	13/2595	0.5	(0.2-1.1)	22/8551	0.3	(0.2-0.5)
35-39	4/1603	0.3	(0.1-0.7)	16/5805	0.3	(0.2-0.5)
40+	4/348	1.2	(0.5-3.1)	7/987	0.7	(0.3-1.6)
Total	32/8813	0.4	(0.2-0.6)	71/26302	0.3	(0.2-0.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S7 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged between 16 and 40 years old (inclusive) additionally adjusted for complicating conditions

	Nulliparous women Adjusted[1] RR	(95% CI)	Multiparous women Adjusted[1] RR	(95% CI)
Maternal composite	1.12	(1.09-1.15)	1.07	(1.02-1.12)
OU[2]	1.11	(1.08-1.14)		
Non-OU[2]	1.21	(1.18-1.24)		
	Wald test for interaction	P^3 <0.001	Wald test for interaction	P^3 =0.50
Augmentation	1.11	(1.06-1.15)	0.98	(0.90-1.07)
OU[2]	1.10	(1.05-1.15)		
Non-OU[2]	1.22	(1.17-1.28)		
	Wald test for interaction	P^3 <0.001	Wald test for interaction	P^3 =0.33
Instrumental delivery	1.18	(1.11-1.25)	1.14	(1.04-1.25)
	Wald test for interaction	P^3 =0. 17	Wald test for interaction	P^3 =0.08
Intrapartum caesarean section	1.25	(1.20-1.30)	1.13	(1.03-1.23)
	Wald test for interaction	P^3 =0.12	Wald test for interaction	P^3 =0.40
General anaesthesia	1.04	(0.91-1.19)	1.07	(0.89-1.29)
	Wald test for interaction	P^3 =0.71	Wald test for interaction	P^3 =0.17
Maternal blood transfusion	1.13	(0.95-1.33)	1.21	(0.93-1.59)
	Wald test for interaction	P^3 =0.38	Wald test for interaction	P^3 =0.50
3^{rd} /4^{th} degree perineal tear	1.12	(1.02-1.23)	1.01	(0.89-1.15)
	Wald test for interaction	P^3 =0.41	Wald test for interaction	P^3 =0.30
Maternal admission for higher level care	1.45	(1.07-1.96)	1.47	(1.04-2.08)
	Wald test for interaction	P^3 =0.43	Wald test for interaction	P^3 =0.16
Neonatal composite	1.04	(0.94-1.16)	0.97	(0.83-1.13)
	Wald test for interaction	P^3 =0.78	Wald test for interaction	P^3 =0.66

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs. Models were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, planned place of birth (OU/AMU/FMU/home), and complicating conditions identified at the start of care in labour.

[2] Results in these rows were weighted and adjusted as in footnote 1, with the exception of planned place of birth.

[3] *P* for interaction, results in these rows were weighted and adjusted as in footnote 1 except that planned place of birth was included as a binary variable (OU vs. non-OU).

Table S8 Event rates in restricted sample of nulliparous women aged 16 and over without complicating conditions identified at the start of care in labour

Age (years)	OU			Non-OU		
	Events / Births	Weighted[1]		Events / Births	Weighted[1]	
	n/N	%	(95% CI)	n/N	%	(95% CI)
Maternal composite						
16-19	335/985	34.4	(30.9-38.1)	221/1418	16.9	(14.6-19.4)
20-24	861/2039	42.3	(38.9-45.9)	768/3382	22.7	(20.6-25.0)
25-29	1160/2302	50.1	(47.4-52.7)	1453/4929	30.2	(27.5-33.0)
30-34	902/1680	54.5	(49.8-59.1)	1524/4442	35.4	(33.2-37.6)
35-39	391/680	57.7	(53.4-62.0)	685/1800	38.0	(34.3-41.9)
40+	67/98	66.1	(53.7-76.6)	70/173	42.4	(32.9-52.5)
Total	3716/7784	48.1	(45.5-50.8)	4721/16144	29.7	(27.8-31.6)
Augmentation						
16-19	224/991	23.0	(19.9-26.4)	119/1428	8.0	(6.5-9.9)
20-24	527/2044	25.8	(22.0-30.0)	417/3406	12.0	(10.5-13.8)
25-29	701/2305	30.0	(27.5-32.6)	777/4944	15.8	(14.1-17.7)
30-34	523/1678	31.4	(27.5-35.6)	838/4462	18.8	(17.2-20.5)
35-39	239/676	34.8	(28.3-42.0)	402/1817	21.1	(18.2-24.3)
40+	41/99	40.2	(27.9-53.9)	37/173	22.6	(14.3-33.8)
Total	2255/7793	29.0	(26.2-32.0)	2590/16230	15.7	(14.5-16.9)
Instrumental delivery						
16-19	139/1008	13.6	(10.8-16.9)	92/1432	8.2	(6.4-10.5)
20-24	354/2073	17.0	(14.9-19.4)	350/3418	10.0	(8.5-11.8)
25-29	512/2328	22.2	(19.9-24.6)	672/4962	14.0	(12.2-16.0)
30-34	411/1700	25.3	(20.0-31.4)	713/4487	16.8	(15.0-18.9)
35-39	191/686	28.9	(24.2-34.1)	353/1819	19.3	(15.8-23.4)
40+	26/99	26.9	(17.8-38.5)	31/174	20.7	(12.8-31.6)
Total	1633/7894	21.2	(18.7-23.9)	2211/16292	14.0	(12.6-15.5)
Intrapartum caesarean section						
16-19	65/1008	6.8	(4.9-9.4)	45/1432	2.7	(2.0-3.7)
20-24	194/2073	9.4	(7.8-11.3)	156/3418	4.6	(3.6-5.8)
25-29	308/2328	13.0	(11.2-15.1)	343/4962	7.3	(6.3-8.5)
30-34	267/1700	15.8	(13.2-18.9)	382/4487	8.3	(7.2-9.6)
35-39	125/686	18.3	(13.9-23.9)	177/1819	10.1	(8.1-12.5)
40+	27/99	25.6	(16.1-38.2)	18/174	8.8	(4.8-15.4)
Total	986/7894	12.6	(11.0-14.5)	1121/16292	6.9	(6.2-7.6)
Perinatal composite						
16-19	26/1003	2.6	(1.8-3.8)	23/1419	2.5	(1.6-4.0)
20-24	58/2064	2.9	(1.9-4.3)	87/3402	2.4	(1.9-3.1)
25-29	57/2319	2.7	(2.0-3.5)	104/4932	2.0	(1.5-2.6)
30-34	67/1694	3.7	(2.6-5.2)	108/4459	2.9	(2.1-4.0)
35-39	14/682	1.8	(1.0-3.4)	56/1804	2.5	(1.8-3.4)
40+	7/99	7.8	(3.8-15.6)	4/172	2.1	(0.5-8.5)
Total	229/7861	2.9	(2.3-3.7)	382/16188	2.4	(2.0-2.9)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S9 Event rates in restricted sample of multiparous women aged 16 and over without complicating conditions identified at the start of care in labour

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	23/149	14.2	(8.7-22.1)	18/323	6.2	(3.8-10.0)
20-24	183/1311	14.1	(11.9-16.8)	130/3320	4.3	(3.4-5.5)
25-29	334/2159	15.5	(13.8-17.3)	272/6663	4.7	(3.9-5.6)
30-34	342/2155	15.7	(13.3-18.5)	376/8033	5.1	(4.4-5.9)
35-39	232/1316	17.8	(15.4-20.3)	242/5421	5.3	(4.5-6.2)
40+	54/265	20.3	(16.4-24.8)	55/917	6.8	(5.1-9.1)
Total	1168/7355	15.9	(14.2-17.8)	1093/24677	5.0	(4.5-5.6)
Augmentation						
16-19	11/150	6.8	(3.5-12.8)	9/324	3.2	(1.7-6.0)
20-24	101/1321	7.6	(6.0-9.6)	53/3352	1.8	(1.3-2.5)
25-29	155/2179	7.2	(5.7-9.0)	94/6743	1.6	(1.2-2.1)
30-34	165/2175	7.5	(5.9-9.6)	112/8118	1.5	(1.2-1.9)
35-39	93/1331	6.9	(5.5-8.7)	80/5476	1.7	(1.2-2.3)
40+	22/268	8.3	(5.0-13.3)	12/927	1.2	(0.6-2.3)
Total	547/7424	7.3	(6.1-8.8)	360/24940	1.6	(1.4-1.9)
Instrumental delivery						
16-19	7/151	4.2	(1.9-9.1)	7/324	3.3	(1.4-7.4)
20-24	45/1334	3.4	(2.4-4.8)	33/3352	1.3	(0.9-1.9)
25-29	111/2205	5.1	(4.3-6.0)	95/6757	1.7	(1.3-2.3)
30-34	126/2194	5.8	(4.7-7.1)	119/8126	1.6	(1.2-2.0)
35-39	80/1338	6.1	(4.7-8.0)	73/5482	1.7	(1.3-2.3)
40+	20/269	7.2	(4.5-11.3)	15/929	2.3	(1.1-4.9)
Total	389/7491	5.3	(4.5-6.2)	342/24970	1.7	(1.4-2.0)
Intrapartum caesarean section						
16-19	4/151	2.5	(0.9-7.2)	4/324	1.0	(0.3-2.7)
20-24	48/1334	3.6	(2.2-6.1)	17/3352	0.5	(0.2-1.0)
25-29	79/2205	3.6	(2.7-4.7)	42/6757	0.6	(0.4-0.9)
30-34	80/2194	3.6	(2.6-4.9)	54/8126	0.7	(0.5-1.1)
35-39	64/1338	4.8	(3.4-6.7)	41/5482	0.9	(0.6-1.4)
40+	11/269	4.0	(2.2-7.4)	14/929	1.4	(0.7-2.6)
Total	286/7491	3.8	(2.9-5.0)	172/24970	0.7	(0.6-0.9)
Perinatal composite						
16-19	4/151	2.2	(0.8-5.7)	4/322	1.5	(0.5-4.5)
20-24	19/1325	1.5	(0.9-2.5)	39/3323	1.2	(0.8-1.7)
25-29	34/2199	1.6	(1.1-2.2)	61/6701	1.0	(0.7-1.6)
30-34	30/2182	1.4	(0.9-2.0)	97/8058	1.1	(0.9-1.4)
35-39	26/1334	2.0	(1.2-3.4)	82/5445	1.6	(1.2-2.1)
40+	6/268	2.2	(0.9-5.1)	17/920	2.1	(1.1-4.0)
Total	119/7459	1.6	(1.2-2.1)	300/24769	1.2	(1.0-1.5)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes – title and abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes, p2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes, p5
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes, p5-6
Methods			
Study design	4	Present key elements of study design early in the paper	Yes, p7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes, p7-8. References also given to other publications providing more details
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes, p8-9 and Table S1
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	Yes, p7, more details in cited reports.
Bias	9	Describe any efforts to address potential sources of bias	Cohort study methods to minimise bias addressed elsewhere – ref 26.
Study size	10	Explain how the study size was arrived at	N/A. Secondary analysis of existing data. Original power calculations described in ref 26.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes, p8-9.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes, p8-10
		(*b*) Describe any methods used to examine subgroups and interactions	Yes, interactions p9
		(*c*) Explain how missing data were addressed	N/A. Low level of missing data
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	Yes, p9
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility,	P11 for current study; refs given for

		confirmed eligible, included in the study, completing follow-up, and analysed	'recruitment' into main study
		(b) Give reasons for non-participation at each stage	Ditto
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes, Tables 1, S2 and S3
		(b) Indicate number of participants with missing data for each variable of interest	Yes, Tables 1, S2 and S3
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes, fully reported in tables
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	Yes, unadjusted & adjusted estimates and 95% CIs reported in tables; adjustment variables described (Table S1)
		(*b*) Report category boundaries when continuous variables were categorized	Yes. Maternal age – Table 1; confounders Table S1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Absolute event rates reported in tables
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	All analyses reported in manuscript or supplementary tables
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes, p14
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	Yes, p14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Other evidence comprehensively summarised p15-17; cautious interpretation p17
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes, p14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes, p18

*Give information separately for exposed and unexposed groups.

BMJ open

The effect of maternal age and planned place of birth on intrapartum outcomes in healthy women with straightforward pregnancies: secondary analysis of the Birthplace national prospective cohort study

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-004026.R1
Article Type:	Research
Date Submitted by the Author:	27-Nov-2013
Complete List of Authors:	Li, Yangmei; University of Oxford, Policy Research Unit in Maternal Health and Care, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Townend, John; University of Oxford, Policy Research Unit in Maternal Health and Care, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Rowe, Rachel; University of Oxford, Policy Research Unit in Maternal Health and Care, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Knight, Marian; University of Oxford, Policy Research Unit in Maternal Health and Care, National Perinatal Epidemiology Unit, Nuffield Department of Population Health Brocklehurst, Peter; University College London, Institute for Women's Health Hollowell, Jennifer; University of Oxford, Policy Research Unit in Maternal Health and Care, National Perinatal Epidemiology Unit, Nuffield Department of Population Health
Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Epidemiology, Medical management, Evidence based practice, Health services research
Keywords:	OBSTETRICS, Midwifery led care, Maternal medicine < OBSTETRICS, Intrapartum care

The effect of maternal age and planned place of birth on intrapartum outcomes in healthy women with straightforward pregnancies: secondary analysis of the Birthplace national prospective cohort study

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Keywords

Maternal age, parity, birthing centre, home birth, augmentation, instrumental delivery, caesarean section, adverse maternal outcomes, adverse perinatal outcomes

Word count

Main text 4,630 words

Abstract

Objectives

To describe the relationship between maternal age and intrapartum outcomes in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth

Design

Prospective cohort study

Setting

Obstetric units, midwifery units and planned home births in England

Participants

63,371 women aged over 16 without known medical or obstetric risk factors, with singleton pregnancies, planning vaginal birth

Methods

Log Poisson regression was used to evaluate the association between maternal age, modelled as a continuous and categorical variable, and risk of intrapartum interventions and adverse maternal and perinatal outcomes.

Main Outcome Measures

Intrapartum caesarean section, instrumental delivery, syntocinon augmentation and a composite measure of maternal interventions/adverse outcomes requiring obstetric care encompassing augmentation, instrumental delivery, intrapartum caesarean section, general anaesthesia, blood transfusion, 3rd/4th degree tear, maternal admission; adverse perinatal outcome (encompassing neonatal unit admission or perinatal death).

Results

Interventions and adverse maternal outcomes requiring obstetric care generally increased with age, particularly in nulliparous women. For nulliparous women aged 16-40, the risk of experiencing an intervention or adverse outcome requiring obstetric care increased more steeply with age in planned non-obstetric unit births than in planned obstetric unit births (adjusted RR 1.21 per 5-year

increase in age, 95% CI 1.18-1.25 vs. adjusted RR 1.12, 95% CI 1.10-1.15) but absolute risks were lower in planned non-OU births at all ages. The risk of neonatal unit admission or perinatal death was significantly raised in nulliparous women aged 40+ relative to women aged 25-29 (adjusted RR 2.29, 95% CI 1.28-4.09).

Conclusions

At all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Younger nulliparous women appear to benefit more from this reduction than older nulliparous women.

Article summary

Article focus

- Does increasing age in women without known medical or obstetric risk factors increase the risk of intrapartum interventions and adverse outcomes that might affect their choice of planned place of birth?

Key messages

- Older women having a first baby appear to benefit less than younger women from planned birth in a non-obstetric unit setting.
- The chances of experiencing an intervention or outcome that requires obstetric care increase with age, even in women who do not have known risk factors.
- Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

Strengths and weaknesses

Strengths

- The study was based on a large, nationally representative cohort of 'low risk' women, with high quality data collected prospectively.

Weaknesses

- The number of women over 40 was relatively small so the study had limited power to explore effects in women over 40, particularly in non-obstetric unit settings.
- Planned births in non-obstetric unit settings were combined; graphical plots indicated that this was reasonable but important differences between settings cannot be ruled out.

Background

The proportion of births in women aged 35 and over has been steadily rising in recent years in the UK and elsewhere.[1, 2] Currently approximately 16% of births in England and Wales are to women aged 35-39 and 4% of births are to women aged 40 and over.[1]

Advanced maternal age is associated with an increased risk of pregnancy complications including gestational diabetes,[3] pregnancy induced hypertension and preeclampsia,[4, 5] twin or higher order pregnancies,[3] breech presentation,[6] placenta praevia,[3, 7-9] preterm birth,[5, 10] post-term birth,[11], severe maternal morbidity,[12] and adverse perinatal outcomes including antepartum stillbirth,[13] intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission.[5] Older women also have an increased risk of interventions such as induction and caesarean section.[16-20] However, many age-related pregnancy complications are known risk factors for intrapartum complications or adverse perinatal outcomes and women with these risk factors would normally be advised to give birth in an obstetric unit (OU). Relatively little is known about the incidence of intrapartum interventions and adverse maternal and perinatal outcomes in older women who do not have known risk factors.[21]

The current clinical guideline in England[22] recommends that healthy women with straightforward pregnancies should be offered a choice of planned birth at home, in a midwife-led unit or in an obstetric unit, but also suggest individual assessment when planning place of birth for women over 40 at booking.[22] The evidence for 'low risk' women in general shows that planned birth in a non-OU setting is associated with a lower incidence of intrapartum interventions[22-28] and research has demonstrated that in 'low risk' women, after adjustment for maternal characteristics, planned birth in a midwifery unit and planned birth at home (multiparous women only) is not associated with an increased risk to the baby compared with planned birth in an OU.[25] However, rates of intrapartum transfer increase with age in nulliparous women[29] and, more generally, the risks that might affect the choice of planned place of birth (PPOB) by healthy older women are not well documented.

The aim of this study was to evaluate the association between maternal age and intrapartum interventions and adverse maternal and perinatal outcomes that may influence the choice of planned place of birth, in 'low risk' women with singleton, term pregnancies planning a vaginal birth.

The main objectives were to describe the relationship between maternal age and intrapartum interventions and adverse outcomes that indicate a need for obstetric or neonatal care in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth.

Methods

Settings and participants

The study used data from the Birthplace in England national prospective cohort study which was designed to compare perinatal and maternal outcomes and interventions by planned place of birth at the start of care in labour.

The cohort study methods are described in full elsewhere.[25, 26] Briefly, the Birthplace cohort included a total of 79,774 births between April 2008 and April 2010, including 32,257 planned OU births from a stratified random sample of 36 OUs, 11,666 planned births in 53 freestanding midwifery units (FMUs), 17,582 planned births in 43 alongside midwifery units (AMUs) and 18,269 planned home births from 142 NHS trusts across England. Births were eligible for inclusion if the woman was planning a vaginal birth and received some labour care from an NHS midwife in her planned birth setting. Women who had an elective caesarean section or caesarean section before the onset of labour, presented in preterm labour (<37 weeks' gestation), had a multiple pregnancy, an unplanned home birth, or who were "unbooked" (received no antenatal care) were excluded. Stillbirths occurring before the start of care in labour were excluded. Women in the cohort were classified as 'low risk' if before the start of labour they were not known to have any of the medical or obstetric risk factors listed in national guidelines on intrapartum care[22] as "indicating increased risk suggesting planned birth in an obstetric unit". The study had a high response rate and low levels of missing data.[25, 26]

The study population for the analyses reported here was 'low risk' women in the Birthplace cohort aged 16 years or over at the time of birth, with a term (gestational age 37^{+0} weeks to 42^{+0} weeks inclusive) pregnancy and parity less than 6. In the NICE intrapartum care guideline individual assessment is recommended when planning place of birth for women with parity of 6 or more and many midwifery units restrict admission to women of parity 5 or less.[30] We additionally excluded women for whom age, parity or gestational age was not known.

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee and did not require consent to be sought from participants as no personally identifiable data were collected.

Data

As described elsewhere,[25] maternal characteristics, and medical or obstetric risk factors known prior to the onset of labour were extracted from the woman's medical records by the midwife

attending the birth. Complicating conditions identified by the midwife at the start of care in labour (for example prolonged rupture of membranes), intrapartum interventions and adverse maternal and perinatal outcomes were recorded by the attending midwife using a data collection form started during labour and completed on or after the fifth postnatal day.

Planned place of birth (OU, AMU, FMU or home) was based on the intended place of birth at the start of care in labour. Women were included in the group in which they planned to give birth at the start of care in labour regardless of whether they were transferred during labour care or immediately after the birth.

Outcomes

We focused on outcome measures that reflected interventions and adverse outcomes that indicated a need for obstetric and/or neonatal care, that is, outcomes that would require the woman and/or baby to be transferred to an obstetric or neonatal unit if labour care or birth took place elsewhere. For women, we considered the following outcomes both separately and as a combined maternal composite outcome ('interventions/adverse outcomes requiring obstetric care'): augmentation with syntocinon, instrumental delivery (ventouse or forceps), intrapartum caesarean section, general anaesthesia, maternal blood transfusion, 3rd/4th degree perineal tear, maternal admission for higher level care. The use of epidural/spinal analgesia was also considered as a secondary outcome. The main outcomes considered for women were the maternal composite outcome ('interventions and adverse outcomes requiring obstetric care'), augmentation, instrumental delivery, and intrapartum caesarean section.

For babies, we considered a single composite outcome measure largely reflecting admission to a neonatal unit. This 'perinatal composite outcome' encompassed one or more of the following events: admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death.

Statistical analysis

Analyses were conducted separately by parity. We modelled age at the time of delivery both as a categorical and continuous variable, using log Poisson regression to estimate relative risks adjusted for the following potential confounders: ethnic group, understanding of English, marital or partner status, body mass index (BMI), index of multiple deprivation (IMD) score, gestational age at birth and, where appropriate, planned place of birth (see supplementary Table S1 for categorisation). We also carried out sensitivity analyses in which we additionally adjusted for the presence of

complicating conditions identified at the start of care in labour (none, one or more) and for the use of epidural/spinal analgesia.

We fitted a series of models following a pre-specified, iterative strategy. In order to test our modelling assumptions regarding age and to determine whether it was appropriate to combine data for planned births in non-OU settings, we plotted outcomes by age and planned place of birth using polynomial smoothing.[31] Visual inspection of these plots (see Figure 1 and 2 for the main outcomes) indicated that it was reasonable to model age as a continuous variable within the age range 16-40 (inclusive) and further indicated that event rates were generally similar in the three non-OU settings, suggesting that it was reasonable to combine the non-OU settings for the purposes of exploring interactions between maternal age and planned place of birth. We did not model age as a continuous variable above the age of 40 because data were sparse, particularly for planned non-OU births to nulliparous women, and we could not be confident that the broadly linear trends seen at younger ages could be extrapolated above this age.

We initially modelled the effect of age on study outcomes separately by parity and for all planned places of birth combined. Models in which age was modelled as a continuous variable were restricted to the age range 16-40 inclusive. For each of the study outcomes, we tested for an interaction between age (as a continuous variable) and planned place of birth (OU vs. non-OU) using a Wald test, and where the interaction was significant at the 5% level, we modelled the effect of age on the outcome separately by planned place of birth. For outcomes where the interaction between age and planned place of birth was significant, we calculated crude and adjusted relative risks associated with planned non-OU birth separately for each age band.

In order to test whether the presence of complicating conditions at the start of care in labour (for example prolonged rupture of membranes) had an effect on the observed relationships, we fitted a further set of models in which we adjusted for both maternal characteristics and the presence of complicating conditions. Because previous analyses have shown that women planning birth in an OU have a higher prevalence of complicating conditions than in other settings[25] and this affects the magnitude of the difference in event rates between settings, we carried out further analyses of the main outcomes restricted to 'low risk' women without complicating conditions at the start of care in labour.

Robust variance estimation was used to allow for the clustered nature of the data and, as described elsewhere,[25, 26] probability weights were incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs. The

weighting is such that, when applied to the pooled data for all four settings, the weighted event rates represent the estimated average event rates for England as a whole.

For each outcome, we calculated the number of events, the number of births, the weighted incidence and 95% confidence intervals. We assessed statistical significance at the 5% level.

Results

Description of the study sample

From the 79,774 women in the Birthplace cohort we excluded 15,553 women who had pre-existing risk factors including 'NICE' medical and obstetric risk factors,[22] grand multiparity (parity 6 or over) and post-term pregnancy, 62 women who were aged under 16, 682 women who had missing data on risk factors, parity or gestational age, and 106 whose age was missing. The study population consisted of 63,371 eligible 'low risk' women. The proportion (weighted) of women who were ineligible because of pre-existing risk factors, increased from 31.9% in women aged 16-19 to 46.7% in women aged 40 and over.

Table 1 describes the characteristics of the sample by age. The percentages shown in the table are weighted so that they provide an estimate of the distribution of maternal characteristics that would apply to eligible 'low risk' births in England. Older women tended to be white, have a fluent understanding of English, and were more likely than younger women to live in a socioeconomically advantaged area. They were less likely than younger women to be nulliparous and more likely to have had multiple previous pregnancies. Planned home births were more common at older ages (Table 1 and supplementary Tables S2 and S3), particularly in multiparous women (supplementary Table S3). Older women were more likely to have complicating conditions, such as prolonged rupture of membranes, noted by the midwife at the start of care in labour (Table 1). Complicating conditions at start of care in labour were more common in nulliparous women (supplementary Tables S2 and S3).

[TABLE 1 HERE]

Maternal interventions and adverse outcomes

Descriptive plots of outcomes by age indicated that the incidence of most outcomes tended to increase steadily with age in the age range 16 to 40, and that incidence rates were generally lower in planned non-OU births (Figure 1 and supplementary Figure S1). Rates for planned OU and non-OU births tended to diverge above this age range, but rates were based on small numbers of older women (supplementary Table S4) particularly for planned AMU and FMU births and therefore these rates have wide confidence intervals.

For nulliparous women in the age range 16-40 (all PPOBs combined), the adjusted risk of having an intervention/ adverse outcome requiring obstetric care (maternal composite) increased significantly with age, as did the risk of augmentation with syntocinon, instrumental delivery, intrapartum

caesarean section, 3rd/4th degree perineal tear, or maternal admission for higher level care (Table 2). For augmentation with syntocinon and the maternal composite outcome, the effect of age differed by PPOB (Table 2). The risk of augmentation increased more steeply with age in non-OU settings (RR 1.23, 95% CI 1.18-1.28 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.07-1.17 for planned OU births). Nevertheless, the proportion of women receiving augmentation was lower in planned non-OU births at all ages (Table 3). For example, 42.2% (95% CI 36.4%-48.1%) of nulliparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 22.6% (95% CI 19.8%-25.7%) of nulliparous women of the same age who planned birth in a non-OU setting. A similar pattern was observed for the maternal composite outcome: the risk of an intervention/adverse outcome requiring obstetric care (maternal composite) increased slightly more steeply with age in the non-OU settings (RR 1.21, 95% CI 1.18-1.25 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.10-1.15 for planned OU births) but the absolute risk was lower in the planned non-OU birth at all ages (Table 3). For example, 65.5% (95% CI 61.8%-69.1%) of nulliparous women aged 35-39 who planned birth in an OU experienced an intervention/adverse outcome requiring obstetric care compared with 39.9% (95% CI 36.0%-43.9%) of nulliparous women of the same age who planned birth in a non-OU setting. In nulliparous women, the risk of instrumental delivery and intrapartum caesarean section increased significantly with age (RR 1.18, 95% CI 1.12-1.25 and RR 1.27, 95% CI 1.23-1.32) across all settings. Again, absolute risks were substantially lower in planned non-OU births (Table 3).

[TABLE 2 AND TABLE 3 HERE]

Similar patterns were observed when we adjusted for complicating conditions at the start of care in labour in order to take account of difference between settings in complicating conditions at the start of care in labour (23.9% in nulliparous planned OU births vs. 8.6% in nulliparous planned-non-OU births) (supplementary Table S5).

However, although the risk of intervention increased with age, at all ages, nulliparous women who planned birth in a non-OU setting had a significantly reduced risk of receiving augmentation or of experiencing an intervention/adverse outcome requiring obstetric care. Table 4 shows the adjusted risks by age for the two outcomes (maternal composite and augmentation) where the effect of planned place of birth differed by age.

[TABLE 4 HERE]

For multiparous women aged 16-40 (all PPOBs combined), the combined risk of having an intervention or adverse outcome requiring obstetric care (maternal composite) or of instrumental delivery, intrapartum caesarean section, and maternal admission for higher level care increased with

age (Table 2). Augmentation with syntocinon, general anaesthesia, blood transfusion, and 3rd/4th degree perineal tear were not associated with maternal age in multiparous women (Table 2). For all of the outcomes considered, the effect of age did not differ by PPOB in multiparous women (Table 2). Again, for the maternal composite outcome, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section, the absolute event rates were lower in planned non-OU births in most age categories (Table 5). For example, 9.8% (95% CI 8.2%-11.6%) of multiparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 1.8% (95% CI 1.3%-2.5%) of women of the same age who planned birth in a non-OU setting.

Up to age 40, other less common outcomes did not increase significantly with maternal age in nulliparous or multiparous women with the exception of maternal admission to higher level care (Table 2 and supplementary Tables S6 and S7).

[TABLE 5 HERE]

Absolute event rates for the main outcomes (maternal composite, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section and perinatal composite) were reduced when the analysis was restricted to women without complicating conditions identified at start of labour care (supplementary Tables S8 and S9). However, at all ages, nulliparous women without complicating conditions who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention/adverse outcome requiring obstetric care (maternal composite outcome) (Table S8 and S10).For example, 38.0% (95% CI 34.3%-41.9%) of nulliparous women aged 35-39 without complicating complications who planned birth in a non-OU setting experienced an intervention/adverse outcome requiring obstetric care, compared with 57.7% (95% CI 53.4%- 62.0%) of women of the same age without complicating conditions who planned birth in an OU.

The use of epidural/spinal analgesia increased significantly with maternal age and lower rates of use were observed in planned non-OU births (supplementary Figure S2). Adjustment for use of epidural in the multivariable models attenuated but did not change the results materially (data not shown).

Perinatal outcome

The perinatal composite outcome (admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death) showed a modest but not statistically significant increase with age in nulliparous women in the age range 16-40 (Table 2). The risk increased significantly in nulliparous women aged 40+ compared with women aged 25-29 (RR 2.29, 95%CI 1.28-4.09, adjusted for maternal characteristics and planned place of birth, all settings combined). Maternal age was not significantly associated with the risk of the perinatal composite outcome in

multiparous women in the age range 16-40 (Table 2) and the risk was not significantly increased in births to multiparous women aged 40+ compared with women aged 25-29 (RR 1.21, 95% CI 0.60-2.43, adjustment as before). Absolute event rates are shown in Table 6.

[TABLE 6 HERE]

Discussion

Principal findings

In women without known medical or obstetric risk factors prior to the onset of labour, interventions and adverse maternal outcomes requiring obstetric care generally increased with age, but there was no age at which there was a step-change in risk. For both nulliparous and multiparous women, maternal intervention rates were lower in births planned in non-OU settings compared with planned OU births at all ages. For nulliparous women the overall risk of experiencing an intervention or adverse outcome requiring obstetric care, and in particular of augmentation with syntocinon, increased more steeply with age in planned non-OU births than in planned OU births. As a consequence, although nulliparous women of all ages who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention or adverse outcome requiring obstetric care, the benefit of planned non-OU birth was greatest at younger ages.

In low risk women up to the age of 40, the risk of neonatal unit admission or intrapartum stillbirth/early neonatal death did not show a statistically significant upward trend with age in either nulliparous or multiparous women. In planned OU births, the risk of neonatal unit admission or perinatal death was significantly higher in nulliparous women aged 40+ relative to women aged 25-29.

Strengths and limitations

A strength of the study is that we were able to evaluate the effect of age on intrapartum outcomes by planned birth setting in a nationally representative sample of 'low risk' women. In order to strengthen the evidence supporting clinical guidelines on planned place of birth, the study specifically focused on outcomes that reflect need for obstetric or neonatal care in a sample of women who meet the current criteria for planned birth in a non-OU setting.[22] To our knowledge, this is the first study to investigate the effect of increasing maternal age in different birth settings with a focus on outcomes that would require transfer to an OU and hence may affect the choice of planned place of birth.

Despite the large overall sample size, the number of older women was relatively small, so we had limited ability to explore effects above age 40 or to separate results of individual non-OU birth settings. We combined data for the non-OU settings, having first explored the data to check that this was reasonable. This increased our statistical power to evaluate the association between maternal age and the study outcomes (maternal and perinatal), but we still lacked the statistical power to evaluate uncommon outcomes. It is important to note that previous analyses[25] have shown that

planned home births are associated with a significantly increased risk of adverse perinatal outcomes in nulliparous women.

The risk of bias due to missing data and non-response was low: the study had a low level of missing data, a high response rate[25, 26] and, because consent was not required, there was no self-selection bias due to non-consent. We addressed potential differences in risk between groups in a number of ways. First, we controlled for important potential confounders such as body mass index. Second, we focused on a relatively homogeneous population of women without known medical or obstetric risk factors prior to the onset of labour. Third, because previous analyses[25] identified that the prevalence of complicating conditions at the start of care in labour was higher in the planned OU birth group, we conducted two additional analyses in which we controlled for complicating conditions and restricted the analysis to women without complicating conditions. Differences in the clinical characteristics of the OU and non-OU groups therefore seem unlikely to explain the age related trends observed or the significant reductions in risks observed in non-OU births. Nevertheless, women self-select their birth setting and it may be that some of the differences in outcomes that we observed between settings may have been due to unmeasured differences in the characteristics of women opting for OU and non-OU births, rather than to differences attributable to the birth setting.

Comparison with the existing literature

Older women have been shown to have an increased risk of intrapartum intervention,[6, 32] but many studies include women known to be at higher risk who would normally be advised to give birth in an obstetric unit. Evidence relating to 'low risk' women[17] or from studies that have controlled for pre-existing risk factors or complications[33] is more limited but is generally consistent with our finding that intervention rates increase with age in 'low risk' women.

There is extensive evidence that 'low risk' women who plan birth in a non-OU setting have a reduced risk of a range of intrapartum interventions, including augmentation, instrumental delivery and intrapartum caesarean section, and are more likely to have a spontaneous vaginal birth.[22-24, 27, 28] Our study found that, across the age range 16-40, women who plan birth in a non-OU setting experience substantially lower intervention rates and are less likely to experience an outcome requiring obstetric care than women of the same age who plan birth in an obstetric unit.

In nulliparous women we found that rates of augmentation of labour with syntocinon increased more steeply with maternal age in planned non-OU births compared with planned OU births, although absolute rates of augmentation were substantially lower in planned non-OU births at all ages. An age-related increase in augmentation is consistent with evidence of poorer uterine function

at older ages,[34] longer labours[34] and an increased incidence of prolonged labour,[35, 36] but the reasons for a steeper increase in augmentation with age in non-OU settings is unclear. It has been suggested that labelling of older women as 'higher risk' and/or heightened concern about the safety of older nulliparous women, particularly those who have required fertility treatment, may result in increased rates of caesarean section for non-medical reasons,[20, 32, 33, 37] and it is possible that similar factors affect midwives' decision making regarding transfer for failure to progress, or for other reasons. Intrapartum transfers from midwifery units in the Birthplace study have been shown to increase significantly with age in nulliparous women[29] and, once transferred, women are 'exposed' to the higher intervention rates found in obstetric units.

It is also possible that age-related differences in women's expectations and expressed preferences may contribute to the pattern of intervention observed in our study. Older nulliparous women have been found to have a more positive attitude towards caesarean section,[38] for example, and also to have a higher perception of pregnancy risk, even in older women without known risk factors.[39] The significant positive association between maternal age and epidural use observed in our study (seen most strongly in nulliparous women planning a non-OU birth), would be consistent with a greater willingness of older women to consider interventions.

We found a significantly increased risk of maternal admission to higher level care at older ages in both nulliparous and multiparous women. The number of events was small and this could be a chance finding but an increase in serious obstetric complications at older ages observed in some studies[3, 6, 12] cannot be ruled out.

Although studies including women with known risk factors have reported increased risks in women aged over 35,[3, 6, 35] our analysis shows that up to the age of 40, risks tend to increase in a broadly linear manner in healthy women with straightforward pregnancies, with no evidence of a step-change in risk below the age of 40. Other studies have similarly concluded that the association of adverse outcomes with maternal age is a continuum,[3] with the increase in adverse perinatal outcomes possibly gaining momentum above the age of 40.[40] Because of the small number of births to mothers aged over 40 in our sample we had limited power to evaluate risks at older ages and other evidence relating to older 'low risk' women is sparse.[21]

There is some evidence that the babies of older women are at increased risk of serious adverse outcomes, including intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission,[5, 33] but these outcomes would be expected to be substantially reduced in 'low risk' women who, by definition, do not have medical or obstetric risk factors such as severe obesity, diabetes or previous caesarean section. Furthermore, the poorer outcomes associated with the

increased risk of pre-term birth at older ages do not apply to women giving birth at term. In our 'low risk' cohort, we did not observe a significant increase with age in our composite measure of neonatal unit admission/perinatal death within the age range 16-40, but graphical plots for nulliparous women suggested a possible upturn in neonatal unit admission/perinatal death around the age of 40 in nulliparous women. Further research evaluating perinatal outcomes in 'low risk' women aged over 40 is needed.

Conclusions and policy implications

The incidence of intrapartum interventions and adverse outcomes requiring obstetric care increases with maternal age, but at all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Amongst nulliparous women, younger women appear to benefit more from the reduction in interventions associated with planned birth in a non-OU setting. Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

All women, irrespective of age and parity, should be given information about the risks and benefits of different birth settings. Nulliparous women planning birth in non-OU setting should be informed that the risk of interventions that require transfer to an OU increases with age. Further research is required to evaluate adverse perinatal outcomes in 'low risk' women aged over 40.

Acknowledgements

We thank Xiaosi Wang for conducting initial literature searches and statistical analysis.

Competing interests

None.

Contribution to authorship

JH conceived and developed the study outline with input from PB; YL developed the protocol and analysis plan with input from JH, JT and MK; YL conducted the analysis; JT provided statistical advice; YL and JH drafted the manuscript with input from RR, MK and PB. All authors were involved in interpretation of data, review and revision of the draft manuscript and approval of the final version.

Ethics Approval

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee (MREC ref 07/H0505/151).

Funding

This paper reports on an independent study which is funded by the Policy Research Programme in the Department of Health. The views expressed are not necessarily those of the Department.

Birthplace combines the Evaluation of Maternity Units in England study funded in 2006 by the National Institute for Health Research Service Delivery and Organisation (NIHR SDO) programme, and the Birth at Home in England study funded in 2007 by the Department of Health Policy Research Programme (DH PRP). From January 2012, the NIHR SDO programme merged with the NIHR Health Services Research programme to establish the new NIHR health Services and Delivery Research (NIHR HS&DR) programme. The views and opinions expressed by the authors do not necessarily reflect those of the HS&DR Programme, NIHR, NHS, DH PRP or the Department of Health.

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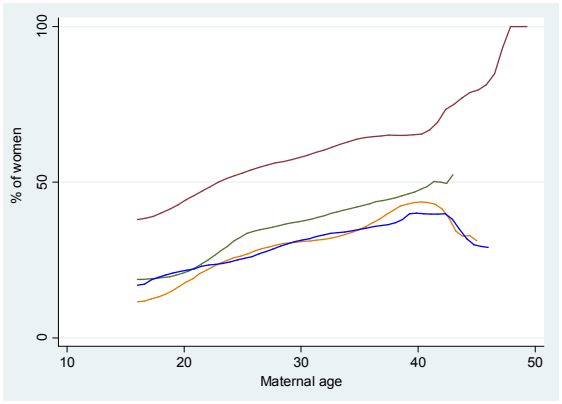
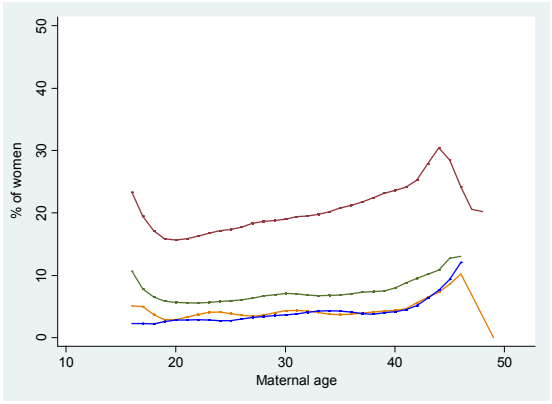


(a) Maternal composite, nulliparous women



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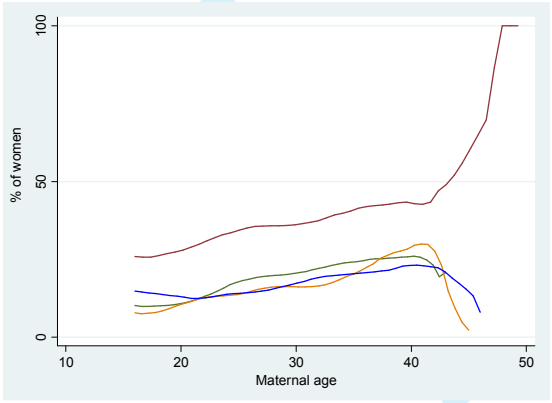
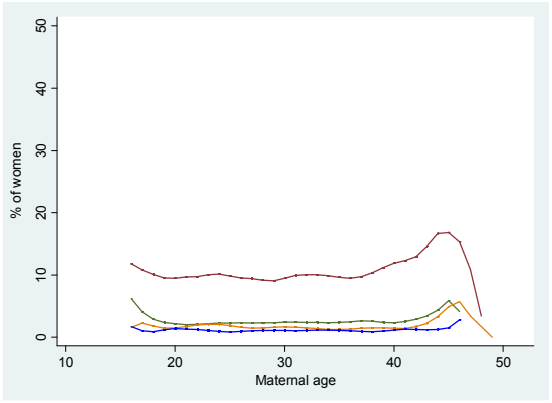
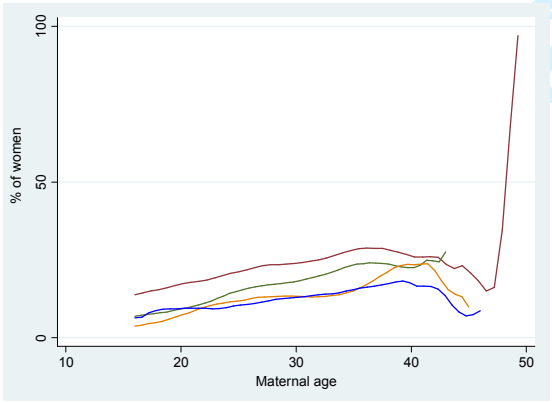


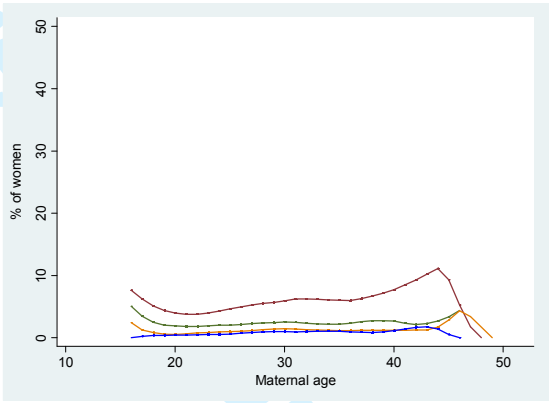
(b) Augmentation, nulliparous women



(f) Augmentation, multiparous women



(c) Instrumental delivery, nulliparous women



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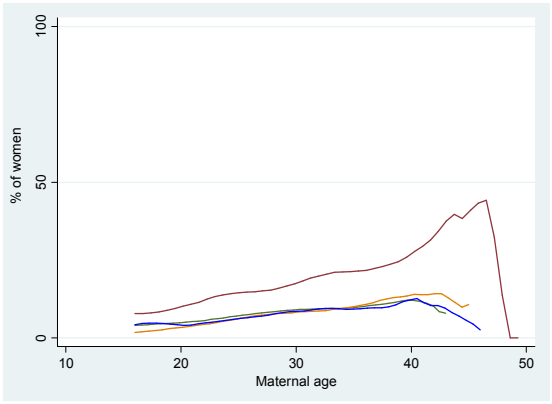
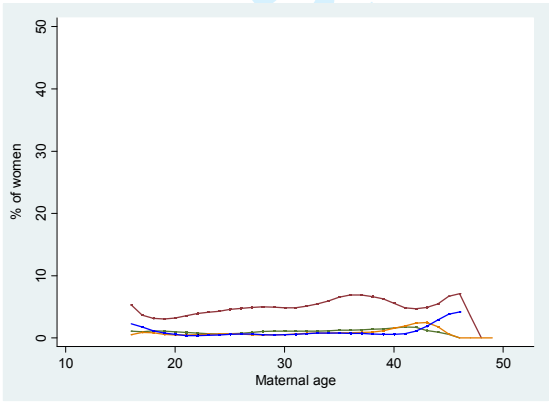


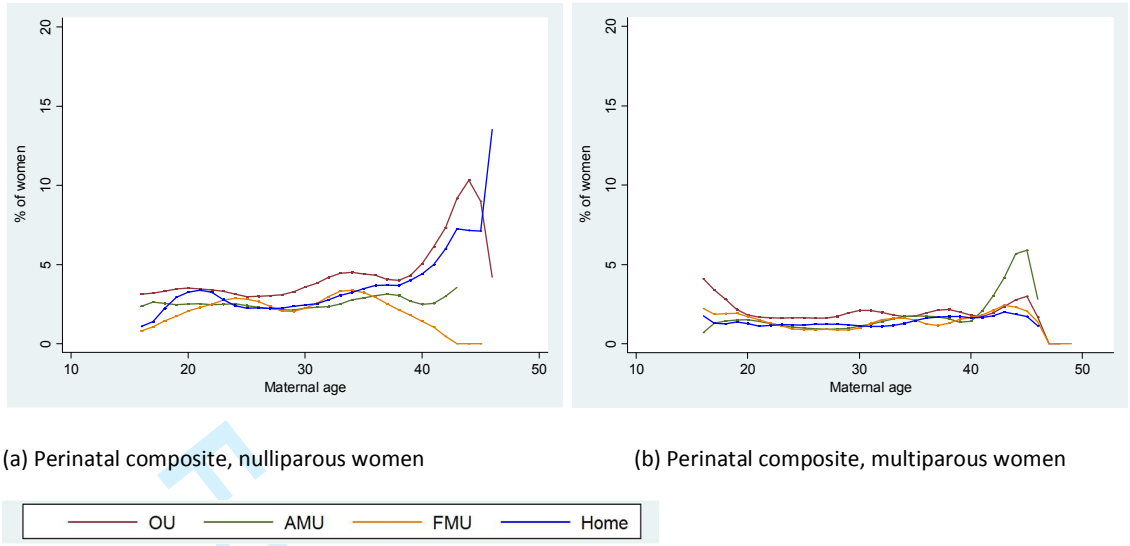
(d) Intrapartum caesarean section, nulliparous



(h) Intrapartum caesarean section, multiparous

Figure 1 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over[1]

[1] NOTE THAT scales for nulliparous women and multiparous women are different.



(a) Perinatal composite, nulliparous women

(b) Perinatal composite, multiparous women

Figure 2 Association between maternal age and perinatal composite outcome in low risk women aged 16 and over

Table 1 Characteristics of low risk women aged 16 and over by maternal age category

	16 - 19 years n=3354		20 - 24 years n=11395		25 - 29 years n=18091		30 - 34 years n=18453		35 - 39 years n=10397		≥ 40 years n=1681	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	3078	90.1	9685	81.2	15146	77.5	16052	80.7	9339	84.3	1527	86.6
Non-white	275	9.9	1697	18.8	2920	22.5	2375	19.3	1044	15.8	153	13.4
Missing	1		13		25		26		14		1	
Understanding of English												
Fluent	3254	96.7	10394	89.6	16757	90.0	17605	92.9	10155	96.3	1638	96.7
Not fluent	94	3.3	948	10.4	1251	10.0	776	7.1	214	3.7	36	3.4
Missing	6		53		83		72		28		7	
Marital/partner status												
Married/living with partner	1836	51.9	9550	81.8	16868	92.1	17782	96.1	10004	95.4	1591	94.4
Single/unsupported by partner	1440	48.1	1677	18.2	1010	7.9	493	3.9	293	4.7	68	5.7
Missing	78		168		213		178		100		22	
BMI in pregnancy (kg/m^2)												
< 18.5	184	6.2	426	4.2	413	2.6	337	2.1	156	1.5	18	0.2
18.5 - 24.9	1753	50.3	5316	45.6	8560	45.9	9059	46.7	4864	44.5	802	46.4
25.0 - 29.9	598	17.9	2558	21.7	4341	24.6	4206	23.2	2572	26.9	415	27.6
30.0 - 35.0	233	7.6	1096	10.0	1627	9.3	1399	8.8	769	8.9	109	8.1
Not recorded	581	18.1	1969	18.4	3091	17.6	3389	19.2	2000	18.3	329	17.7
Missing	5		30		59		63		36		8	
IMD quintile												
1st (Least deprived)	245	6.8	1102	8.5	2875	13.8	4255	20.5	2783	24.6	434	26.0
2nd	405	12.3	1521	13.3	3259	17.5	4114	21.7	2434	22.3	396	22.0
3rd	637	18.2	2115	18.0	3657	18.6	3759	19.7	2135	20.0	357	21.6
4th	827	25.3	2784	23.9	3957	22.7	3479	19.8	1765	17.9	291	16.9
5th (Most deprived)	1221	37.5	3821	36.2	4262	27.5	2759	18.4	1215	15.2	197	13.7
Missing	19		52		81		87		65		6	
Previous pregnancies ≥ 24 weeks												
0	2835	86.8	6341	62.0	8438	53.6	7307	46.7	2989	36.9	346	28.0

1	474	12.1	3772	29.4	5892	29.9	6963	33.9	3929	35.5	540	32.3
2	38	0.8	1006	6.8	2549	10.9	2779	12.2	2260	17.4	414	20.2
3-5	7	0.3	276	1.9	1212	5.6	1404	7.2	1219	10.2	381	19.5
Missing												
Gestation at delivery (completed weeks)												
37	119	4.1	351	3.5	530	3.6	534	3.5	275	3.1	52	3.2
38	305	11.0	1136	10.1	1743	9.9	1739	9.9	971	10.2	146	9.9
39	783	22.5	2788	24.4	4409	24.2	4439	23.5	2516	23.2	410	27.2
40	1292	36.7	4361	36.7	6970	36.2	7090	37.5	3933	35.9	639	35.0
41 - 42+0 days	855	25.7	2759	25.3	4439	26.1	4651	25.6	2702	27.7	434	24.7
Planned place of birth												
OU	1445	87.5	4150	84.9	5601	82.6	4946	80.7	2571	80.2	497	83.2
AMU	1038	8.5	3445	9.6	4958	10.1	4540	10.3	2212	9.6	294	7.9
FMU	661	3.2	2115	3.5	3242	3.8	3216	3.9	1674	3.8	249	3.0
Home	210	0.8	1685	2.0	4290	3.5	5751	5.1	3940	6.4	641	5.8
Birth weight (grams)												
< 2500	53	1.9	146	1.8	166	1.4	159	1.1	75	1.0	17	1.3
2500 - 2999	561	18.4	1728	16.4	2281	14.5	1924	12.7	1100	12.5	168	12.8
3000 - 3499	1502	44.6	4678	41.1	7171	39.3	6960	38.2	3644	36.5	596	37.1
3500 - 3999	977	28.4	3664	30.9	6256	33.4	6767	35.0	3888	35.3	617	36.9
4000 - 4499	233	6.0	1023	8.7	1926	10.0	2294	11.4	1432	12.5	239	9.9
≥ 4500	21	0.7	135	1.2	262	1.5	303	1.6	237	2.3	40	2.0
Missing	7		21		29		46		21		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	145	7.1	411	6.1	678	6.5	706	7.1	415	7.0	78	8.9
Meconium stained liquor	126	5.8	322	4.8	469	5.0	541	6.1	295	5.9	60	7.4
Proteinuria 1+ or more	79	2.3	203	1.7	261	1.9	226	1.6	109	1.7	20	1.6
Hypertension	55	2.6	160	2.2	232	2.4	207	2.0	102	2.1	17	2.0
Abnormal vaginal bleeding	16	0.7	57	0.9	79	0.9	119	1.5	77	2.1	16	2.1

Non-cephalic presentation	5	0.2	31	0.5	44	0.4	64	0.5	46	0.7	3	0.3
Abnormal fetal heart rate	41	1.5	106	1.7	162	1.8	143	1.7	82	1.7	27	3.0
Other complications	14	0.6	24	0.3	23	0.2	27	0.1	11	0.2	2	0.2
Any complicating condition	431	18.5	1175	16.1	1744	16.6	1829	18.0	1001	18.1	199	22.5

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 2 Association between maternal age (per 5-year increase) and maternal and perinatal outcomes in low risk women aged between 16 and 40 years old (inclusive)

	Nulliparous women				Multiparous women			
	Unadjusted[1]		Adjusted[1, 2]		Unadjusted[1]		Adjusted[1, 2]	
	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Maternal composite	1.13	(1.11-1.16)	1.13	(1.11-1.16)	1.07	(1.03-1.13)	1.08	(1.03-1.14)
OU	1.13	(1.11-1.16)	1.12	(1.10-1.15)				
Non-OU[1, 3]	1.22	(1.19-1.26)	1.21	(1.18-1.25)				
		Wald test for interaction	$P^{1,4}$ <0.001			Wald test for interaction	$P^{1,4}$ =0.34	
Augmentation	1.13	(1.09-1.16)	1.12	(1.08-1.17)	1.00	(0.92-1.08)	1.01	(0.92-1.11)
OU	1.13	(1.09-1.17)	1.12	(1.07-1.17)				
Non- OU[1, 3]	1.25	(1.20-1.31)	1.23	(1.18-1.28)				
		Wald test for interaction	$P^{1,4}$<0.001			Wald test for interaction	$P^{1,4}$ =0.24	
Instrumental delivery	1.20	(1.13-1.26)	1.18	(1.12-1.25)	1.14	(1.04-1.25)	1.15	(1.05-1.27)
		Wald test for interaction	$P^{1,4}$ =0.18			Wald test for interaction	$P^{1,4}$ =0.06	
Intrapartum caesarean section	1.27	(1.23-1.31)	1.27	(1.23-1.32)	1.16	(1.07-1.26)	1.16	(1.06-1.28)
		Wald test for interaction	$P^{1,4}$ =0.26			Wald test for interaction	$P^{1,4}$ =0.50	
General anaesthesia	1.06	(0.93-1.20)	1.06	(0.92-1.22)	1.05	(0.87-1.27)	1.09	(0.91-1.32)
		Wald test for interaction	$P^{1,4}$ =0.83			Wald test for interaction	$P^{1,4}$ =0.15	
Maternal blood transfusion	1.09	(0.97-1.23)	1.13	(0.95-1.34)	1.23	(0.95-1.60)	1.24	(0.94-1.62)
		Wald test for interaction	$P^{1,4}$ =0.38			Wald test for interaction	$P^{1,4}$ =0.44	
Third/fourth degree perineal tear	1.17	(1.09-1.27)	1.12	(1.02-1.23)	1.10	(0.98-1.23)	1.01	(0.89-1.15)
		Wald test for interaction	$P^{1,4}$ =0.43			Wald test for interaction	$P^{1,4}$ =0.29	
Maternal admission for higher level care	1.28	(1.03-1.58)	1.46	(1.07-1.99)	1.40	(1.01-1.92)	1.49	(1.06-2.10)
		Wald test for interaction	$P^{1,4}$ =0.41			Wald test for interaction	$P^{1,4}$ =0.15	
Perinatal composite	1.07	(0.97-1.17)	1.06	(0.95-1.17)	1.02	(0.87-1.19)	0.98	(0.84-1.15)
		Wald test for interaction	$P^{1,4}$ =0.92			Wald test for interaction	$P^{1,4}$ =0.66	

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. AMU vs. FMU vs. home).

[3] Results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[4] P for interaction, results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. non-OU).

Table 3 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	480/1239	39.4	(35.6-43.3)	252/1553	17.5	(15.2-20.1)
20-24	1229/2577	47.9	(44.7-51.1)	886/3679	24.2	(21.8-26.8)
25-29	1670/3003	55.6	(53.4-57.9)	1680/5354	32.3	(29.5-35.2)
30-34	1402/2322	61.1	(57.3-64.8)	1730/4897	36.6	(34.2-39.1)
35-39	622/957	65.5	(61.8-69.1)	792/1995	39.9	(36.0-43.9)
40+	108/148	71.9	(63.0-79.3)	83/196	44.8	(35.2-54.7)
Total	5511/10246	54.4	(51.9-56.9)	5423/17674	31.3	(29.3-33.4)
Augmentation						
16-19	317/1245	25.9	(22.5-29.7)	141/1564	8.6	(7.0-10.5)
20-24	790/2584	30.7	(26.9-34.7)	489/3706	12.9	(11.1-14.9)
25-29	1079/3011	35.7	(33.4-38.1)	918/5372	17.4	(15.6-19.3)
30-34	867/2318	37.5	(34.1-41.1)	964/4921	19.9	(18.3-21.7)
35-39	402/955	42.2	(36.4-48.1)	473/2015	22.6	(19.8-25.7)
40+	71/149	47.6	(37.0-58.4)	44/196	23.7	(15.7-34.1)
Total	3526/10262	34.6	(31.9-37.4)	3029/17774	16.9	(15.7-18.1)
Instrumental delivery						
16-19	191/1266	15.1	(12.5-18.2)	99/1568	7.9	(6.2-10.2)
20-24	469/2618	17.9	(15.9-20.0)	392/3717	10.6	(8.9-12.5)
25-29	707/3039	23.4	(21.3-25.6)	772/5391	15.0	(13.1-17.0)
30-34	591/2349	26.3	(21.3-32.1)	795/4950	17.0	(15.2-19.1)
35-39	275/968	29.5	(25.0-34.4)	401/2018	19.4	(15.9-23.6)
40+	41/149	30.4	(20.0-43.2)	37/197	21.0	(13.3-31.5)
Total	2274/10389	22.5	(19.9-25.3)	2496/17841	14.5	(13.0-16.0)
Intrapartum caesarean section						
16-19	101/1266	8.3	(6.5-10.5)	55/1568	3.3	(2.5-4.2)
20-24	313/2618	12.2	(10.4-14.2)	194/3717	5.2	(4.2-6.5)
25-29	461/3039	15.2	(13.3-17.2)	408/5391	8.0	(6.9-9.3)
30-34	466/2349	19.8	(17.5-22.3)	452/4950	9.0	(7.9-10.4)
35-39	223/968	23.0	(19.8-26.5)	212/2018	11.2	(9.0-13.9)
40+	47/149	29.2	(20.9-39.3)	22/197	9.7	(5.2-17.2)
Total	1611/10389	15.7	(14.1-17.5)	1343/17841	7.6	(6.8-8.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 4 Relative risk for non-OU compared to OU by age groups in nulliparous women

Age (years)	Unadjusted RR[1] (95% CI)	Adjusted RR[1, 2] (95% CI)	Adjusted RR[1, 3] (95% CI)
Maternal composite			
16-19	0.44 (0.38-0.53)	0.45 (0.38-0.54)	0.49 (0.42-0.58)
20-24	0.51 (0.45-0.57)	0.51 (0.45-0.58)	0.55 (0.49-0.62)
25-29	0.58 (0.53-0.64)	0.59 (0.54-0.65)	0.63 (0.57-0.70)
30-34	0.60 (0.55-0.66)	0.61 (0.56-0.67)	0.66 (0.60-0.73)
35-39	0.61 (0.54-0.68)	0.62 (0.56-0.69)	0.68 (0.61-0.76)
40+	0.62 (0.49-0.80)	0.66 (0.51-0.87)	0.70 (0.53-0.93)
Augmentation			
16-19	0.33 (0.26-0.42)	0.34 (0.27-0.44)	0.37 (0.29-0.47)
20-24	0.42 (0.35-0.51)	0.43 (0.35-0.52)	0.47 (0.39-0.57)
25-29	0.49 (0.43-0.55)	0.50 (0.45-0.57)	0.56 (0.49-0.63)
30-34	0.53 (0.47-0.60)	0.55 (0.48-0.63)	0.61 (0.53-0.71)
35-39	0.54 (0.44-0.65)	0.54 (0.46-0.64)	0.61 (0.51-0.74)
40+	0.50 (0.32-0.78)	0.53 (0.33-0.84)	0.58 (0.36-0.94)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[3] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and complicating conditions identified at the start of care in labour.

Table 5 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	35/177	20.2	(14.1-28.0)	20/338	6.6	(4.1-10.6)
20-24	242/1506	16.2	(13.8-19.0)	146/3486	4.6	(3.6-5.8)
25-29	468/2504	18.9	(16.9-20.9)	297/6989	4.8	(4.1-5.7)
30-34	492/2548	19.2	(16.8-21.8)	418/8440	5.4	(4.7-6.2)
35-39	344/1575	21.9	(19.4-24.7)	273/5737	5.6	(4.8-6.6)
40+	82/340	24.1	(20.7-28.0)	65/975	7.4	(5.6-9.7)
Total	1663/8650	19.3	(17.6-21.1)	1219/25965	5.3	(4.7-5.9)
Augmentation						
16-19	19/178	10.5	(5.9-17.9)	11/340	3.8	(2.0-7.1)
20-24	144/1516	9.4	(7.5-11.8)	62/3520	2.0	(1.4-2.7)
25-29	247/2529	9.9	(8.2-12.0)	109/7077	1.8	(1.4-2.3)
30-34	255/2572	9.7	(8.0-11.7)	132/8535	1.6	(1.3-2.0)
35-39	156/1592	9.8	(8.2-11.6)	89/5796	1.8	(1.3-2.5)
40+	42/345	12.2	(9.5-15.5)	18/985	1.8	(1.1-3.2)
Total	863/8732	9.8	(8.5-11.4)	421/26253	1.8	(1.5-2.1)
Instrumental delivery						
16-19	12/179	7.5	(3.6-14.9)	7/340	3.1	(1.3-7.1)
20-24	55/1530	3.6	(2.7-4.9)	38/3520	1.4	(1.0-2.0)
25-29	139/2557	5.5	(4.6-6.5)	102/7092	1.8	(1.4-2.3)
30-34	159/2594	6.1	(5.0-7.5)	124/8544	1.6	(1.2-2.0)
35-39	102/1600	6.6	(5.0-8.6)	82/5802	1.8	(1.4-2.4)
40+	30/347	8.8	(5.5-13.8)	17/987	2.5	(1.3-4.7)
Total	497/8807	5.7	(4.9-6.7)	370/26285	1.7	(1.4-2.1)
Intrapartum caesarean section						
16-19	6/179	3.4	(1.4-7.7)	4/340	0.9	(0.3-2.5)
20-24	62/1530	4.1	(2.6-6.3)	21/3520	0.6	(0.3-1.1)
25-29	121/2557	4.8	(3.8-6.1)	48/7092	0.7	(0.5-0.9)
30-34	134/2594	5.1	(4.0-6.5)	70/8544	0.9	(0.6-1.2)
35-39	110/1600	6.8	(5.1-9.1)	53/5802	1.1	(0.8-1.5)
40+	16/347	4.8	(3.1-7.4)	15/987	1.5	(0.8-2.7)
Total	449/8807	5.1	(4.2-6.3)	211/26285	0.8	(0.7-1.1)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 6 Perinatal outcomes by maternal age in low risk women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births	Weighted[1]		Events / Births	Weighted[1]	
	n/N	%	(95% CI)	n/N	%	(95% CI)
Nulliparous						
16-19	39/1260	3.2	(2.2-4.5)	31/1553	2.9	(1.9-4.4)
20-24	89/2610	3.5	(2.5-5.0)	94/3700	2.4	(1.9-3.2)
25-29	92/3026	3.3	(2.6-4.0)	123/5357	2.1	(1.7-2.8)
30-34	101/2340	4.2	(3.1-5.6)	128/4918	3.0	(2.2-4.0)
35-39	37/962	3.9	(2.8-5.4)	65/1999	3.0	(2.1-4.1)
40+	10/149	7.5	(3.4-15.7)	8/195	3.9	(1.0-14.0)
Total	368/10347	3.7	(2.9-4.6)	449/17722	2.6	(2.2-3.1)
Multiparous						
16-19	6/179	3.0	(1.4-6.4)	5/337	1.7	(0.6-4.6)
20-24	26/1519	1.8	(1.2-2.7)	43/3489	1.3	(0.8-2.0)
25-29	41/2547	1.6	(1.2-2.3)	73/7032	1.1	(0.8-1.6)
30-34	50/2578	2.0	(1.5-2.6)	111/8468	1.2	(1.0-1.5)
35-39	33/1594	2.1	(1.3-3.3)	88/5761	1.6	(1.2-2.2)
40+	7/345	2.1	(0.9-4.6)	20/978	2.3	(1.3-4.1)
Total	163/8762	1.9	(1.5-2.4)	340/26065	1.3	(1.1-1.6)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

The effect of maternal age and planned place of birth on intrapartum outcomes in healthy women with straightforward pregnancies: secondary analysis of the Birthplace national prospective cohort study

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Keywords

Maternal age, parity, birthing centre, home birth, augmentation, instrumental delivery, caesarean section, adverse maternal outcomes, adverse perinatal outcomes

Word count

Main text 4,~~277~~ 630 words

Abstract

Objectives

To describe the relationship between maternal age and intrapartum outcomes in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth

Design

Prospective cohort study

Setting

Obstetric units, midwifery units and planned home births in England

Participants

63,371 women aged over 16 without ~~any~~ known medical or obstetric risk factors, with singleton pregnancies, planning ~~a~~ vaginal birth

Methods

Log Poisson regression was used to evaluate the association between maternal age, modelled as a continuous and categorical variable, and risk of intrapartum interventions and adverse maternal and perinatal outcomes.

Main Outcome Measures

Intrapartum caesarean section, instrumental delivery, syntocinon augmentation and a composite measure of maternal interventions/adverse outcomes requiring obstetric care encompassing augmentation, instrumental delivery, intrapartum caesarean section, general anaesthesia, ~~maternal~~ blood transfusion, 3rd/4th degree ~~perineal~~ tear, maternal admission ~~for higher level care~~; adverse perinatal outcome (~~composite of~~ encompassing neonatal unit admission or perinatal death).

Results

Interventions and adverse maternal outcomes requiring obstetric care generally increased with age, particularly in nulliparous women. For nulliparous women aged 16-40, the risk of experiencing an intervention or adverse outcome requiring obstetric care increased more steeply with age in planned non-obstetric unit births than in planned obstetric unit births (adjusted RR 1.21 per 5-year

increase in age, 95% CI 1.18-1.25 vs. adjusted RR 1.12, 95% CI 1.10-1.15) but absolute risks were lower in planned non-OU births at all ages. The risk of neonatal unit admission or perinatal death was significantly raised in nulliparous women aged 40+ relative to women aged 25-29 (adjusted RR 2.29, 95% CI 1.28-4.09).

Conclusions

At all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Younger nulliparous women appear to benefit more from this reduction than older nulliparous women. ~~Younger nulliparous women appear to benefit more than older nulliparous women from planned birth in a non-obstetric unit setting. Age 40 is an appropriate threshold for recommending individual assessment when planning place of birth.~~

Article summary

Article focus

- Does increasing age in women without known medical or obstetric risk factors increase the risk of intrapartum interventions and adverse outcomes that might affect their choice of planned place of birth?

Key messages

- Older women having a first baby appear to benefit less than younger women from planned birth in a non-obstetric unit setting.
- The chances of experiencing an intervention or outcome that requires obstetric care increase with age, even in women who do not have known risk factors.
- Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

Strengths and weaknesses

Strengths

- The study was based on a large, nationally representative cohort of 'low risk' women, with high quality data collected prospectively.

Weaknesses

- The number of women over 40 was relatively small so the study had limited power to explore effects in women over 40, particularly in non-obstetric unit settings.
- Planned births in non-obstetric unit settings were combined; graphical plots indicated that this was reasonable but important differences between settings cannot be ruled out.

Background

The proportion of births in women aged 35 and over has been steadily rising in recent years in the UK and elsewhere.[1, 2] Currently approximately 16% of births in England and Wales are to women aged 35-39 and 4% of births are to women aged 40 and over.[1]

Advanced maternal age is associated with an increased risk of pregnancy complications including gestational diabetes,[3] pregnancy induced hypertension and preeclampsia,[4, 5] twin or higher order pregnancies,[3] breech presentation,[6] placenta praevia,[3, 7-9] preterm birth,[5, 10] post-term birth,[11], severe maternal morbidity,[12] and adverse perinatal outcomes including antepartum stillbirth,[13] intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission.[5] Older women also have an increased risk of interventions such as induction and caesarean section.[16-20] However, many age-related pregnancy complications are known risk factors for intrapartum complications or adverse perinatal outcomes and women with these risk factors would normally be advised to give birth in an obstetric unit (OU). Relatively little is known about the incidence of intrapartum interventions and adverse maternal and perinatal outcomes in older women who do not have known risk factors.[21]

The ~~C~~current clinical guideline~~s~~ in England[22] recommends that healthy women with straightforward pregnancies should be offered a choice of planned birth at home, in a midwife-led unit or in an obstetric unit, but also suggest individual assessment when planning place of birth for women over 40 at booking.[22] The evidence for 'low risk' women in general shows that planned birth in a non-OU setting is associated with a lower incidence of intrapartum interventions[22-28] and research has demonstrated that in 'low risk' women, after adjustment for maternal characteristics, planned birth in a midwifery unit and planned birth at home (multiparous women only) is not associated with an increased risk to the baby compared with planned birth in an OU.[25] However, rates of intrapartum transfer increase with age in nulliparous women[29] and, more generally, the risks that might affect the choice of planned place of birth (PPOB) by healthy older women ~~(and in particular nulliparous older women)~~ are not well documented.

The aim of this study was to evaluate the association between maternal age and intrapartum interventions and adverse maternal and perinatal outcomes that may influence the choice of planned place of birth, in 'low risk' women with singleton, term pregnancies planning a vaginal birth.

The main objectives were to describe the relationship between maternal age and intrapartum interventions and adverse outcomes that indicate a need for obstetric or neonatal care in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth.

Methods

Settings and participants

The study used data from the Birthplace in England national prospective cohort study which was designed to compare perinatal and maternal outcomes and interventions by planned place of birth at the start of care in labour.

The cohort study methods are described in full elsewhere.[25, 26] Briefly, the Birthplace cohort included a total of 79,774 births between April 2008 and April 2010, including 32,257 planned OU births from a stratified random sample of 36 OUs, 11,666 planned births in 53 freestanding midwifery units (FMUs), 17,582 planned births in 43 alongside midwifery units (AMUs) and 18,269 planned home births from 142 NHS trusts across England. Births were eligible for inclusion if the woman was planning a vaginal birth and received some labour care from an NHS midwife in her planned birth setting. Women who had an elective caesarean section or caesarean section before the onset of labour, presented in preterm labour (<37 weeks' gestation), had a multiple pregnancy, an unplanned home birth, or who were "unbooked" (received no antenatal care) were excluded. Stillbirths occurring before the start of care in labour were excluded. Women in the cohort were classified as 'low risk' if before the start of labour they were not known to have any of the medical or obstetric risk factors listed in national guidelines on intrapartum care[22] as "indicating increased risk suggesting planned birth in an obstetric unit". The study had a high response rate and low levels of missing data.[25, 26]

The study population for the analyses reported here was 'low risk' women in the Birthplace cohort aged 16 years or over at the time of birth, with a term (gestational age 37^{+0} weeks to 42^{+0} weeks inclusive) pregnancy and parity less than 6. In the NICE intrapartum care guideline individual assessment is recommended when planning place of birth for women with parity of 6 or more and many midwifery units restrict admission to women of parity 5 or less.[30] We additionally excluded women for whom age, parity or gestational age was not known.

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee and did not require consent to be sought from participants as no personally identifiable data were collected.

Data

As described elsewhere,[25] maternal characteristics, and medical or obstetric risk factors known prior to the onset of labour were extracted from the woman's medical records by the midwife

attending the birth. Complicating conditions identified by the midwife at the start of care in labour (for example prolonged rupture of membranes), intrapartum interventions and adverse maternal and perinatal outcomes were recorded by the attending midwife using a data collection form started during labour and completed on or after the fifth postnatal day.

Planned place of birth (OU, AMU, FMU or home) was based on the intended place of birth at the start of care in labour. Women were included in the group in which they planned to give birth at the start of care in labour regardless of whether they were transferred during labour care or immediately after the birth.

Outcomes

We focused on outcome measures that reflected interventions and adverse outcomes that indicated a need for obstetric and/or neonatal care, that is, outcomes that would require the woman and/or baby to be transferred to an obstetric or neonatal unit if labour care or birth took place elsewhere. For women, we considered the following outcomes both separately and as a combined maternal composite outcome ('interventions/adverse outcomes requiring obstetric care'): augmentation with syntocinon, instrumental delivery (ventouse or forceps), intrapartum caesarean section, general anaesthesia, maternal blood transfusion, 3rd/4th degree perineal tear, maternal admission for higher level care. The use of epidural/spinal analgesia was also considered as a secondary outcome. The main outcomes considered for women were the maternal composite outcome ('interventions and adverse outcomes requiring obstetric care'), augmentation, instrumental delivery, and intrapartum caesarean section.

For babies, we considered a single composite outcome measure largely reflecting admission to a neonatal unit. This 'perinatal composite outcome' encompassed one or more of the following events: admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death.

Statistical analysis

Analyses were conducted separately by parity. We modelled age at the time of delivery both as a categorical and continuous variable, using log Poisson regression to estimate relative risks adjusted for the following potential confounders: ethnic group, understanding of English, marital or partner status, body mass index (BMI), index of multiple deprivation (IMD) score, gestational age at birth and, where appropriate, planned place of birth (see supplementary Table S1 for categorisation). We also carried out sensitivity analyses in which we additionally adjusted for the presence of

complicating conditions identified at the start of care in labour (none, one or more) and for the use of epidural/spinal analgesia.

We fitted a series of models following a pre-specified, iterative strategy. In order to test our modelling assumptions regarding age and to determine whether it was appropriate to combine data for planned births in non-OU settings, we plotted outcomes by age and planned place of birth using polynomial smoothing.[31] Visual inspection of these plots (see Figure 1 and 2 for the main outcomes) indicated that it was reasonable to model age as a continuous variable within the age range 16-40 (inclusive) and further indicated that event rates were generally similar in the three non-OU settings, suggesting that it was reasonable to combine the non-OU settings for the purposes of exploring interactions between maternal age and planned place of birth. We did not model age as a continuous variable above the age of 40 because data were sparse, particularly for planned non-OU births to nulliparous women, and we could not be confident that the broadly linear trends seen at younger ages could be extrapolated above this age.

We initially modelled the effect of age on study outcomes separately by parity and for all planned places of birth combined. Models in which age was modelled as a continuous variable were restricted to the age range 16-40 inclusive. For each of the study outcomes, we tested for an interaction between age (as a continuous variable) and planned place of birth (OU vs. non-OU) using a Wald test, and where the interaction was significant at the 5% level, we modelled the effect of age on the outcome separately by planned place of birth. For outcomes where the interaction between age and planned place of birth was significant, we calculated crude and adjusted relative risks associated with planned non-OU birth separately for each age band.

In order to test whether the presence of complicating conditions at the start of care in labour (for example prolonged rupture of membranes) had an effect on the observed relationships, we fitted a further set of models in which we adjusted for both maternal characteristics and the presence of complicating conditions. Because previous analyses have shown that women planning birth in an OU have a higher prevalence of complicating conditions than in other settings[25] and this affects the magnitude of the difference in event rates between settings, we carried out further analyses of the main outcomes restricted to 'low risk' women without complicating conditions at the start of care in labour.

Robust variance estimation was used to allow for the clustered nature of the data and, as described elsewhere,[25, 26] probability weights were incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs. The

weighting is such that, when applied to the pooled data for all four settings, the weighted event rates represent the estimated average event rates for England as a whole.

For each outcome, we calculated the number of events, the number of births, the weighted incidence and ~~the unadjusted and adjusted relative risks.~~ 95% confidence intervals. We assessed statistical significance at the 5% level.

Results

Description of the study sample

From the 79,774 women in the Birthplace cohort we excluded 15,553 women who had pre-existing ~~medical and obstetric~~ risk factors including 'NICE' medical and obstetric risk factors,[22] grand multiparity (parity 6 or over) and post-term pregnancy, 62 women who were aged ~~<~~under 16, 682 women who had missing data on risk factors, parity or gestational age, and 106 whose age was missing~~.~~. The study population consisted of 63,371 eligible 'low risk' women. The proportion (weighted) of women who were ineligible because of pre-existing ~~medical or obstetric~~ risk factors, increased from 31.9% in women aged 16-19 to 46.7% in women aged 40 and over.

Table 1 describes the characteristics of the sample by age. The percentages shown in the table are weighted so that they provide an estimate of the distribution of maternal characteristics that would apply to eligible 'low risk' births in England. Older women tended to be white, have a fluent understanding of English, and were more likely than younger women to live in a socioeconomically advantaged area. They were less likely than younger women to be nulliparous and more likely to have had multiple previous pregnancies. Planned home births were more common at older ages (Table 1 and supplementary Tables S2 and S3), particularly in multiparous women (supplementary Table S3). Older women were more likely to have complicating conditions, such as prolonged rupture of membranes, noted by the midwife at the start of care in labour (Table 1). Complicating conditions at start of care in labour were more common in nulliparous women (supplementary Tables S2 and S3).

[TABLE 1 HERE]

Maternal interventions and adverse outcomes

Descriptive plots of outcomes by age indicated that the incidence of most outcomes tended to increase steadily with age in the age range 16 to 40, and that incidence rates were generally lower in planned non-OU births (Figure 1 and supplementary Figure S1). Rates for planned OU and non-OU births tended to diverge above this age range, but rates were based on small numbers of older women (supplementary Table S4) particularly for planned AMU and FMU births and therefore these rates have wide confidence intervals.

For nulliparous women in the age range 16-40 (all PPOBs combined), the adjusted risk of having an intervention/ adverse outcome requiring obstetric care (maternal composite) increased significantly with age, as did the risk of augmentation with syntocinon, instrumental delivery, intrapartum

caesarean section, 3rd/4th degree perineal tear, or maternal admission for higher level care (Table 2). For augmentation with syntocinon and the maternal composite outcome, the effect of age differed by PPOB (Table 2). The risk of augmentation increased more steeply with age in non-OU settings (RR 1.23, 95% CI 1.18-1.28 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.07-1.17 for planned OU births). Nevertheless, the proportion of women receiving augmentation was lower in planned non-OU births at all ages (Table 3). For example, 42.2% (95% CI 36.4%-48.1%) of nulliparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 22.6% (95% CI 19.8%-25.7%) of nulliparous women of the same age who planned birth in a non-OU setting. A similar pattern was observed for the maternal composite outcome: the risk of an intervention/adverse outcome requiring obstetric care (maternal composite) increased slightly more steeply with age in the non-OU settings (RR 1.21, 95% CI 1.18-1.25 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.10-1.15 for planned OU births) but the absolute risk was lower in the planned non-OU birth at all ages (Table 3). For example, 65.5% (95% CI 61.8%-69.1%) of nulliparous women aged 35-39 who planned birth in an OU experienced an intervention/adverse outcome requiring obstetric care compared with 39.9% (95% CI 36.0%-43.9%) of nulliparous women of the same age who planned birth in a non-OU setting.

~~[TABLE 2 AND TABLE 3 HERE]~~

In nulliparous women, the risk of instrumental delivery and intrapartum caesarean section increased significantly with age (RR 1.18, 95% CI 1.12-1.25 and RR 1.27, 95% CI 1.23-1.32) across all settings. Again, absolute risks were substantially lower in planned non-OU births (Table 3).

[TABLE 2 AND TABLE 3 HERE]

Similar patterns were observed when we adjusted for complicating conditions at the start of care in labour in order to take account of difference between settings in complicating conditions at the start of care in labour (23.9% in nulliparous planned OU births vs. 8.6% in nulliparous planned-non-OU births) (supplementary Table S5).

However, although the risk of intervention increased with age, at all ages, nulliparous women who planned birth in a non-OU setting had a significantly reduced risk of receiving augmentation or of experiencing an intervention/adverse outcome requiring obstetric care. Table 4 shows the adjusted risks by age for the two outcomes (maternal composite and augmentation) where the effect of planned place of birth differed by age.

[TABLE 4 HERE]

For multiparous women aged 16-40 (all PPOBs combined), the combined risk of having an intervention or adverse outcome requiring obstetric care (maternal composite) or of instrumental delivery, intrapartum caesarean section, and maternal admission for higher level care increased with age (Table 2). Augmentation with syntocinon, general anaesthesia, blood transfusion, and 3rd/4th degree perineal tear were not associated with maternal age in multiparous women (Table 2). For all of the outcomes considered, the effect of age did not differ by PPOB in multiparous women (Table 2). Again, for the maternal composite outcome, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section, the absolute event rates were lower in planned non-OU births in most age categories (Table ~~4~~5). For example, 9.8% (95% CI 8.2%-11.6%) of multiparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 1.8% (95% CI 1.3%-2.5%) of women of the same age who planned birth in a non-OU setting.

Up to age 40, other less common outcomes did not increase significantly with maternal age in nulliparous or multiparous women with the exception of maternal admission to higher level care (Table 2 and supplementary Tables ~~S5~~ S6 and ~~S6~~S7).

[TABLE ~~4~~ 5 HERE]

~~Adjustment for complicating conditions at the start of care in labour had a negligible effect on the relationship between age and the study outcomes (supplementary Table S7).~~ Absolute event rates for the main outcomes (maternal composite, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section and perinatal composite) were reduced when the analysis was restricted to women without complicating conditions identified at start of labour care (supplementary Tables S8 and S9). However, at all ages, nulliparous women without complicating conditions who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention/adverse outcome requiring obstetric care (maternal composite outcome) (Table S8 and S10).~~but absolute intervention rates remained substantially higher at all ages in planned OU births vs. planned births in other settings (supplementary Tables S8 and S9).~~ For example, 38.0% (95% CI 34.3%-41.9%) of nulliparous women aged 35-39 without complicating complications who planned birth in a non-OU setting experienced an intervention/adverse outcome requiring obstetric care, compared with 57.7% (95% CI 53.4%- 62.0%) of women of the same age without complicating conditions who planned birth in an OU.

The use of epidural/spinal analgesia increased significantly with maternal age and lower rates of use were observed in planned non-OU births (supplementary Figure S2). Adjustment for use of epidural in the multivariable models attenuated but did not change the results materially (data not shown).

Perinatal outcome

The perinatal composite outcome (admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death) showed a modest but not statistically significant increase with age in nulliparous women in the age range 16-40 (Table 2). The risk increased significantly in nulliparous women aged 40+ compared with women aged 25-29 (RR 2.29, 95%CI 1.28-4.09, adjusted for maternal characteristics and planned place of birth, all settings combined). Maternal age was not significantly associated with the risk of the perinatal composite outcome in multiparous women in the age range 16-40 (Table 2) and the risk was not significantly increased in births to multiparous women aged 40+ compared with women aged 25-29 (RR 1.21, 95% CI 0.60-2.43, adjustment as before). Absolute event rates are shown in Table ~~5~~6.

[TABLE ~~5~~ 6 HERE]

Discussion

Principal findings

In women without known medical or obstetric risk factors prior to the onset of labour, interventions and adverse maternal outcomes requiring obstetric care generally increased with age, but there was no age at which there was a step-change in risk. For both nulliparous and multiparous women, maternal intervention rates were lower in births planned in non-OU settings compared with planned OU births at all ages. ~~, but f~~For nulliparous women the overall risk of experiencing an intervention or adverse outcome requiring obstetric care, and in particular of augmentation with syntocinon, increased more steeply with age in planned non-OU births than in planned OU births. As a consequence, although nulliparous women of all ages who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention or adverse outcome requiring obstetric care, the benefit of planned non-OU birth was greatest at younger ages. ~~and reduced with increasing age.~~

In low risk women up to the age of 40, the risk of neonatal unit admission or intrapartum stillbirth/early neonatal death did not show a statistically significant upward trend with age in either nulliparous or multiparous women. In planned OU births, the risk of neonatal unit admission or perinatal death was significantly higher in nulliparous women aged 40+ relative to women aged 25-29.

Strengths and limitations

A strength of the study is that we were able to evaluate the effect of age on intrapartum outcomes by planned birth setting in a nationally representative sample of 'low risk' women. In order to strengthen the evidence supporting clinical guidelines on planned place of birth, the study specifically focused on outcomes that reflect need for obstetric or neonatal care in a sample of women who meet the current criteria for planned birth in a non-OU setting.[22] To our knowledge, this is the first study to investigate the effect of increasing maternal age in different birth settings with a focus on outcomes that would require transfer to an OU and hence may affect the choice of planned place of birth.

Despite the large overall sample size, the number of older women was relatively small, so we had limited ability to explore effects above age 40 or to separate results of individual non-OU birth settings. We combined data for the non-OU settings, having first explored the data to check that this was reasonable. This increased our statistical power to evaluate the association between maternal age and the study outcomes (maternal and perinatal), but we still lacked the statistical power to

evaluate uncommon outcomes. It is important to note that previous analyses[25] have shown that planned home births are associated with a significantly increased risk of adverse perinatal outcomes in nulliparous women.

The risk of bias due to missing data and non-response was low: the study had a low level of missing data, a high response rate[25, 26] and, because consent was not required, there was no self-selection bias due to non-consent. We addressed potential differences in risk between groups in a number of ways. First, we ~~We~~ controlled for important potential confounders such as body mass index. Second, we ~~and, because the study~~ focused on a relatively homogeneous population of women without known medical or obstetric risk factors prior to the onset of labour. Third, because previous analyses[25] identified that the prevalence of complicating conditions at the start of care in labour was higher in the planned OU birth group, we conducted two additional analyses in which we controlled for complicating conditions and restricted the analysis to women without complicating conditions. ~~, uncontrolled d~~Differences in the clinical characteristics of the OU and non-OU ~~in clinical risks between~~ groups therefore seem unlikely to explain ~~our findings.~~ the age related trends observed or the significant reductions in risks observed in non-OU births. Nevertheless, women self-select their birth setting and it may be that some of the differences in outcomes that we observed between settings may have been due to unmeasured differences in the characteristics of women opting for OU and non-OU births, rather than to differences attributable to the birth setting.

Comparison with the existing literature

Older women have been shown to have an increased risk of intrapartum intervention,[6, 32] but many studies include women known to be at higher risk who would normally be advised to give birth in an obstetric unit. Evidence relating to 'low risk' women[17] or from studies that have controlled for pre-existing risk factors or complications[33] is more limited but is generally consistent with our finding that intervention rates increase with age in 'low risk' women.

There is extensive evidence that 'low risk' women who plan birth in a non-OU setting have a reduced risk of a range of intrapartum interventions, including augmentation, instrumental delivery and intrapartum caesarean section, and are more likely to have a spontaneous vaginal birth.[22-24, 27, 28] Our study found that, across the age range 16-40, women who plan birth in a non-OU setting experience substantially lower intervention rates and are less likely to experience an outcome requiring obstetric care than women of the same age who plan birth in an obstetric unit.

In nulliparous women we found that rates of augmentation of labour with syntocinon increased more steeply with maternal age in planned non-OU births compared with planned OU births, although absolute rates of augmentation were substantially lower in planned non-OU births at all

ages. An age-related increase in augmentation is consistent with evidence of poorer uterine function at older ages,[34] longer labours[34] and an increased incidence of prolonged labour,[35, 36] but the reasons for a steeper increase in augmentation with age in non-OU settings is unclear. It has been suggested that labelling of older women as 'higher risk' and/or heightened concern about the safety of older nulliparous women, particularly those who have required fertility treatment, may result in increased rates of caesarean section for non-medical reasons,[20, 32, 33, 37] and it is possible that similar factors affect midwives' decision making regarding transfer for failure to progress, or for other reasons. Intrapartum transfers from midwifery units in the Birthplace study have been shown to increase significantly with age in nulliparous women[29] and, once transferred, women are 'exposed' to the higher intervention rates found in obstetric units.

It is also possible that age-related differences in women's expectations and expressed preferences may contribute to the pattern of intervention observed in our study. Older nulliparous women have been found to have a more positive attitude towards caesarean section,[38] for example, and also to have a higher perception of pregnancy risk, even in older women without known risk factors.[39] The significant positive association between maternal age and epidural use observed in our study (seen most strongly in nulliparous women planning a non-OU birth), would be consistent with a greater willingness of older women to consider interventions.

We found a significantly increased risk of maternal admission to higher level care at older ages in both nulliparous and multiparous women. The number of events was small and this could be a chance finding but an increase in serious obstetric complications at older ages observed in some studies[3, 6, 12] cannot be ruled out.

Although studies including women with known risk factors have reported increased risks in women aged over 35,[3, 6, 35] our analysis shows that up to the age of 40, risks tend to increase in a broadly linear manner in healthy women with straightforward pregnancies, with no evidence of a step-change in risk below the age of 40. Other studies have similarly concluded that the association of adverse outcomes with maternal age is a continuum,[3] with the increase in adverse perinatal outcomes possibly gaining momentum above the age of 40.[40] Because of the small number of births to mothers aged over 40 in our sample we had limited power to evaluate risks at older ages and other evidence relating to older 'low risk' women is sparse.[21]

There is some evidence that the babies of older women are at increased risk of serious adverse outcomes, including intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission,[5, 33] but these outcomes would be expected to be substantially reduced in 'low risk' women who, by definition, do not have medical or obstetric risk factors such as severe obesity,

diabetes or previous caesarean section. Furthermore, the poorer outcomes associated with the increased risk of pre-term birth at older ages do not apply to women giving birth at term. In our 'low risk' cohort, we did not observe a significant increase with age in our composite measure of neonatal unit admission/perinatal death within the age range 16-40, but graphical plots for nulliparous women suggested a possible upturn in neonatal unit admission/perinatal death around the age of 40 in nulliparous women. Further research evaluating perinatal outcomes in 'low risk' women aged over 40 is needed.

Conclusions and policy implications

The incidence of intrapartum interventions and adverse outcomes requiring obstetric care increases with maternal age, but at all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Amongst~~Younger~~ nulliparous women, younger women appear to benefit more ~~than older nulliparous women~~ from the reduction in interventions associated with planned birth in a non-OU setting. Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

~~The findings support the current threshold of age 40 for recommending individual assessment when planning place of birth. Healthy older nulliparous women with straightforward pregnancies~~All women, irrespective of age and parity, should be given information about the risks and benefits of different birth settings. Nulliparous women planning birth in non-OU setting should be informed that ~~they have an increased risk of~~ the risk of interventions that require transfer to an OU increases with age. Further research is required to evaluate adverse perinatal outcomes in 'low risk' women aged over 40.

Acknowledgements

We thank Xiaosi Wang for conducting initial literature searches and statistical analysis.

Competing interests

None.

Contribution to authorship

JH conceived and developed the study outline with input from PB; YL developed the protocol and analysis plan with input from JH, JT and MK; YL conducted the analysis; JT provided statistical advice; YL and JH drafted the manuscript with input from RR, MK and PB. All authors were involved in interpretation of data, review and revision of the draft manuscript and approval of the final version.

Ethics Approval

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee (MREC ref 07/H0505/151).

Funding

This paper reports on an independent study which is funded by the Policy Research Programme in the Department of Health. The views expressed are not necessarily those of the Department.

Birthplace combines the Evaluation of Maternity Units in England study funded in 2006 by the National Institute for Health Research Service Delivery and Organisation (NIHR SDO) programme, and the Birth at Home in England study funded in 2007 by the Department of Health Policy Research Programme (DH PRP). From January 2012, the NIHR SDO programme merged with the NIHR Health Services Research programme to establish the new NIHR health Services and Delivery Research (NIHR HS&DR) programme. The views and opinions expressed by the authors do not necessarily reflect those of the HS&DR Programme, NIHR, NHS, DH PRP or the Department of Health.

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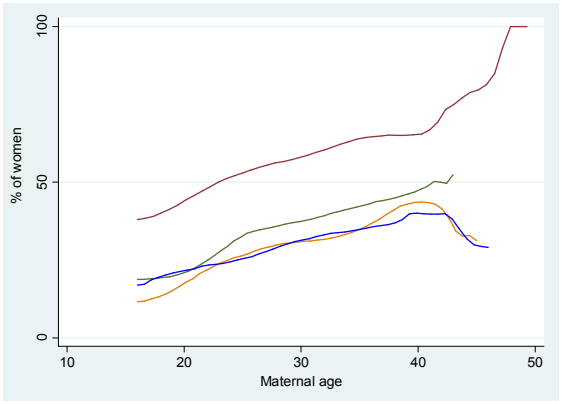
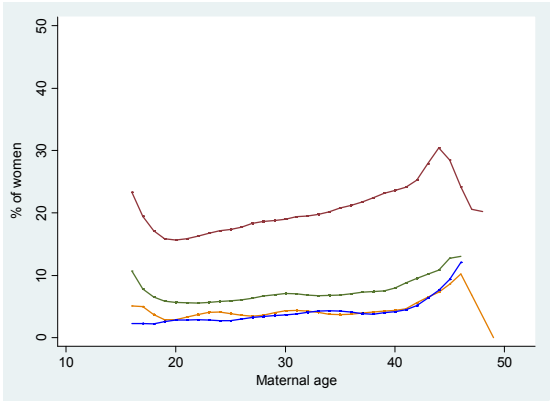
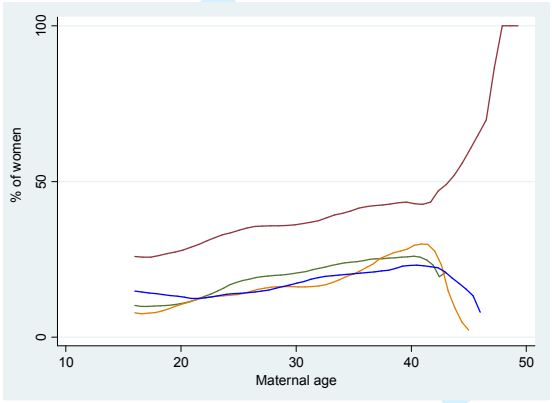


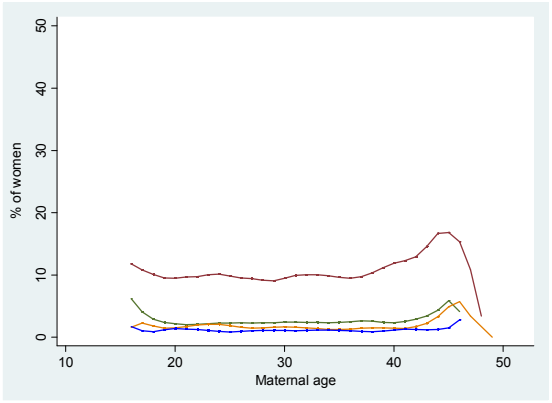
(a) Maternal composite, nulliparous women



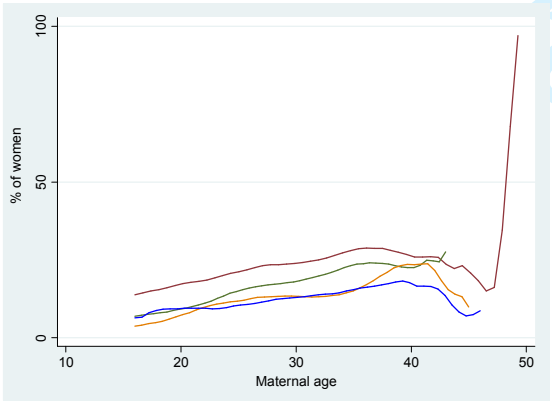
(e) Maternal composite, multiparous women



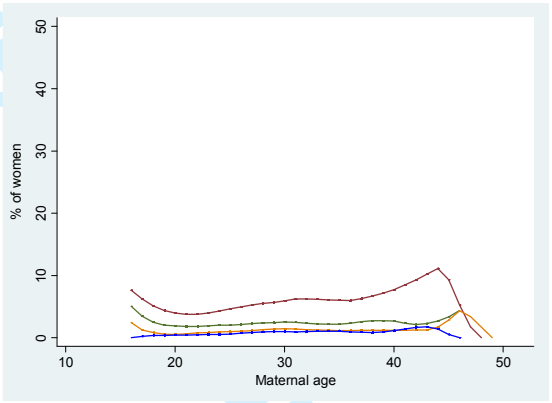
(b) Augmentation, nulliparous women



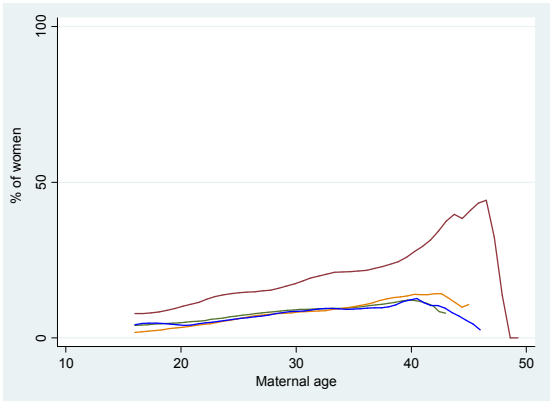
(f) Augmentation, multiparous women



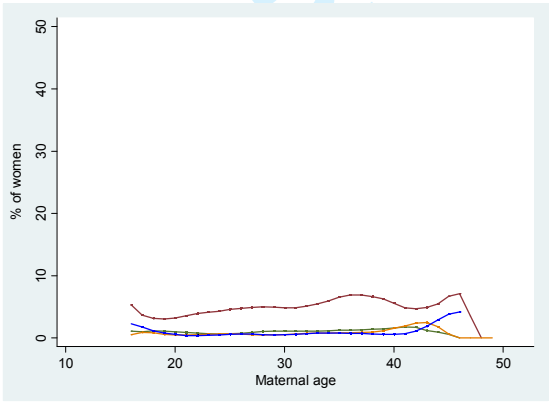
(c) Instrumental delivery, nulliparous women



(g) Instrumental delivery, multiparous women



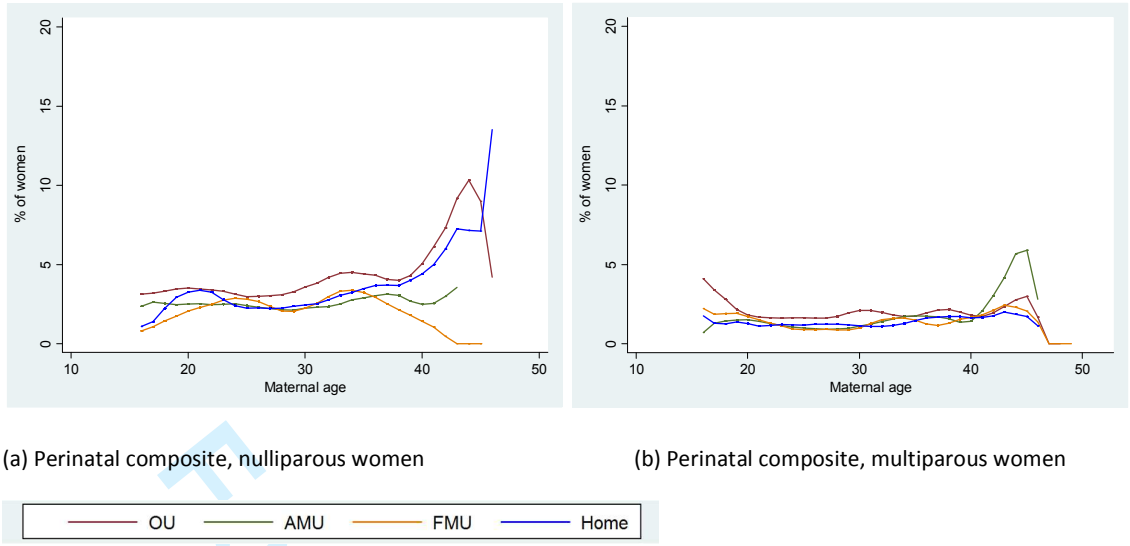
(d) Intrapartum caesarean section, nulliparous



(h) Intrapartum caesarean section, multiparous

Figure 1 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over[1]

[1] NOTE THAT scales for nulliparous women and multiparous women are different.



(a) Perinatal composite, nulliparous women

(b) Perinatal composite, multiparous women

Figure 2 Association between maternal age and perinatal composite outcome in low risk women aged 16 and over

Table 1 Characteristics of low risk women aged 16 and over by maternal age category

	16 - 19 years n=3354		20 - 24 years n=11395		25 - 29 years n=18091		30 - 34 years n=18453		35 - 39 years n=10397		≥ 40 years n=1681	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	3078	90.1	9685	81.2	15146	77.5	16052	80.7	9339	84.3	1527	86.6
Non-white	275	9.9	1697	18.8	2920	22.5	2375	19.3	1044	15.8	153	13.4
Missing	1		13		25		26		14		1	
Understanding of English												
Fluent	3254	96.7	10394	89.6	16757	90.0	17605	92.9	10155	96.3	1638	96.7
Not fluent	94	3.3	948	10.4	1251	10.0	776	7.1	214	3.7	36	3.4
Missing	6		53		83		72		28		7	
Marital/partner status												
Married/living with partner	1836	51.9	9550	81.8	16868	92.1	17782	96.1	10004	95.4	1591	94.4
Single/unsupported by partner	1440	48.1	1677	18.2	1010	7.9	493	3.9	293	4.7	68	5.7
Missing	78		168		213		178		100		22	
BMI in pregnancy (kg/m^2)												
< 18.5	184	6.2	426	4.2	413	2.6	337	2.1	156	1.5	18	0.2
18.5 - 24.9	1753	50.3	5316	45.6	8560	45.9	9059	46.7	4864	44.5	802	46.4
25.0 - 29.9	598	17.9	2558	21.7	4341	24.6	4206	23.2	2572	26.9	415	27.6
30.0 - 35.0	233	7.6	1096	10.0	1627	9.3	1399	8.8	769	8.9	109	8.1
Not recorded	581	18.1	1969	18.4	3091	17.6	3389	19.2	2000	18.3	329	17.7
Missing	5		30		59		63		36		8	
IMD quintile												
1st (Least deprived)	245	6.8	1102	8.5	2875	13.8	4255	20.5	2783	24.6	434	26.0
2nd	405	12.3	1521	13.3	3259	17.5	4114	21.7	2434	22.3	396	22.0
3rd	637	18.2	2115	18.0	3657	18.6	3759	19.7	2135	20.0	357	21.6
4th	827	25.3	2784	23.9	3957	22.7	3479	19.8	1765	17.9	291	16.9
5th (Most deprived)	1221	37.5	3821	36.2	4262	27.5	2759	18.4	1215	15.2	197	13.7
Missing	19		52		81		87		65		6	
Previous pregnancies ≥ 24 weeks												
0	2835	86.8	6341	62.0	8438	53.6	7307	46.7	2989	36.9	346	28.0

1	474	12.1	3772	29.4	5892	29.9	6963	33.9	3929	35.5	540	32.3
2	38	0.8	1006	6.8	2549	10.9	2779	12.2	2260	17.4	414	20.2
3-5	7	0.3	276	1.9	1212	5.6	1404	7.2	1219	10.2	381	19.5
Missing												
Gestation at delivery (completed weeks)												
37	119	4.1	351	3.5	530	3.6	534	3.5	275	3.1	52	3.2
38	305	11.0	1136	10.1	1743	9.9	1739	9.9	971	10.2	146	9.9
39	783	22.5	2788	24.4	4409	24.2	4439	23.5	2516	23.2	410	27.2
40	1292	36.7	4361	36.7	6970	36.2	7090	37.5	3933	35.9	639	35.0
41 - 42+0 days	855	25.7	2759	25.3	4439	26.1	4651	25.6	2702	27.7	434	24.7
Planned place of birth												
OU	1445	87.5	4150	84.9	5601	82.6	4946	80.7	2571	80.2	497	83.2
AMU	1038	8.5	3445	9.6	4958	10.1	4540	10.3	2212	9.6	294	7.9
FMU	661	3.2	2115	3.5	3242	3.8	3216	3.9	1674	3.8	249	3.0
Home	210	0.8	1685	2.0	4290	3.5	5751	5.1	3940	6.4	641	5.8
Birth weight (grams)												
< 2500	53	1.9	146	1.8	166	1.4	159	1.1	75	1.0	17	1.3
2500 - 2999	561	18.4	1728	16.4	2281	14.5	1924	12.7	1100	12.5	168	12.8
3000 - 3499	1502	44.6	4678	41.1	7171	39.3	6960	38.2	3644	36.5	596	37.1
3500 - 3999	977	28.4	3664	30.9	6256	33.4	6767	35.0	3888	35.3	617	36.9
4000 - 4499	233	6.0	1023	8.7	1926	10.0	2294	11.4	1432	12.5	239	9.9
≥ 4500	21	0.7	135	1.2	262	1.5	303	1.6	237	2.3	40	2.0
Missing	7		21		29		46		21		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	145	7.1	411	6.1	678	6.5	706	7.1	415	7.0	78	8.9
Meconium stained liquor	126	5.8	322	4.8	469	5.0	541	6.1	295	5.9	60	7.4
Proteinuria 1+ or more	79	2.3	203	1.7	261	1.9	226	1.6	109	1.7	20	1.6
Hypertension	55	2.6	160	2.2	232	2.4	207	2.0	102	2.1	17	2.0
Abnormal vaginal bleeding	16	0.7	57	0.9	79	0.9	119	1.5	77	2.1	16	2.1

Non-cephalic presentation	5	0.2	31	0.5	44	0.4	64	0.5	46	0.7	3	0.3
Abnormal fetal heart rate	41	1.5	106	1.7	162	1.8	143	1.7	82	1.7	27	3.0
Other complications	14	0.6	24	0.3	23	0.2	27	0.1	11	0.2	2	0.2
Any complicating condition	431	18.5	1175	16.1	1744	16.6	1829	18.0	1001	18.1	199	22.5

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 2 Association between maternal age (per 5-year increase) and maternal and perinatal outcomes in low risk women aged between 16 and 40 years old (inclusive)

	Nulliparous women				Multiparous women			
	Unadjusted[1]		Adjusted[1, 2]		Unadjusted[1]		Adjusted[1, 2]	
	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Maternal composite	1.13	(1.11-1.16)	1.13	(1.11-1.16)	1.07	(1.03-1.13)	1.08	(1.03-1.14)
OU	1.13	(1.11-1.16)	1.12	(1.10-1.15)				
Non-OU[1, 3]	1.22	(1.19-1.26)	1.21	(1.18-1.25)				
		Wald test for interaction	$P^{1,4}$ <0.001			Wald test for interaction	$P^{1,4}$ =0.34	
Augmentation	1.13	(1.09-1.16)	1.12	(1.08-1.17)	1.00	(0.92-1.08)	1.01	(0.92-1.11)
OU	1.13	(1.09-1.17)	1.12	(1.07-1.17)				
Non- OU[1, 3]	1.25	(1.20-1.31)	1.23	(1.18-1.28)				
		Wald test for interaction	$P^{1,4}$<0.001			Wald test for interaction	$P^{1,4}$ =0.24	
Instrumental delivery	1.20	(1.13-1.26)	1.18	(1.12-1.25)	1.14	(1.04-1.25)	1.15	(1.05-1.27)
		Wald test for interaction	$P^{1,4}$ =0.18			Wald test for interaction	$P^{1,4}$ =0.06	
Intrapartum caesarean section	1.27	(1.23-1.31)	1.27	(1.23-1.32)	1.16	(1.07-1.26)	1.16	(1.06-1.28)
		Wald test for interaction	$P^{1,4}$ =0.26			Wald test for interaction	$P^{1,4}$ =0.50	
General anaesthesia	1.06	(0.93-1.20)	1.06	(0.92-1.22)	1.05	(0.87-1.27)	1.09	(0.91-1.32)
		Wald test for interaction	$P^{1,4}$ =0.83			Wald test for interaction	$P^{1,4}$ =0.15	
Maternal blood transfusion	1.09	(0.97-1.23)	1.13	(0.95-1.34)	1.23	(0.95-1.60)	1.24	(0.94-1.62)
		Wald test for interaction	$P^{1,4}$ =0.38			Wald test for interaction	$P^{1,4}$ =0.44	
Third/fourth degree perineal tear	1.17	(1.09-1.27)	1.12	(1.02-1.23)	1.10	(0.98-1.23)	1.01	(0.89-1.15)
		Wald test for interaction	$P^{1,4}$ =0.43			Wald test for interaction	$P^{1,4}$ =0.29	
Maternal admission for higher level care	1.28	(1.03-1.58)	1.46	(1.07-1.99)	1.40	(1.01-1.92)	1.49	(1.06-2.10)
		Wald test for interaction	$P^{1,4}$ =0.41			Wald test for interaction	$P^{1,4}$ =0.15	
Perinatal composite	1.07	(0.97-1.17)	1.06	(0.95-1.17)	1.02	(0.87-1.19)	0.98	(0.84-1.15)
		Wald test for interaction	$P^{1,4}$ =0.92			Wald test for interaction	$P^{1,4}$ =0.66	

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. AMU vs. FMU vs. home).

[3] Results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[4] P for interaction, results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. non-OU).

Table 3 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	480/1239	39.4	(35.6-43.3)	252/1553	17.5	(15.2-20.1)
20-24	1229/2577	47.9	(44.7-51.1)	886/3679	24.2	(21.8-26.8)
25-29	1670/3003	55.6	(53.4-57.9)	1680/5354	32.3	(29.5-35.2)
30-34	1402/2322	61.1	(57.3-64.8)	1730/4897	36.6	(34.2-39.1)
35-39	622/957	65.5	(61.8-69.1)	792/1995	39.9	(36.0-43.9)
40+	108/148	71.9	(63.0-79.3)	83/196	44.8	(35.2-54.7)
Total	5511/10246	54.4	(51.9-56.9)	5423/17674	31.3	(29.3-33.4)
Augmentation						
16-19	317/1245	25.9	(22.5-29.7)	141/1564	8.6	(7.0-10.5)
20-24	790/2584	30.7	(26.9-34.7)	489/3706	12.9	(11.1-14.9)
25-29	1079/3011	35.7	(33.4-38.1)	918/5372	17.4	(15.6-19.3)
30-34	867/2318	37.5	(34.1-41.1)	964/4921	19.9	(18.3-21.7)
35-39	402/955	42.2	(36.4-48.1)	473/2015	22.6	(19.8-25.7)
40+	71/149	47.6	(37.0-58.4)	44/196	23.7	(15.7-34.1)
Total	3526/10262	34.6	(31.9-37.4)	3029/17774	16.9	(15.7-18.1)
Instrumental delivery						
16-19	191/1266	15.1	(12.5-18.2)	99/1568	7.9	(6.2-10.2)
20-24	469/2618	17.9	(15.9-20.0)	392/3717	10.6	(8.9-12.5)
25-29	707/3039	23.4	(21.3-25.6)	772/5391	15.0	(13.1-17.0)
30-34	591/2349	26.3	(21.3-32.1)	795/4950	17.0	(15.2-19.1)
35-39	275/968	29.5	(25.0-34.4)	401/2018	19.4	(15.9-23.6)
40+	41/149	30.4	(20.0-43.2)	37/197	21.0	(13.3-31.5)
Total	2274/10389	22.5	(19.9-25.3)	2496/17841	14.5	(13.0-16.0)
Intrapartum caesarean section						
16-19	101/1266	8.3	(6.5-10.5)	55/1568	3.3	(2.5-4.2)
20-24	313/2618	12.2	(10.4-14.2)	194/3717	5.2	(4.2-6.5)
25-29	461/3039	15.2	(13.3-17.2)	408/5391	8.0	(6.9-9.3)
30-34	466/2349	19.8	(17.5-22.3)	452/4950	9.0	(7.9-10.4)
35-39	223/968	23.0	(19.8-26.5)	212/2018	11.2	(9.0-13.9)
40+	47/149	29.2	(20.9-39.3)	22/197	9.7	(5.2-17.2)
Total	1611/10389	15.7	(14.1-17.5)	1343/17841	7.6	(6.8-8.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 4 Relative risk for non-OU compared to OU by age groups in nulliparous women

Age (years)	Unadjusted RR[1] (95% CI)	Adjusted RR[1, 2] (95% CI)	Adjusted RR[1, 3] (95% CI)
Maternal composite			
16-19	0.44 (0.38-0.53)	0.45 (0.38-0.54)	0.49 (0.42-0.58)
20-24	0.51 (0.45-0.57)	0.51 (0.45-0.58)	0.55 (0.49-0.62)
25-29	0.58 (0.53-0.64)	0.59 (0.54-0.65)	0.63 (0.57-0.70)
30-34	0.60 (0.55-0.66)	0.61 (0.56-0.67)	0.66 (0.60-0.73)
35-39	0.61 (0.54-0.68)	0.62 (0.56-0.69)	0.68 (0.61-0.76)
40+	0.62 (0.49-0.80)	0.66 (0.51-0.87)	0.70 (0.53-0.93)
Augmentation			
16-19	0.33 (0.26-0.42)	0.34 (0.27-0.44)	0.37 (0.29-0.47)
20-24	0.42 (0.35-0.51)	0.43 (0.35-0.52)	0.47 (0.39-0.57)
25-29	0.49 (0.43-0.55)	0.50 (0.45-0.57)	0.56 (0.49-0.63)
30-34	0.53 (0.47-0.60)	0.55 (0.48-0.63)	0.61 (0.53-0.71)
35-39	0.54 (0.44-0.65)	0.54 (0.46-0.64)	0.61 (0.51-0.74)
40+	0.50 (0.32-0.78)	0.53 (0.33-0.84)	0.58 (0.36-0.94)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[3] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and complicating conditions identified at the start of care in labour.

Table ~~4~~ 5 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	35/177	20.2	(14.1-28.0)	20/338	6.6	(4.1-10.6)
20-24	242/1506	16.2	(13.8-19.0)	146/3486	4.6	(3.6-5.8)
25-29	468/2504	18.9	(16.9-20.9)	297/6989	4.8	(4.1-5.7)
30-34	492/2548	19.2	(16.8-21.8)	418/8440	5.4	(4.7-6.2)
35-39	344/1575	21.9	(19.4-24.7)	273/5737	5.6	(4.8-6.6)
40+	82/340	24.1	(20.7-28.0)	65/975	7.4	(5.6-9.7)
Total	1663/8650	19.3	(17.6-21.1)	1219/25965	5.3	(4.7-5.9)
Augmentation						
16-19	19/178	10.5	(5.9-17.9)	11/340	3.8	(2.0-7.1)
20-24	144/1516	9.4	(7.5-11.8)	62/3520	2.0	(1.4-2.7)
25-29	247/2529	9.9	(8.2-12.0)	109/7077	1.8	(1.4-2.3)
30-34	255/2572	9.7	(8.0-11.7)	132/8535	1.6	(1.3-2.0)
35-39	156/1592	9.8	(8.2-11.6)	89/5796	1.8	(1.3-2.5)
40+	42/345	12.2	(9.5-15.5)	18/985	1.8	(1.1-3.2)
Total	863/8732	9.8	(8.5-11.4)	421/26253	1.8	(1.5-2.1)
Instrumental delivery						
16-19	12/179	7.5	(3.6-14.9)	7/340	3.1	(1.3-7.1)
20-24	55/1530	3.6	(2.7-4.9)	38/3520	1.4	(1.0-2.0)
25-29	139/2557	5.5	(4.6-6.5)	102/7092	1.8	(1.4-2.3)
30-34	159/2594	6.1	(5.0-7.5)	124/8544	1.6	(1.2-2.0)
35-39	102/1600	6.6	(5.0-8.6)	82/5802	1.8	(1.4-2.4)
40+	30/347	8.8	(5.5-13.8)	17/987	2.5	(1.3-4.7)
Total	497/8807	5.7	(4.9-6.7)	370/26285	1.7	(1.4-2.1)
Intrapartum caesarean section						
16-19	6/179	3.4	(1.4-7.7)	4/340	0.9	(0.3-2.5)
20-24	62/1530	4.1	(2.6-6.3)	21/3520	0.6	(0.3-1.1)
25-29	121/2557	4.8	(3.8-6.1)	48/7092	0.7	(0.5-0.9)
30-34	134/2594	5.1	(4.0-6.5)	70/8544	0.9	(0.6-1.2)
35-39	110/1600	6.8	(5.1-9.1)	53/5802	1.1	(0.8-1.5)
40+	16/347	4.8	(3.1-7.4)	15/987	1.5	(0.8-2.7)
Total	449/8807	5.1	(4.2-6.3)	211/26285	0.8	(0.7-1.1)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table ~~5~~ 6 Perinatal outcomes by maternal age in low risk women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Nulliparous						
16-19	39/1260	3.2	(2.2-4.5)	31/1553	2.9	(1.9-4.4)
20-24	89/2610	3.5	(2.5-5.0)	94/3700	2.4	(1.9-3.2)
25-29	92/3026	3.3	(2.6-4.0)	123/5357	2.1	(1.7-2.8)
30-34	101/2340	4.2	(3.1-5.6)	128/4918	3.0	(2.2-4.0)
35-39	37/962	3.9	(2.8-5.4)	65/1999	3.0	(2.1-4.1)
40+	10/149	7.5	(3.4-15.7)	8/195	3.9	(1.0-14.0)
Total	368/10347	3.7	(2.9-4.6)	449/17722	2.6	(2.2-3.1)
Multiparous						
16-19	6/179	3.0	(1.4-6.4)	5/337	1.7	(0.6-4.6)
20-24	26/1519	1.8	(1.2-2.7)	43/3489	1.3	(0.8-2.0)
25-29	41/2547	1.6	(1.2-2.3)	73/7032	1.1	(0.8-1.6)
30-34	50/2578	2.0	(1.5-2.6)	111/8468	1.2	(1.0-1.5)
35-39	33/1594	2.1	(1.3-3.3)	88/5761	1.6	(1.2-2.2)
40+	7/345	2.1	(0.9-4.6)	20/978	2.3	(1.3-4.1)
Total	163/8762	1.9	(1.5-2.4)	340/26065	1.3	(1.1-1.6)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

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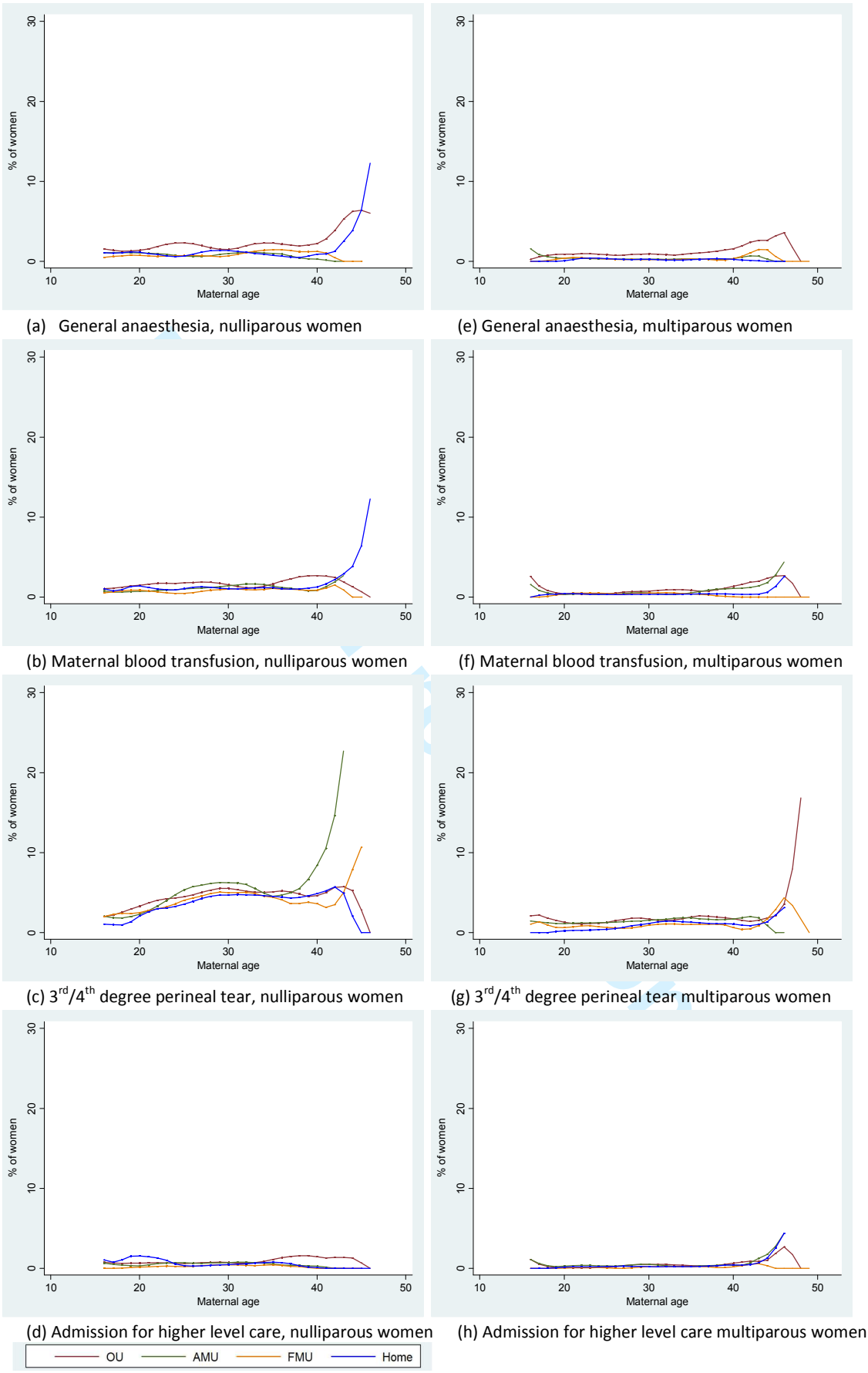


(a) General anaesthesia, nulliparous women

(e) General anaesthesia, multiparous women

(b) Maternal blood transfusion, nulliparous women

(f) Maternal blood transfusion, multiparous women

(c) 3rd/4th degree perineal tear, nulliparous women

(g) 3rd/4th degree perineal tear multiparous women

(d) Admission for higher level care, nulliparous women

(h) Admission for higher level care multiparous women

Figure S1 Association between maternal age and less common intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over

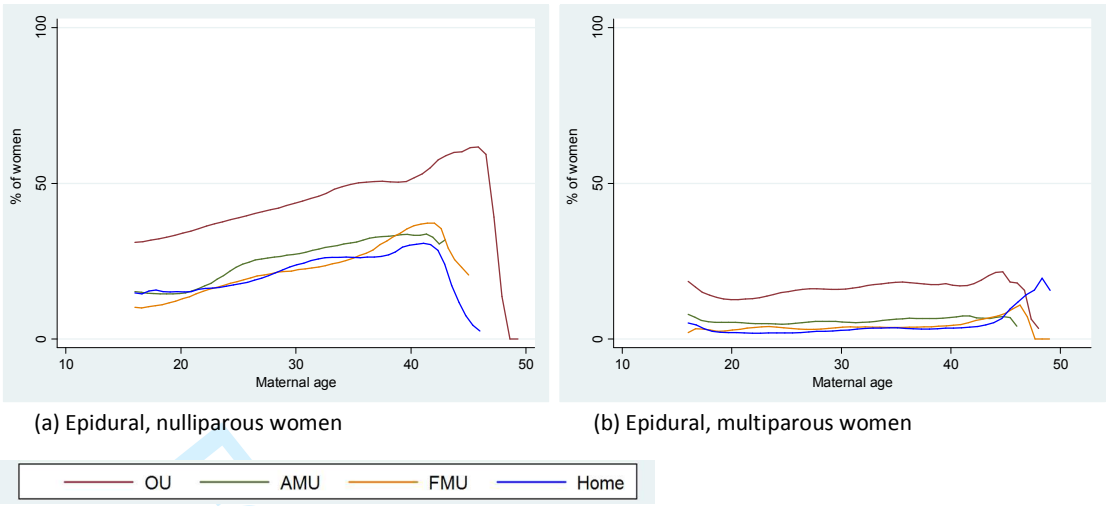


Figure S2 Association between maternal age and epidural in low risk women aged 16 and over

Table S1 Categorisation of potential confounders

Covariate	Response categories	Alternative categories in case of few events
Ethnic group	1 White 2 Non-white	
Understanding of English	1 Fluent 2 Not fluent (some/none)	
Marital/partner status	1 Married/living with partner 2 Single/unsupported by partner	
BMI in pregnancy (kg/m^2)	1 Less than 18.5 2 18.5 to 24.9 3 25.0 to 29.9 4 30.0 to 35.0 5 Not recorded	
Index of Multiple Deprivation (IMD) quintile	1 1st quintile (least deprived) 2 2nd quintile 3 3rd quintile 4 4th quintile 5 5th quintile (most deprived)	1 1st to 3rd quintile 2 4th to 5th quintile
Previous pregnancies ≥24 weeks	1 0 Nulliparous 2 1 previous 3 2 previous 4 3 or more previous	1 Nulliparous 2 Multiparous
Gestation at delivery (completed weeks)	1 37 weeks 2 38 weeks 3 39 weeks 4 40 weeks 5 41 weeks to 42 weeks+0 days	1 37 - 39 weeks 2 ≥ 40 weeks
Planned place of birth	1 Obstetric unit 2 Alongside midwifery unit 3 Freestanding midwifery unit 4 Home	
Complicating conditions identified at the start of care in labour	1 No complicating conditions 2 One or more complicating conditions	

Table S2 Characteristics of low risk nulliparous women aged 16 and over by maternal age category

	16 - 19 years n=2835		20 - 24 years n=6341		25 - 29 years n=8438		30 - 34 years n=7307		35 - 39 years n=2989		≥ 40 years n=346	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	2600	90.4	5329	80.6	7085	78.5	6434	82.7	2686	86.0	314	86.1
Non-white	234	9.6	1004	19.4	1340	21.5	859	17.3	298	14.0	31	13.9
Missing	1		8		13		14		5		1	
Understanding of English												
Fluent	2749	96.8	5709	88.6	7757	89.8	6999	94.4	2931	97.5	341	98.7
Not fluent	81	3.2	602	11.4	636	10.2	276	5.7	48	2.5	3	1.3
Missing	5		30		45		32		10		2	
Marital/partner status												
Married/living with partner	1484	50.2	5171	80.1	7869	92.2	7015	95.9	2854	94.9	320	92.8
Single/unsupported by partner	1284	49.8	1072	19.9	474	7.8	217	4.1	97	5.1	23	7.3
Missing	67		98		95		75		38		3	
BMI in pregnancy (kg/m^2)												
< 18.5	163	6.2	237	3.9	183	2.6	140	2.2	49	1.6	0	0.0
18.5 - 24.9	1510	51.0	3136	47.8	4216	47.2	3813	48.7	1441	46.0	170	44.8
25.0 - 29.9	494	18.1	1358	20.9	1897	23.6	1528	21.7	682	25.6	74	24.3
30.0 - 35.0	189	7.1	535	9.0	641	8.3	438	7.6	192	8.1	21	8.0
Not recorded	477	17.7	1059	18.4	1477	18.3	1363	19.9	616	18.8	80	22.9
Missing	2		16		24		25		9		1	
IMD quintile												
1st (Least deprived)	212	7.2	670	9.2	1475	14.5	1667	21.4	741	22.8	89	26.9
2nd	356	12.6	940	14.5	1690	19.7	1641	22.1	689	22.0	89	23.8
3rd	538	17.7	1239	18.9	1769	19.3	1544	20.7	633	21.1	69	20.0
4th	689	25.3	1525	23.6	1808	22.7	1455	20.7	558	20.3	56	16.9
5th (Most deprived)	1025	37.2	1932	33.8	1663	23.7	972	15.2	353	13.9	40	12.5
Missing	15		35		33		28		15		3	
Gestation at delivery (completed weeks)												
37	93	3.7	189	3.4	275	4.0	243	3.7	90	3.2	9	2.4
38	255	10.9	631	10.1	813	9.8	717	9.6	287	9.3	29	6.0
39	649	21.9	1462	23.5	1989	23.3	1652	22.2	700	23.3	76	23.6
40	1075	36.5	2393	36.3	3107	34.3	2688	36.6	1076	35.0	132	36.5
41 - 42+0 days	763	27.1	1666	26.8	2254	28.6	2007	27.9	836	29.2	100	31.6

Planned place of birth												
OU	1266	88.0	2620	86.6	3043	85.0	2351	83.5	968	84.4	149	89.2
AMU	882	8.4	2040	9.3	2535	9.7	1984	10.0	752	9.2	56	5.9
FMU	564	3.2	1235	3.3	1531	3.3	1302	3.4	456	2.7	47	2.0
Home	123	0.5	446	0.8	1329	2.0	1670	3.2	813	3.7	94	3.0
Birth weight (grams)												
< 2500	46	2.0	105	2.1	88	1.4	87	1.3	43	1.5	6	1.9
2500 - 2999	470	17.8	1053	17.4	1209	16.0	914	14.1	453	16.2	48	10.9
3000 - 3499	1286	44.7	2709	43.0	3536	41.1	3053	41.0	1167	38.8	139	43.0
3500 - 3999	826	28.8	1913	28.9	2782	31.8	2481	33.4	997	32.1	110	32.3
4000 - 4499	185	6.0	487	7.6	734	8.5	669	8.7	282	10.0	38	9.2
≥ 4500	15	0.7	64	0.9	77	1.1	82	1.5	40	1.5	5	2.7
Missing	7		10		12		21		7		0	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	130	7.2	293	7.4	457	8.7	466	10.6	209	10.8	34	14.7
Meconium stained liquor	112	5.9	220	5.6	285	6.0	286	7.4	127	7.6	16	6.1
Proteinuria 1+ or more	73	2.4	150	2.1	161	2.4	129	2.0	49	2.5	8	3.5
Hypertension	51	2.8	128	2.9	156	3.2	127	2.8	48	3.6	10	5.0
Abnormal vaginal bleeding	16	0.8	38	1.0	54	1.2	66	1.8	42	3.3	7	2.9
Non-cephalic presentation	5	0.2	20	0.5	29	0.4	38	0.7	18	0.7	1	0.5
Abnormal fetal heart rate	35	1.5	79	2.1	108	2.3	83	2.1	41	2.6	9	3.7
Other complications	14	0.6	15	0.3	16	0.2	14	0.2	5	0.3	0	0.0
Any complicating conditions	390	19.0	825	19.1	1112	21.0	1073	24.1	465	25.7	73	32.2

[1]Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S3 Characteristics of low risk multiparous women aged 16 and over by maternal age category

	16-19 years n=519		20 - 24 years n=5054		25 - 29 years n=9653		30 - 34 years n=11146		35 - 39 years n=7408		≥ 40 years n=1335	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	478	88.2	4356	82.1	8061	76.3	9618	78.9	6653	83.2	1213	86.8
Non-white	41	11.8	693	17.9	1580	23.7	1516	21.1	746	16.8	122	13.2
Missing	0		5		12		12		9		0	
Understanding of English												
Fluent	505	96.3	4685	91.3	9000	90.3	10606	91.7	7224	95.6	1297	95.9
Not fluent	13	3.8	346	8.8	615	9.7	500	8.3	166	4.5	33	4.1
Missing	1		23		38		40		18		5	
Marital/partner status												
Married/living with partner	352	63.0	4379	84.5	8999	92.0	10767	96.3	7150	95.6	1271	95.0
Single/unsupported by partner	156	37.1	605	15.5	536	8.0	276	3.7	196	4.4	45	5.0
Missing	11		70		118		103		62		19	
BMI in pregnancy (kg/m^2)												
< 18.5	21	5.9	189	4.6	230	2.6	197	2.0	107	1.5	18	0.3
18.5 - 24.9	243	45.8	2180	42.2	4344	44.4	5246	45.0	3423	43.7	632	47.0
25.0 - 29.9	104	17.2	1200	23.1	2444	25.7	2678	24.6	1890	27.6	341	28.9
30.0 - 35.0	44	10.4	561	11.7	986	10.5	961	10.0	577	9.3	88	8.1
Not recorded	104	20.7	910	18.5	1614	16.9	2026	18.5	1384	17.9	249	15.7
Missing	3		14		35		38		27		7	
IMD quintile												
1st (Least deprived)	33	3.6	432	7.4	1400	13.0	2588	19.6	2042	25.7	345	25.6
2nd	49	10.0	581	11.4	1569	15.0	2473	21.4	1745	22.4	307	21.3
3rd	99	21.2	876	16.4	1888	17.7	2215	19.0	1502	19.4	288	22.2
4th	138	25.6	1259	24.6	2149	22.6	2024	18.9	1207	16.5	235	16.8
5th (Most deprived)	196	39.6	1889	40.2	2599	31.7	1787	21.1	862	16.0	157	14.1
Missing	4		17		48		59		50		3	
Previous pregnancies ≥ 24 weeks												
1	474	91.6	3772	77.1	5892	64.5	6963	63.6	3929	56.3	540	44.9
2	38	6.3	1006	17.9	2549	23.4	2779	22.9	2260	27.5	414	28.0
3-5	7	2.2	276	5.0	1212	12.1	1404	13.5	1219	16.2	381	27.1

Gestation at delivery (completed weeks)												
37	26	6.9	162	3.8	255	3.2	291	3.4	185	3.0	43	3.6
38	50	12.3	505	10.0	930	10.0	1022	10.3	684	10.8	117	11.4
39	134	26.5	1326	26.0	2420	25.2	2787	24.5	1816	23.1	334	28.6
40	217	37.7	1968	37.4	3863	38.4	4402	38.2	2857	36.3	507	34.4
41 - 42+0 days	92	16.7	1093	22.8	2185	23.2	2644	23.6	1866	26.8	334	22.0
Planned place of birth												
OU	179	84.6	1530	82.2	2558	79.8	2595	78.3	1603	77.7	348	80.9
AMU	156	9.6	1405	10.0	2423	10.6	2556	10.5	1460	9.8	238	8.7
FMU	97	3.4	880	3.9	1711	4.4	1914	4.4	1218	4.5	202	3.4
Home	87	2.5	1239	3.9	2961	5.3	4081	6.7	3127	8.0	547	6.9
Birth weight (grams)												
< 2500	7	0.8	41	1.3	78	1.3	72	1.0	32	0.7	11	1.1
2500 - 2999	91	22.7	675	14.6	1072	12.7	1010	11.5	647	10.3	120	13.5
3000 - 3499	216	44.0	1969	37.9	3635	37.3	3907	35.8	2477	35.2	457	34.9
3500 - 3999	151	26.0	1751	34.0	3474	35.2	4286	36.3	2891	37.1	507	38.7
4000 - 4499	48	6.1	536	10.6	1192	11.6	1625	13.8	1150	14.0	201	10.1
≥ 4500	6	0.5	71	1.7	185	1.9	221	1.6	197	2.8	35	1.8
Missing	0		11		17		25		14		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	15	6.1	118	4.0	221	4.0	240	4.0	206	4.8	44	6.6
Meconium stained liquor	14	5.6	102	3.7	184	3.8	255	4.9	168	4.9	44	7.9
Proteinuria 1+ or more	6	1.9	53	0.9	100	1.3	97	1.2	60	1.2	12	0.9
Hypertension	4	1.6	32	0.9	76	1.5	80	1.4	54	1.2	7	0.8
Abnormal vaginal bleeding	0	0.0	19	0.8	25	0.5	53	1.2	35	1.4	9	1.8
Non-cephalic presentation	0	0.0	11	0.4	15	0.3	26	0.4	28	0.8	2	0.3
Abnormal fetal heart rate	6	1.9	27	1.0	54	1.2	60	1.3	41	1.2	18	2.8
Other complications	0	0.0	9	0.3	7	0.2	13	0.1	6	0.2	2	0.3
Any complicating conditions	41	15.5	350	11.2	632	11.5	756	12.7	536	13.6	126	18.7

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S4 Sample size of low risk women aged 40 and over by planned place of birth and parity

Age (years)	Nulliparous women				Multiparous women			
	OU	AMU	FMU	Home	OU	AMU	FMU	Home
40	64	32	24	38	157	103	93	242
41	31	17	11	26	86	63	47	147
42	24	6	3	13	53	39	25	83
43	12	1	2	10	29	18	22	37
44	14	0	4	4	12	10	10	23
45	2	0	3	2	4	4	2	9
46	1	0	0	1	5	1	1	5
47	0	0	0	0	1	0	1	0
48	0	0	0	0	1	0	0	0
49	0	0	0	0	0	0	1	0
50	1	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	1
Total	**149**	**56**	**47**	**94**	**348**	**238**	**202**	**547**

Table S5 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	17/1251	1.4	(0.8-2.4)	14/1562	0.8	(0.4-1.5)
20-24	47/2587	1.8	(1.4-2.4)	31/3698	0.9	(0.6-1.4)
25-29	58/2984	1.9	(1.5-2.5)	41/5349	0.8	(0.5-1.3)
30-34	44/2312	1.8	(1.3-2.7)	57/4900	1.3	(0.9-1.9)
35-39	20/949	2.0	(1.2-3.5)	16/2001	0.9	(0.4-1.9)
40+	5/143	3.0	(1.2-7.6)	2/195	0.6	(0.1-2.5)
Total	191/10226	1.9	(1.5-2.3)	161/17705	1.0	(0.8-1.2)
Maternal blood transfusion						
16-19	13/1260	1.1	(0.7-1.9)	10/1555	0.6	(0.3-1.2)
20-24	47/2606	1.8	(1.4-2.5)	29/3697	0.8	(0.6-1.2)
25-29	57/3024	1.8	(1.2-2.6)	54/5359	1.0	(0.8-1.3)
30-34	27/2335	1.2	(0.8-1.8)	64/4923	1.7	(1.2-2.5)
35-39	21/961	2.3	(1.3-3.9)	21/2002	1.2	(0.7-2.1)
40+	4/149	2.8	(1.1-6.8)	5/196	1.6	(0.5-4.6)
Total	169/10335	1.6	(1.3-2.0)	183/17732	1.1	(1.0-1.4)
3rd/4th degree perineal tear						
16-19	25/1259	2.0	(1.2-3.2)	30/1567	1.9	(1.2-2.8)
20-24	107/2609	4.1	(3.3-5.3)	118/3709	3.2	(2.5-4.1)
25-29	153/3030	4.8	(3.9-5.8)	274/5389	5.4	(4.7-6.3)
30-34	121/2343	5.1	(4.3-6.1)	267/4942	5.8	(5.0-6.7)
35-39	49/968	5.0	(3.4-7.2)	85/2007	4.1	(3.2-5.2)
40+	9/149	5.3	(2.9-9.6)	17/196	11.1	(5.0-22.7)
Total	464/10358	4.4	(3.8-5.1)	791/17810	4.6	(4.1-5.2)
Maternal admission for higher level care						
16-19	9/1266	0.7	(0.3-1.6)	5/1569	0.3	(0.1-0.8)
20-24	18/2620	0.7	(0.4-1.2)	22/3721	0.8	(0.4-1.5)
25-29	22/3043	0.7	(0.4-1.3)	24/5395	0.7	(0.4-1.3)
30-34	16/2351	0.7	(0.4-1.3)	31/4956	1.3	(0.5-3.1)
35-39	14/968	1.9	(0.7-4.8)	10/2021	0.5	(0.2-1.1)
40+	2/149	1.5	(0.3-6.8)	0/197	0	-
Total	81/10397	0.8	(0.5-1.4)	92/17859	0.8	(0.4-1.5)

[1]Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum-specific probabilities of selection of OUs.

Table S6 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	1/177	0.7	(0.1-4.3)	1/339	0.5	(0.1-3.6)
20-24	15/1516	1.0	(0.6-1.7)	15/3518	0.4	(0.2-0.8)
25-29	19/2528	0.8	(0.5-1.2)	18/7072	0.3	(0.1-0.5)
30-34	21/2569	0.8	(0.5-1.3)	17/8526	0.2	(0.1-0.4)
35-39	19/1584	1.1	(0.7-1.7)	16/5790	0.3	(0.1-0.5)
40+	9/343	2.6	(1.5-4.6)	5/985	0.5	(0.2-1.6)
Total	84/8717	0.9	(0.7-1.2)	72/26230	0.3	(0.2-0.4)
Maternal blood transfusion						
16-19	3/179	1.7	(0.4-6.4)	1/339	0.5	(0.1-3.6)
20-24	6/1519	0.4	(0.2-0.9)	15/3495	0.5	(0.2-0.9)
25-29	16/2544	0.6	(0.3-1.0)	26/7024	0.4	(0.3-0.6)
30-34	23/2575	0.9	(0.5-1.6)	35/8478	0.4	(0.3-0.5)
35-39	11/1593	0.6	(0.3-1.1)	30/5759	0.6	(0.4-1.0)
40+	7/345	2.2	(1.1-4.3)	6/979	0.8	(0.3-1.8)
Total	66/8755	0.7	(0.6-1.0)	113/26074	0.5	(0.4-0.6)
3rd/4th degree perineal tear						
16-19	5/179	2.7	(1.2-5.9)	4/340	0.9	(0.3-2.4)
20-24	15/1529	1.1	(0.6-1.8)	29/3518	1.0	(0.7-1.4)
25-29	44/2550	1.8	(1.3-2.3)	60/7075	1.0	(0.7-1.3)
30-34	42/2588	1.6	(1.1-2.3)	123/8531	1.6	(1.3-2.1)
35-39	32/1600	2.0	(1.3-3.1)	71/5792	1.3	(1.0-1.7)
40+	5/345	1.4	(0.6-3.3)	12/985	1.2	(0.6-2.2)
Total	143/8791	1.7	(1.3-2.1)	299/26241	1.3	(1.1-1.5)
Maternal admission for higher level care						
16-19	1/179	0.5	(0.1-3.6)	1/340	0.5	(0.1-3.6)
20-24	1/1530	0.1	(0.0-0.5)	8/3524	0.2	(0.1-0.5)
25-29	9/2558	0.3	(0.2-0.7)	17/7095	0.3	(0.2-0.5)
30-34	13/2595	0.5	(0.2-1.1)	22/8551	0.3	(0.2-0.5)
35-39	4/1603	0.3	(0.1-0.7)	16/5805	0.3	(0.2-0.5)
40+	4/348	1.2	(0.5-3.1)	7/987	0.7	(0.3-1.6)
Total	32/8813	0.4	(0.2-0.6)	71/26302	0.3	(0.2-0.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum-specific probabilities of selection of OUs.

Table ~~S7~~ S5 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged between 16 and 40 years old (inclusive) additionally adjusted for complicating conditions

	Nulliparous women Adjusted[1] RR	(95% CI)	Multiparous women Adjusted[1] RR	(95% CI)
Maternal composite	1.12	(1.09-1.15)	1.07	(1.02-1.12)
OU[2]	1.11	(1.08-1.14)		
Non-OU[2]	1.21	(1.18-1.24)		
	Wald test for interaction	P^3 <0.001	Wald test for interaction	P^3 =0.50
Augmentation	1.11	(1.06-1.15)	0.98	(0.90-1.07)
OU[2]	1.10	(1.05-1.15)		
Non-OU[2]	1.22	(1.17-1.28)		
	Wald test for interaction	P^3 <0.001	Wald test for interaction	P^3 =0.33
Instrumental delivery	1.18	(1.11-1.25)	1.14	(1.04-1.25)
	Wald test for interaction	P^3 =0. 17	Wald test for interaction	P^3 =0.08
Intrapartum caesarean section	1.25	(1.20-1.30)	1.13	(1.03-1.23)
	Wald test for interaction	P^3 =0.12	Wald test for interaction	P^3 =0.40
General anaesthesia	1.04	(0.91-1.19)	1.07	(0.89-1.29)
	Wald test for interaction	P^3 =0.71	Wald test for interaction	P^3 =0.17
Maternal blood transfusion	1.13	(0.95-1.33)	1.21	(0.93-1.59)
	Wald test for interaction	P^3 =0.38	Wald test for interaction	P^3 =0.50
3rd /4th degree perineal tear	1.12	(1.02-1.23)	1.01	(0.89-1.15)
	Wald test for interaction	P^3 =0.41	Wald test for interaction	P^3 =0.30
Maternal admission for higher level care	1.45	(1.07-1.96)	1.47	(1.04-2.08)
	Wald test for interaction	P^3 =0.43	Wald test for interaction	P^3 =0.16
Neonatal composite	1.04	(0.94-1.16)	0.97	(0.83-1.13)
	Wald test for interaction	P^3 =0.78	Wald test for interaction	P^3 =0.66

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs. Models were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, planned place of birth (OU/AMU/FMU/home), and complicating conditions identified at the start of care in labour.

[2] Results in these rows were weighted and adjusted as in footnote 1, with the exception of planned place of birth.

[3] *P* for interaction, results in these rows were weighted and adjusted as in footnote 1 except that planned place of birth was included as a binary variable (OU vs. non-OU).

Table ~~S5~~ S6 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	17/1251	1.4	(0.8-2.4)	14/1562	0.8	(0.4-1.5)
20-24	47/2587	1.8	(1.4-2.4)	31/3698	0.9	(0.6-1.4)
25-29	58/2984	1.9	(1.5-2.5)	41/5349	0.8	(0.5-1.3)
30-34	44/2312	1.8	(1.3-2.7)	57/4900	1.3	(0.9-1.9)
35-39	20/949	2.0	(1.2-3.5)	16/2001	0.9	(0.4-1.9)
40+	5/143	3.0	(1.2-7.6)	2/195	0.6	(0.1-2.5)
Total	191/10226	1.9	(1.5-2.3)	161/17705	1.0	(0.8-1.2)
Maternal blood transfusion						
16-19	13/1260	1.1	(0.7-1.9)	10/1555	0.6	(0.3-1.2)
20-24	47/2606	1.8	(1.4-2.5)	29/3697	0.8	(0.6-1.2)
25-29	57/3024	1.8	(1.2-2.6)	54/5359	1.0	(0.8-1.3)
30-34	27/2335	1.2	(0.8-1.8)	64/4923	1.7	(1.2-2.5)
35-39	21/961	2.3	(1.3-3.9)	21/2002	1.2	(0.7-2.1)
40+	4/149	2.8	(1.1-6.8)	5/196	1.6	(0.5-4.6)
Total	169/10335	1.6	(1.3-2.0)	183/17732	1.1	(1.0-1.4)
3rd/4th degree perineal tear						
16-19	25/1259	2.0	(1.2-3.2)	30/1567	1.9	(1.2-2.8)
20-24	107/2609	4.1	(3.3-5.3)	118/3709	3.2	(2.5-4.1)
25-29	153/3030	4.8	(3.9-5.8)	274/5389	5.4	(4.7-6.3)
30-34	121/2343	5.1	(4.3-6.1)	267/4942	5.8	(5.0-6.7)
35-39	49/968	5.0	(3.4-7.2)	85/2007	4.1	(3.2-5.2)
40+	9/149	5.3	(2.9-9.6)	17/196	11.1	(5.0-22.7)
Total	464/10358	4.4	(3.8-5.1)	791/17810	4.6	(4.1-5.2)
Maternal admission for higher level care						
16-19	9/1266	0.7	(0.3-1.6)	5/1569	0.3	(0.1-0.8)
20-24	18/2620	0.7	(0.4-1.2)	22/3721	0.8	(0.4-1.5)
25-29	22/3043	0.7	(0.4-1.3)	24/5395	0.7	(0.4-1.3)
30-34	16/2351	0.7	(0.4-1.3)	31/4956	1.3	(0.5-3.1)
35-39	14/968	1.9	(0.7-4.8)	10/2021	0.5	(0.2-1.1)
40+	2/149	1.5	(0.3-6.8)	0/197	0	-
Total	81/10397	0.8	(0.5-1.4)	92/17859	0.8	(0.4-1.5)

[1]Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table ~~S6~~ S7 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	1/177	0.7	(0.1-4.3)	1/339	0.5	(0.1-3.6)
20-24	15/1516	1.0	(0.6-1.7)	15/3518	0.4	(0.2-0.8)
25-29	19/2528	0.8	(0.5-1.2)	18/7072	0.3	(0.1-0.5)
30-34	21/2569	0.8	(0.5-1.3)	17/8526	0.2	(0.1-0.4)
35-39	19/1584	1.1	(0.7-1.7)	16/5790	0.3	(0.1-0.5)
40+	9/343	2.6	(1.5-4.6)	5/985	0.5	(0.2-1.6)
Total	84/8717	0.9	(0.7-1.2)	72/26230	0.3	(0.2-0.4)
Maternal blood transfusion						
16-19	3/179	1.7	(0.4-6.4)	1/339	0.5	(0.1-3.6)
20-24	6/1519	0.4	(0.2-0.9)	15/3495	0.5	(0.2-0.9)
25-29	16/2544	0.6	(0.3-1.0)	26/7024	0.4	(0.3-0.6)
30-34	23/2575	0.9	(0.5-1.6)	35/8478	0.4	(0.3-0.5)
35-39	11/1593	0.6	(0.3-1.1)	30/5759	0.6	(0.4-1.0)
40+	7/345	2.2	(1.1-4.3)	6/979	0.8	(0.3-1.8)
Total	66/8755	0.7	(0.6-1.0)	113/26074	0.5	(0.4-0.6)
3rd/4th degree perineal tear						
16-19	5/179	2.7	(1.2-5.9)	4/340	0.9	(0.3-2.4)
20-24	15/1529	1.1	(0.6-1.8)	29/3518	1.0	(0.7-1.4)
25-29	44/2550	1.8	(1.3-2.3)	60/7075	1.0	(0.7-1.3)
30-34	42/2588	1.6	(1.1-2.3)	123/8531	1.6	(1.3-2.1)
35-39	32/1600	2.0	(1.3-3.1)	71/5792	1.3	(1.0-1.7)
40+	5/345	1.4	(0.6-3.3)	12/985	1.2	(0.6-2.2)
Total	143/8791	1.7	(1.3-2.1)	299/26241	1.3	(1.1-1.5)
Maternal admission for higher level care						
16-19	1/179	0.5	(0.1-3.6)	1/340	0.5	(0.1-3.6)
20-24	1/1530	0.1	(0.0-0.5)	8/3524	0.2	(0.1-0.5)
25-29	9/2558	0.3	(0.2-0.7)	17/7095	0.3	(0.2-0.5)
30-34	13/2595	0.5	(0.2-1.1)	22/8551	0.3	(0.2-0.5)
35-39	4/1603	0.3	(0.1-0.7)	16/5805	0.3	(0.2-0.5)
40+	4/348	1.2	(0.5-3.1)	7/987	0.7	(0.3-1.6)
Total	32/8813	0.4	(0.2-0.6)	71/26302	0.3	(0.2-0.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S8 Event rates in restricted sample of nulliparous women aged 16 and over without complicating conditions identified at the start of care in labour

Age (years)	OU			Non-OU		
	Events / Births	Weighted[1]		Events / Births	Weighted[1]	
	n/N	%	(95% CI)	n/N	%	(95% CI)
Maternal composite						
16-19	335/985	34.4	(30.9-38.1)	221/1418	16.9	(14.6-19.4)
20-24	861/2039	42.3	(38.9-45.9)	768/3382	22.7	(20.6-25.0)
25-29	1160/2302	50.1	(47.4-52.7)	1453/4929	30.2	(27.5-33.0)
30-34	902/1680	54.5	(49.8-59.1)	1524/4442	35.4	(33.2-37.6)
35-39	391/680	57.7	(53.4-62.0)	685/1800	38.0	(34.3-41.9)
40+	67/98	66.1	(53.7-76.6)	70/173	42.4	(32.9-52.5)
Total	3716/7784	48.1	(45.5-50.8)	4721/16144	29.7	(27.8-31.6)
Augmentation						
16-19	224/991	23.0	(19.9-26.4)	119/1428	8.0	(6.5-9.9)
20-24	527/2044	25.8	(22.0-30.0)	417/3406	12.0	(10.5-13.8)
25-29	701/2305	30.0	(27.5-32.6)	777/4944	15.8	(14.1-17.7)
30-34	523/1678	31.4	(27.5-35.6)	838/4462	18.8	(17.2-20.5)
35-39	239/676	34.8	(28.3-42.0)	402/1817	21.1	(18.2-24.3)
40+	41/99	40.2	(27.9-53.9)	37/173	22.6	(14.3-33.8)
Total	2255/7793	29.0	(26.2-32.0)	2590/16230	15.7	(14.5-16.9)
Instrumental delivery						
16-19	139/1008	13.6	(10.8-16.9)	92/1432	8.2	(6.4-10.5)
20-24	354/2073	17.0	(14.9-19.4)	350/3418	10.0	(8.5-11.8)
25-29	512/2328	22.2	(19.9-24.6)	672/4962	14.0	(12.2-16.0)
30-34	411/1700	25.3	(20.0-31.4)	713/4487	16.8	(15.0-18.9)
35-39	191/686	28.9	(24.2-34.1)	353/1819	19.3	(15.8-23.4)
40+	26/99	26.9	(17.8-38.5)	31/174	20.7	(12.8-31.6)
Total	1633/7894	21.2	(18.7-23.9)	2211/16292	14.0	(12.6-15.5)
Intrapartum caesarean section						
16-19	65/1008	6.8	(4.9-9.4)	45/1432	2.7	(2.0-3.7)
20-24	194/2073	9.4	(7.8-11.3)	156/3418	4.6	(3.6-5.8)
25-29	308/2328	13.0	(11.2-15.1)	343/4962	7.3	(6.3-8.5)
30-34	267/1700	15.8	(13.2-18.9)	382/4487	8.3	(7.2-9.6)
35-39	125/686	18.3	(13.9-23.9)	177/1819	10.1	(8.1-12.5)
40+	27/99	25.6	(16.1-38.2)	18/174	8.8	(4.8-15.4)
Total	986/7894	12.6	(11.0-14.5)	1121/16292	6.9	(6.2-7.6)
Perinatal composite						
16-19	26/1003	2.6	(1.8-3.8)	23/1419	2.5	(1.6-4.0)
20-24	58/2064	2.9	(1.9-4.3)	87/3402	2.4	(1.9-3.1)
25-29	57/2319	2.7	(2.0-3.5)	104/4932	2.0	(1.5-2.6)
30-34	67/1694	3.7	(2.6-5.2)	108/4459	2.9	(2.1-4.0)
35-39	14/682	1.8	(1.0-3.4)	56/1804	2.5	(1.8-3.4)
40+	7/99	7.8	(3.8-15.6)	4/172	2.1	(0.5-8.5)
Total	229/7861	2.9	(2.3-3.7)	382/16188	2.4	(2.0-2.9)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S9 Event rates in restricted sample of multiparous women aged 16 and over without complicating conditions identified at the start of care in labour

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	23/149	14.2	(8.7-22.1)	18/323	6.2	(3.8-10.0)
20-24	183/1311	14.1	(11.9-16.8)	130/3320	4.3	(3.4-5.5)
25-29	334/2159	15.5	(13.8-17.3)	272/6663	4.7	(3.9-5.6)
30-34	342/2155	15.7	(13.3-18.5)	376/8033	5.1	(4.4-5.9)
35-39	232/1316	17.8	(15.4-20.3)	242/5421	5.3	(4.5-6.2)
40+	54/265	20.3	(16.4-24.8)	55/917	6.8	(5.1-9.1)
Total	1168/7355	15.9	(14.2-17.8)	1093/24677	5.0	(4.5-5.6)
Augmentation						
16-19	11/150	6.8	(3.5-12.8)	9/324	3.2	(1.7-6.0)
20-24	101/1321	7.6	(6.0-9.6)	53/3352	1.8	(1.3-2.5)
25-29	155/2179	7.2	(5.7-9.0)	94/6743	1.6	(1.2-2.1)
30-34	165/2175	7.5	(5.9-9.6)	112/8118	1.5	(1.2-1.9)
35-39	93/1331	6.9	(5.5-8.7)	80/5476	1.7	(1.2-2.3)
40+	22/268	8.3	(5.0-13.3)	12/927	1.2	(0.6-2.3)
Total	547/7424	7.3	(6.1-8.8)	360/24940	1.6	(1.4-1.9)
Instrumental delivery						
16-19	7/151	4.2	(1.9-9.1)	7/324	3.3	(1.4-7.4)
20-24	45/1334	3.4	(2.4-4.8)	33/3352	1.3	(0.9-1.9)
25-29	111/2205	5.1	(4.3-6.0)	95/6757	1.7	(1.3-2.3)
30-34	126/2194	5.8	(4.7-7.1)	119/8126	1.6	(1.2-2.0)
35-39	80/1338	6.1	(4.7-8.0)	73/5482	1.7	(1.3-2.3)
40+	20/269	7.2	(4.5-11.3)	15/929	2.3	(1.1-4.9)
Total	389/7491	5.3	(4.5-6.2)	342/24970	1.7	(1.4-2.0)
Intrapartum caesarean section						
16-19	4/151	2.5	(0.9-7.2)	4/324	1.0	(0.3-2.7)
20-24	48/1334	3.6	(2.2-6.1)	17/3352	0.5	(0.2-1.0)
25-29	79/2205	3.6	(2.7-4.7)	42/6757	0.6	(0.4-0.9)
30-34	80/2194	3.6	(2.6-4.9)	54/8126	0.7	(0.5-1.1)
35-39	64/1338	4.8	(3.4-6.7)	41/5482	0.9	(0.6-1.4)
40+	11/269	4.0	(2.2-7.4)	14/929	1.4	(0.7-2.6)
Total	286/7491	3.8	(2.9-5.0)	172/24970	0.7	(0.6-0.9)
Perinatal composite						
16-19	4/151	2.2	(0.8-5.7)	4/322	1.5	(0.5-4.5)
20-24	19/1325	1.5	(0.9-2.5)	39/3323	1.2	(0.8-1.7)
25-29	34/2199	1.6	(1.1-2.2)	61/6701	1.0	(0.7-1.6)
30-34	30/2182	1.4	(0.9-2.0)	97/8058	1.1	(0.9-1.4)
35-39	26/1334	2.0	(1.2-3.4)	82/5445	1.6	(1.2-2.1)
40+	6/268	2.2	(0.9-5.1)	17/920	2.1	(1.1-4.0)
Total	119/7459	1.6	(1.2-2.1)	300/24769	1.2	(1.0-1.5)

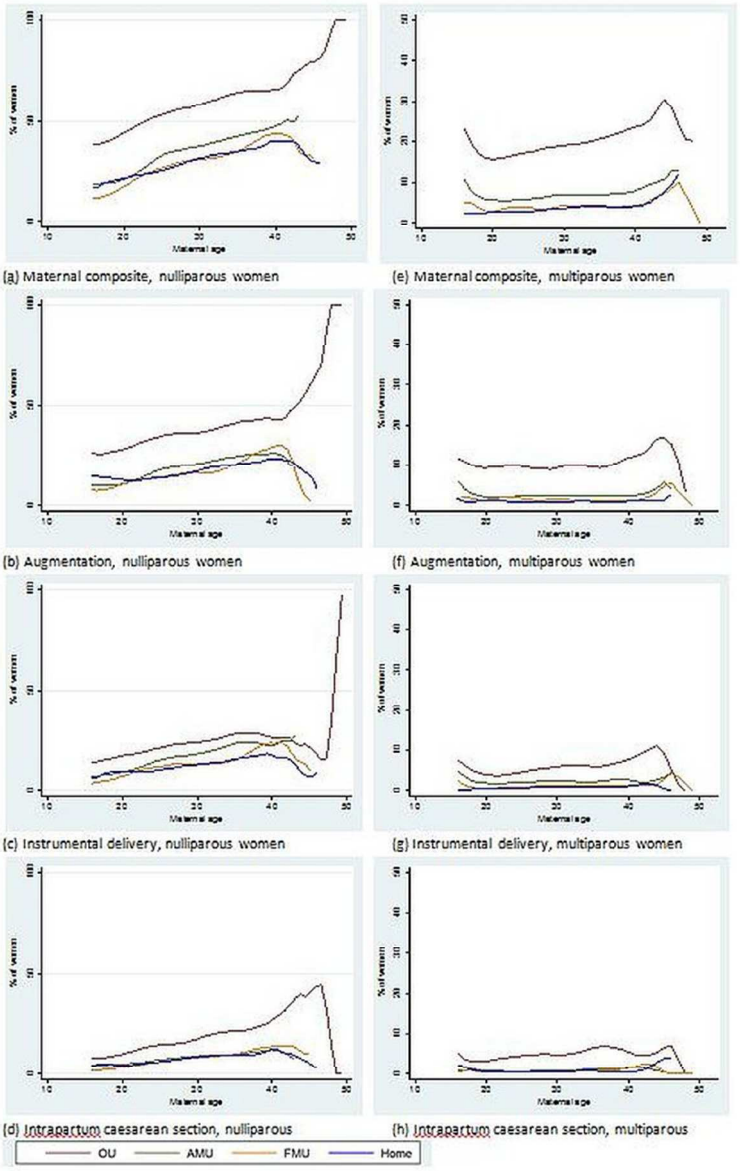
[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S10 Relative risk for non-OU compared to OU by age groups in nulliparous women without complicating conditions

Age (years)	Unadjusted RR[1] (95% CI)	Adjusted RR[1, 2] (95% CI)
Maternal composite		
16-19	0.49 (0.41-0.59)	0.52 (0.43-0.62)
20-24	0.54 (0.47-0.61)	0.54 (0.48-0.61)
25-29	0.60 (0.54-0.67)	0.61 (0.55-0.68)
30-34	0.65 (0.58-0.72)	0.67 (0.61-0.74)
35-39	0.66 (0.58-0.75)	0.67 (0.60-0.76)
40+	0.64 (0.48-0.86)	0.67 (0.48-0.92)
Augmentation		
16-19	0.35 (0.27-0.45)	0.37 (0.29-0.47)
20-24	0.47 (0.38-0.57)	0.47 (0.39-0.57)
25-29	0.53 (0.46-0.61)	0.54 (0.47-0.61)
30-34	0.60 (0.52-0.70)	0.63 (0.53-0.74)
35-39	0.61 (0.48-0.77)	0.61 (0.49-0.75)
40+	0.56 (0.33-0.97)	0.56 (0.33-0.95)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.



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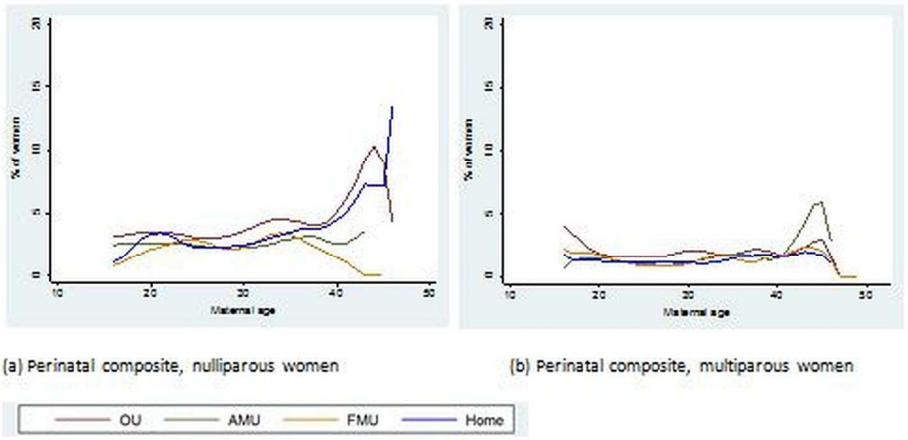

Figure 2 Association between maternal age and perinatal composite outcome in low risk women aged 16 and over

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Please NOTE that the pages have been updated to be related to **the revised version with "track changes"**.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes – title and abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes, p2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes, p5
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes, p5
Methods			
Study design	4	Present key elements of study design early in the paper	Yes, p6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes, p6-7. References also given to other publications providing more details
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes, p7-8 and Table S1
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	Yes, p8, more details in cited reports.
Bias	9	Describe any efforts to address potential sources of bias	Cohort study methods to minimise bias addressed elsewhere – ref 26.
Study size	10	Explain how the study size was arrived at	N/A. Secondary analysis of existing data. Original power calculations described in ref 26.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes, p7-9.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes, p7-9
		(*b*) Describe any methods used to examine subgroups and interactions	Yes, interactions p8
		(*c*) Explain how missing data were addressed	N/A. Low level of missing data
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	Yes, p8

Results			
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	P10 for current study; refs given for 'recruitment' into main study
		(b) Give reasons for non-participation at each stage	Ditto
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes, Tables 1, S2 and S3
		(b) Indicate number of participants with missing data for each variable of interest	Yes, Tables 1, S2 and S3
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes, fully reported in tables
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	Yes, unadjusted & adjusted estimates and 95% CIs reported in tables; adjustment variables described (Table S1)
		(*b*) Report category boundaries when continuous variables were categorized	Yes. Maternal age – Table 1; confounders Table S1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Absolute event rates reported in tables
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	All analyses reported in manuscript or supplementary tables
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes, p14
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	Yes, p14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Other evidence comprehensively summarised p15-17; cautious interpretation p17
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes, p14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes, p18

*Give information separately for exposed and unexposed groups.

BMJ open

The effect of maternal age and planned place of birth on intrapartum outcomes in healthy women with straightforward pregnancies: secondary analysis of the Birthplace national prospective cohort study

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-004026.R2
Article Type:	Research
Date Submitted by the Author:	12-Dec-2013
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Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Epidemiology, Medical management, Evidence based practice, Health services research
Keywords:	OBSTETRICS, Midwifery led care, Maternal medicine < OBSTETRICS, Intrapartum care

The effect of maternal age and planned place of birth on intrapartum outcomes in healthy women with straightforward pregnancies: secondary analysis of the Birthplace national prospective cohort study

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Keywords

Maternal age, parity, birthing centre, home birth, augmentation, instrumental delivery, caesarean section, adverse maternal outcomes, adverse perinatal outcomes

Word count

Main text 4,630 words

Abstract

Objectives

To describe the relationship between maternal age and intrapartum outcomes in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth

Design

Prospective cohort study

Setting

Obstetric units, midwifery units and planned home births in England

Participants

63,371 women aged over 16 without known medical or obstetric risk factors, with singleton pregnancies, planning vaginal birth

Methods

Log Poisson regression was used to evaluate the association between maternal age, modelled as a continuous and categorical variable, and risk of intrapartum interventions and adverse maternal and perinatal outcomes.

Main Outcome Measures

Intrapartum caesarean section, instrumental delivery, syntocinon augmentation and a composite measure of maternal interventions/adverse outcomes requiring obstetric care encompassing augmentation, instrumental delivery, intrapartum caesarean section, general anaesthesia, blood transfusion, 3rd/4th degree tear, maternal admission; adverse perinatal outcome (encompassing neonatal unit admission or perinatal death).

Results

Interventions and adverse maternal outcomes requiring obstetric care generally increased with age, particularly in nulliparous women. For nulliparous women aged 16-40, the risk of experiencing an intervention or adverse outcome requiring obstetric care increased more steeply with age in

planned non-obstetric unit births than in planned obstetric unit births (adjusted RR 1.21 per 5-year increase in age, 95% CI 1.18-1.25 vs. adjusted RR 1.12, 95% CI 1.10-1.15) but absolute risks were lower in planned non-OU births at all ages. The risk of neonatal unit admission or perinatal death was significantly raised in nulliparous women aged 40+ relative to women aged 25-29 (adjusted RR 2.29, 95% CI 1.28-4.09).

Conclusions

At all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Younger nulliparous women appear to benefit more from this reduction than older nulliparous women.

Article summary

Article focus

- Does increasing age in women without known medical or obstetric risk factors increase the risk of intrapartum interventions and adverse outcomes that might affect their choice of planned place of birth?

Key messages

- At all ages 'low risk' women who plan birth in a non-obstetric unit setting have lower intervention rates than comparable women who plan their birth in an obstetric unit
- The chances of experiencing an intervention or outcome that requires obstetric care increase with age, even in women who do not have known risk factors.
- Younger nulliparous women appear to benefit more than older nulliparous women from the reduction in interventions associated with planned birth in a non-obstetric unit setting

Strengths and weaknesses

Strengths

- The study was based on a large, nationally representative cohort of 'low risk' women, with high quality data collected prospectively.

Weaknesses

- The number of women over 40 was relatively small so the study had limited power to explore effects in women over 40, particularly in non-obstetric unit settings.
- Planned births in non-obstetric unit settings were combined; graphical plots indicated that this was reasonable but important differences between settings cannot be ruled out.

Background

The proportion of births in women aged 35 and over has been steadily rising in recent years in the UK and elsewhere.[1, 2] Currently approximately 16% of births in England and Wales are to women aged 35-39 and 4% of births are to women aged 40 and over.[1]

Advanced maternal age is associated with an increased risk of pregnancy complications including gestational diabetes,[3] pregnancy induced hypertension and preeclampsia,[4, 5] twin or higher order pregnancies,[3] breech presentation,[6] placenta praevia,[3, 7-9] preterm birth,[5, 10] post-term birth,[11], severe maternal morbidity,[12] and adverse perinatal outcomes including antepartum stillbirth,[13] intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission.[5] Older women also have an increased risk of interventions such as induction and caesarean section.[16-20] However, many age-related pregnancy complications are known risk factors for intrapartum complications or adverse perinatal outcomes and women with these risk factors would normally be advised to give birth in an obstetric unit (OU). Relatively little is known about the incidence of intrapartum interventions and adverse maternal and perinatal outcomes in older women who do not have known risk factors.[21]

The current clinical guideline in England[22] recommends that healthy women with straightforward pregnancies should be offered a choice of planned birth at home, in a midwife-led unit or in an obstetric unit, but also suggest individual assessment when planning place of birth for women over 40 at booking.[22] The evidence for 'low risk' women in general shows that planned birth in a non-OU setting is associated with a lower incidence of intrapartum interventions[22-28] and research has demonstrated that in 'low risk' women, after adjustment for maternal characteristics, planned birth in a midwifery unit and planned birth at home (multiparous women only) is not associated with an increased risk to the baby compared with planned birth in an OU.[25] However, rates of intrapartum transfer increase with age in nulliparous women[29] and, more generally, the risks that might affect the choice of planned place of birth (PPOB) by healthy older women are not well documented.

The aim of this study was to evaluate the association between maternal age and intrapartum interventions and adverse maternal and perinatal outcomes that may influence the choice of planned place of birth, in 'low risk' women with singleton, term pregnancies planning a vaginal birth.

The main objectives were to describe the relationship between maternal age and intrapartum interventions and adverse outcomes that indicate a need for obstetric or neonatal care in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum

interventions and adverse outcomes differs by planned place of birth.

Methods

Settings and participants

The study used data from the Birthplace in England national prospective cohort study which was designed to compare perinatal and maternal outcomes and interventions by planned place of birth at the start of care in labour.

The cohort study methods are described in full elsewhere.[25, 26] Briefly, the Birthplace cohort included a total of 79,774 births between April 2008 and April 2010, including 32,257 planned OU births from a stratified random sample of 36 OUs, 11,666 planned births in 53 freestanding midwifery units (FMUs), 17,582 planned births in 43 alongside midwifery units (AMUs) and 18,269 planned home births from 142 NHS trusts across England. Births were eligible for inclusion if the woman was planning a vaginal birth and received some labour care from an NHS midwife in her planned birth setting. Women who had an elective caesarean section or caesarean section before the onset of labour, presented in preterm labour (<37 weeks' gestation), had a multiple pregnancy, an unplanned home birth, or who were "unbooked" (received no antenatal care) were excluded. Stillbirths occurring before the start of care in labour were excluded. Women in the cohort were classified as 'low risk' if before the start of labour they were not known to have any of the medical or obstetric risk factors listed in national guidelines on intrapartum care[22] as "indicating increased risk suggesting planned birth in an obstetric unit". The study had a high response rate and low levels of missing data.[25, 26]

The study population for the analyses reported here was 'low risk' women in the Birthplace cohort aged 16 years or over at the time of birth, with a term (gestational age 37^{+0} weeks to 42^{+0} weeks inclusive) pregnancy and parity less than 6. In the NICE intrapartum care guideline individual assessment is recommended when planning place of birth for women with parity of 6 or more and many midwifery units restrict admission to women of parity 5 or less.[30] We additionally excluded women for whom age, parity or gestational age was not known.

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee and did not require consent to be sought from participants as no personally identifiable data were collected.

Data

As described elsewhere,[25] maternal characteristics, and medical or obstetric risk factors known prior to the onset of labour were extracted from the woman's medical records by the midwife attending the birth. Complicating conditions identified by the midwife at the start of care in labour (for example prolonged rupture of membranes), intrapartum interventions and adverse maternal and perinatal outcomes were recorded by the attending midwife using a data collection form started during labour and completed on or after the fifth postnatal day.

Planned place of birth (OU, AMU, FMU or home) was based on the intended place of birth at the start of care in labour. Women were included in the group in which they planned to give birth at the start of care in labour regardless of whether they were transferred during labour care or immediately after the birth.

Outcomes

We focused on outcome measures that reflected interventions and adverse outcomes that indicated a need for obstetric and/or neonatal care, that is, outcomes that would require the woman and/or baby to be transferred to an obstetric or neonatal unit if labour care or birth took place elsewhere. For women, we considered the following outcomes both separately and as a combined maternal composite outcome ('interventions/adverse outcomes requiring obstetric care'): augmentation with syntocinon, instrumental delivery (ventouse or forceps), intrapartum caesarean section, general anaesthesia, maternal blood transfusion, $3^{rd}/4^{th}$ degree perineal tear, maternal admission for higher level care. The use of epidural/spinal analgesia was also considered as a secondary outcome. The main outcomes considered for women were the maternal composite outcome ('interventions and adverse outcomes requiring obstetric care'), augmentation, instrumental delivery, and intrapartum caesarean section.

For babies, we considered a single composite outcome measure largely reflecting admission to a neonatal unit. This 'perinatal composite outcome' encompassed one or more of the following events: admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death.

Statistical analysis

Analyses were conducted separately by parity. We modelled age at the time of delivery both as a categorical and continuous variable, using log Poisson regression to estimate relative risks adjusted for the following potential confounders: ethnic group, understanding of English, marital or partner status, body mass index (BMI), index of multiple deprivation (IMD) score, gestational age at birth and, where appropriate, planned place of birth (see supplementary Table S1 for categorisation). We

also carried out sensitivity analyses in which we additionally adjusted for the presence of complicating conditions identified at the start of care in labour (none, one or more) and for the use of epidural/spinal analgesia.

We fitted a series of models following a pre-specified, iterative strategy. In order to test our modelling assumptions regarding age and to determine whether it was appropriate to combine data for planned births in non-OU settings, we plotted outcomes by age and planned place of birth using polynomial smoothing.[31] Visual inspection of these plots (see Figure 1 and 2 for the main outcomes) indicated that it was reasonable to model age as a continuous variable within the age range 16-40 (inclusive) and further indicated that event rates were generally similar in the three non-OU settings, suggesting that it was reasonable to combine the non-OU settings for the purposes of exploring interactions between maternal age and planned place of birth. We did not model age as a continuous variable above the age of 40 because data were sparse, particularly for planned non-OU births to nulliparous women, and we could not be confident that the broadly linear trends seen at younger ages could be extrapolated above this age.

We initially modelled the effect of age on study outcomes separately by parity and for all planned places of birth combined. Models in which age was modelled as a continuous variable were restricted to the age range 16-40 inclusive. For each of the study outcomes, we tested for an interaction between age (as a continuous variable) and planned place of birth (OU vs. non-OU) using a Wald test, and where the interaction was significant at the 5% level, we modelled the effect of age on the outcome separately by planned place of birth. For outcomes where the interaction between age and planned place of birth was significant, we calculated crude and adjusted relative risks associated with planned non-OU birth separately for each age band.

In order to test whether the presence of complicating conditions at the start of care in labour (for example prolonged rupture of membranes) had an effect on the observed relationships, we fitted a further set of models in which we adjusted for both maternal characteristics and the presence of complicating conditions. Because previous analyses have shown that women planning birth in an OU have a higher prevalence of complicating conditions than in other settings[25] and this affects the magnitude of the difference in event rates between settings, we carried out further analyses of the main outcomes restricted to 'low risk' women without complicating conditions at the start of care in labour.

Robust variance estimation was used to allow for the clustered nature of the data and, as described elsewhere,[25, 26] probability weights were incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each

unit/trust's period of participation and the stratum specific probabilities of selection of OUs. The weighting is such that, when applied to the pooled data for all four settings, the weighted event rates represent the estimated average event rates for England as a whole.

For each outcome, we calculated the number of events, the number of births, the weighted incidence and 95% confidence intervals. We assessed statistical significance at the 5% level.

Results

Description of the study sample

From the 79,774 women in the Birthplace cohort we excluded 15,553 women who had pre-existing risk factors including 'NICE' medical and obstetric risk factors,[22] grand multiparity (parity 6 or over) and post-term pregnancy, 62 women who were aged under 16, 682 women who had missing data on risk factors, parity or gestational age, and 106 whose age was missing. The study population consisted of 63,371 eligible 'low risk' women. The proportion (weighted) of women who were ineligible because of pre-existing risk factors, increased from 31.9% in women aged 16-19 to 46.7% in women aged 40 and over.

Table 1 describes the characteristics of the sample by age. The percentages shown in the table are weighted so that they provide an estimate of the distribution of maternal characteristics that would apply to eligible 'low risk' births in England. Older women tended to be white, have a fluent understanding of English, and were more likely than younger women to live in a socioeconomically advantaged area. They were less likely than younger women to be nulliparous and more likely to have had multiple previous pregnancies. Planned home births were more common at older ages (Table 1 and supplementary Tables S2 and S3), particularly in multiparous women (supplementary Table S3). Older women were more likely to have complicating conditions, such as prolonged rupture of membranes, noted by the midwife at the start of care in labour (Table 1). Complicating conditions at start of care in labour were more common in nulliparous women (supplementary Tables S2 and S3).

[TABLE 1 HERE]

Maternal interventions and adverse outcomes

Descriptive plots of outcomes by age indicated that the incidence of most outcomes tended to increase steadily with age in the age range 16 to 40, and that incidence rates were generally lower in planned non-OU births (Figure 1 and supplementary Figure S1). Rates for planned OU and non-OU births tended to diverge above this age range, but rates were based on small numbers of older women (supplementary Table S4) particularly for planned AMU and FMU births and therefore these rates have wide confidence intervals.

For nulliparous women in the age range 16-40 (all PPOBs combined), the adjusted risk of having an intervention/ adverse outcome requiring obstetric care (maternal composite) increased significantly

with age, as did the risk of augmentation with syntocinon, instrumental delivery, intrapartum caesarean section, 3rd/4th degree perineal tear, or maternal admission for higher level care (Table 2). For augmentation with syntocinon and the maternal composite outcome, the effect of age differed by PPOB (Table 2). The risk of augmentation increased more steeply with age in non-OU settings (RR 1.23, 95% CI 1.18-1.28 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.07-1.17 for planned OU births). Nevertheless, the proportion of women receiving augmentation was lower in planned non-OU births at all ages (Table 3). For example, 42.2% (95% CI 36.4%-48.1%) of nulliparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 22.6% (95% CI 19.8%-25.7%) of nulliparous women of the same age who planned birth in a non-OU setting. A similar pattern was observed for the maternal composite outcome: the risk of an intervention/adverse outcome requiring obstetric care (maternal composite) increased slightly more steeply with age in the non-OU settings (RR 1.21, 95% CI 1.18-1.25 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.10-1.15 for planned OU births) but the absolute risk was lower in the planned non-OU birth at all ages (Table 3). For example, 65.5% (95% CI 61.8%-69.1%) of nulliparous women aged 35-39 who planned birth in an OU experienced an intervention/adverse outcome requiring obstetric care compared with 39.9% (95% CI 36.0%-43.9%) of nulliparous women of the same age who planned birth in a non-OU setting. In nulliparous women, the risk of instrumental delivery and intrapartum caesarean section increased significantly with age (RR 1.18, 95% CI 1.12-1.25 and RR 1.27, 95% CI 1.23-1.32) across all settings. Again, absolute risks were substantially lower in planned non-OU births (Table 3).

[TABLE 2 AND TABLE 3 HERE]

Similar patterns were observed when we adjusted for complicating conditions at the start of care in labour in order to take account of difference between settings in complicating conditions at the start of care in labour (23.9% in nulliparous planned OU births vs. 8.6% in nulliparous planned-non-OU births) (supplementary Table S5).

However, although the risk of intervention increased with age, at all ages, nulliparous women who planned birth in a non-OU setting had a significantly reduced risk of receiving augmentation or of experiencing an intervention/adverse outcome requiring obstetric care. Table 4 shows the adjusted risks by age for the two outcomes (maternal composite and augmentation) where the effect of planned place of birth differed by age.

[TABLE 4 HERE]

For multiparous women aged 16-40 (all PPOBs combined), the combined risk of having an intervention or adverse outcome requiring obstetric care (maternal composite) or of instrumental

delivery, intrapartum caesarean section, and maternal admission for higher level care increased with age (Table 2). Augmentation with syntocinon, general anaesthesia, blood transfusion, and 3rd/4th degree perineal tear were not associated with maternal age in multiparous women (Table 2). For all of the outcomes considered, the effect of age did not differ by PPOB in multiparous women (Table 2). Again, for the maternal composite outcome, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section, the absolute event rates were lower in planned non-OU births in most age categories (Table 5). For example, 9.8% (95% CI 8.2%-11.6%) of multiparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 1.8% (95% CI 1.3%-2.5%) of women of the same age who planned birth in a non-OU setting.

Up to age 40, other less common outcomes did not increase significantly with maternal age in nulliparous or multiparous women with the exception of maternal admission to higher level care (Table 2 and supplementary Tables S6 and S7).

[TABLE 5 HERE]

Absolute event rates for the main outcomes (maternal composite, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section and perinatal composite) were reduced when the analysis was restricted to women without complicating conditions identified at start of labour care (supplementary Tables S8 and S9). However, at all ages, nulliparous women without complicating conditions who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention/adverse outcome requiring obstetric care (maternal composite outcome) (Table S8 and S10).For example, 38.0% (95% CI 34.3%-41.9%) of nulliparous women aged 35-39 without complicating complications who planned birth in a non-OU setting experienced an intervention/adverse outcome requiring obstetric care, compared with 57.7% (95% CI 53.4%- 62.0%) of women of the same age without complicating conditions who planned birth in an OU.

The use of epidural/spinal analgesia increased significantly with maternal age and lower rates of use were observed in planned non-OU births (supplementary Figure S2). Adjustment for use of epidural in the multivariable models attenuated but did not change the results materially (data not shown).

Perinatal outcome

The perinatal composite outcome (admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death) showed a modest but not statistically significant increase with age in nulliparous women in the age range 16-40 (Table 2). The risk increased significantly in nulliparous women aged 40+ compared with women aged 25-29 (RR 2.29, 95%CI 1.28-4.09, adjusted for maternal characteristics and planned place of birth, all settings combined).

Maternal age was not significantly associated with the risk of the perinatal composite outcome in multiparous women in the age range 16-40 (Table 2) and the risk was not significantly increased in births to multiparous women aged 40+ compared with women aged 25-29 (RR 1.21, 95% CI 0.60-2.43, adjustment as before). Absolute event rates are shown in Table 6.

[TABLE 6 HERE]

Discussion

Principal findings

In women without known medical or obstetric risk factors prior to the onset of labour, interventions and adverse maternal outcomes requiring obstetric care generally increased with age, but there was no age at which there was a step-change in risk. For both nulliparous and multiparous women, maternal intervention rates were lower in births planned in non-OU settings compared with planned OU births at all ages. For nulliparous women the overall risk of experiencing an intervention or adverse outcome requiring obstetric care, and in particular of augmentation with syntocinon, increased more steeply with age in planned non-OU births than in planned OU births. As a consequence, although nulliparous women of all ages who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention or adverse outcome requiring obstetric care, the benefit of planned non-OU birth was greatest at younger ages.

In low risk women up to the age of 40, the risk of neonatal unit admission or intrapartum stillbirth/early neonatal death did not show a statistically significant upward trend with age in either nulliparous or multiparous women. In planned OU births, the risk of neonatal unit admission or perinatal death was significantly higher in nulliparous women aged 40+ relative to women aged 25-29.

Strengths and limitations

A strength of the study is that we were able to evaluate the effect of age on intrapartum outcomes by planned birth setting in a nationally representative sample of 'low risk' women. In order to strengthen the evidence supporting clinical guidelines on planned place of birth, the study specifically focused on outcomes that reflect need for obstetric or neonatal care in a sample of women who meet the current criteria for planned birth in a non-OU setting.[22] To our knowledge, this is the first study to investigate the effect of increasing maternal age in different birth settings with a focus on outcomes that would require transfer to an OU and hence may affect the choice of planned place of birth.

Despite the large overall sample size, the number of older women was relatively small, so we had limited ability to explore effects above age 40 or to separate results of individual non-OU birth settings. We combined data for the non-OU settings, having first explored the data to check that this was reasonable. This increased our statistical power to evaluate the association between maternal

age and the study outcomes (maternal and perinatal), but we still lacked the statistical power to evaluate uncommon outcomes. It is important to note that previous analyses[25] have shown that planned home births are associated with a significantly increased risk of adverse perinatal outcomes in nulliparous women.

The risk of bias due to missing data and non-response was low: the study had a low level of missing data, a high response rate[25, 26] and, because consent was not required, there was no self-selection bias due to non-consent. We addressed potential differences in risk between groups in a number of ways. First, we controlled for important potential confounders such as body mass index. Second, we focused on a relatively homogeneous population of women without known medical or obstetric risk factors prior to the onset of labour. Third, because previous analyses[25] identified that the prevalence of complicating conditions at the start of care in labour was higher in the planned OU birth group, we conducted two additional analyses in which we controlled for complicating conditions and restricted the analysis to women without complicating conditions. Differences in the clinical characteristics of the OU and non-OU groups therefore seem unlikely to explain the age related trends observed or the significant reductions in risks observed in non-OU births. Nevertheless, women self-select their birth setting and it may be that some of the differences in outcomes that we observed between settings may have been due to unmeasured differences in the characteristics of women opting for OU and non-OU births, rather than to differences attributable to the birth setting.

Comparison with the existing literature

Older women have been shown to have an increased risk of intrapartum intervention,[6, 32] but many studies include women known to be at higher risk who would normally be advised to give birth in an obstetric unit. Evidence relating to 'low risk' women[17] or from studies that have controlled for pre-existing risk factors or complications[33] is more limited but is generally consistent with our finding that intervention rates increase with age in 'low risk' women.

There is extensive evidence that 'low risk' women who plan birth in a non-OU setting have a reduced risk of a range of intrapartum interventions, including augmentation, instrumental delivery and intrapartum caesarean section, and are more likely to have a spontaneous vaginal birth.[22-24, 27, 28] Our study found that, at all ages, women who plan birth in a non-OU setting experience substantially lower intervention rates and are less likely to experience an outcome requiring obstetric care than women of the same age who plan birth in an obstetric unit.

In nulliparous women we found that rates of augmentation of labour with syntocinon increased more steeply with maternal age in planned non-OU births compared with planned OU births,

although absolute rates of augmentation were substantially lower in planned non-OU births at all ages. An age-related increase in augmentation is consistent with evidence of poorer uterine function at older ages,[34] longer labours[34] and an increased incidence of prolonged labour,[35, 36] but the reasons for a steeper increase in augmentation with age in non-OU settings is unclear. It has been suggested that labelling of older women as 'higher risk' and/or heightened concern about the safety of older nulliparous women, particularly those who have required fertility treatment, may result in increased rates of caesarean section for non-medical reasons,[20, 32, 33, 37] and it is possible that similar factors affect midwives' decision making regarding transfer for failure to progress, or for other reasons. Intrapartum transfers from midwifery units in the Birthplace study have been shown to increase significantly with age in nulliparous women[29] and, once transferred, women are 'exposed' to the higher intervention rates found in obstetric units.

It is also possible that age-related differences in women's expectations and expressed preferences may contribute to the pattern of intervention observed in our study. Older nulliparous women have been found to have a more positive attitude towards caesarean section,[38] for example, and also to have a higher perception of pregnancy risk, even in older women without known risk factors.[39] The significant positive association between maternal age and epidural use observed in our study (seen most strongly in nulliparous women planning a non-OU birth), would be consistent with a greater willingness of older women to consider interventions.

We found a significantly increased risk of maternal admission to higher level care at older ages in both nulliparous and multiparous women. The number of events was small and this could be a chance finding but an increase in serious obstetric complications at older ages observed in some studies[3, 6, 12] cannot be ruled out.

Although studies including women with known risk factors have reported increased risks in women aged over 35,[3, 6, 35] our analysis shows that up to the age of 40, risks tend to increase in a broadly linear manner in healthy women with straightforward pregnancies, with no evidence of a step-change in risk below the age of 40. Other studies have similarly concluded that the association of adverse outcomes with maternal age is a continuum,[3] with the increase in adverse perinatal outcomes possibly gaining momentum above the age of 40.[40] Because of the small number of births to mothers aged over 40 in our sample we had limited power to evaluate risks at older ages and other evidence relating to older 'low risk' women is sparse.[21]

There is some evidence that the babies of older women are at increased risk of serious adverse outcomes, including intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission,[5, 33] but these outcomes would be expected to be substantially reduced in 'low

risk' women who, by definition, do not have medical or obstetric risk factors such as severe obesity, diabetes or previous caesarean section. Furthermore, the poorer outcomes associated with the increased risk of pre-term birth at older ages do not apply to women giving birth at term. In our 'low risk' cohort, we did not observe a significant increase with age in our composite measure of neonatal unit admission/perinatal death within the age range 16-40, but graphical plots for nulliparous women suggested a possible upturn in neonatal unit admission/perinatal death around the age of 40 in nulliparous women. Further research evaluating perinatal outcomes in 'low risk' women aged over 40 is needed.

Conclusions and policy implications

The incidence of intrapartum interventions and adverse outcomes requiring obstetric care increases with maternal age, but at all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Amongst nulliparous women, younger women appear to benefit more from the reduction in interventions associated with planned birth in a non-OU setting. Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

All women, irrespective of age and parity, should be given information about the risks and benefits of different birth settings. Nulliparous women planning birth in non-OU setting should be informed that the risk of interventions that require transfer to an OU increases with age. Further research is required to evaluate adverse perinatal outcomes in 'low risk' women aged over 40.

Acknowledgements

We thank Xiaosi Wang for conducting initial literature searches and statistical analysis.

Competing interests

None.

Contribution to authorship

JH conceived and developed the study outline with input from PB; YL developed the protocol and analysis plan with input from JH, JT and MK; YL conducted the analysis; JT provided statistical advice; YL and JH drafted the manuscript with input from RR, MK and PB. All authors were involved in interpretation of data, review and revision of the draft manuscript and approval of the final version.

Ethics Approval

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee (MREC ref 07/H0505/151).

Funding

This paper reports on an independent study which is funded by the Policy Research Programme in the Department of Health. The views expressed are not necessarily those of the Department.

Birthplace combines the Evaluation of Maternity Units in England study funded in 2006 by the National Institute for Health Research Service Delivery and Organisation (NIHR SDO) programme, and the Birth at Home in England study funded in 2007 by the Department of Health Policy Research Programme (DH PRP). From January 2012, the NIHR SDO programme merged with the NIHR Health Services Research programme to establish the new NIHR health Services and Delivery Research (NIHR HS&DR) programme. The views and opinions expressed by the authors do not necessarily reflect those of the HS&DR Programme, NIHR, NHS, DH PRP or the Department of Health.

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(a) Maternal composite, nulliparous women

(b) Augmentation, nulliparous women

(c) Instrumental delivery, nulliparous women

(d) Intrapartum caesarean section, nulliparous

(e) Maternal composite, multiparous women

(f) Augmentation, multiparous women

(g) Instrumental delivery, multiparous women

(h) Intrapartum caesarean section, multiparous

Figure 1 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over[1]

[1] NOTE THAT scales for nulliparous women and multiparous women are different.

(a) Perinatal composite, nulliparous women

(b) Perinatal composite, multiparous women

Figure 2 Association between maternal age and perinatal composite outcome in low risk women aged 16 and over

Table 1 Characteristics of low risk women aged 16 and over by maternal age category

	16 - 19 years n=3354		20 - 24 years n=11395		25 - 29 years n=18091		30 - 34 years n=18453		35 - 39 years n=10397		≥ 40 years n=1681	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	3078	90.1	9685	81.2	15146	77.5	16052	80.7	9339	84.3	1527	86.6
Non-white	275	9.9	1697	18.8	2920	22.5	2375	19.3	1044	15.8	153	13.4
Missing	1		13		25		26		14		1	
Understanding of English												
Fluent	3254	96.7	10394	89.6	16757	90.0	17605	92.9	10155	96.3	1638	96.7
Not fluent	94	3.3	948	10.4	1251	10.0	776	7.1	214	3.7	36	3.4
Missing	6		53		83		72		28		7	
Marital/partner status												
Married/living with partner	1836	51.9	9550	81.8	16868	92.1	17782	96.1	10004	95.4	1591	94.4
Single/unsupported by partner	1440	48.1	1677	18.2	1010	7.9	493	3.9	293	4.7	68	5.7
Missing	78		168		213		178		100		22	
BMI in pregnancy (kg/m^2)												
< 18.5	184	6.2	426	4.2	413	2.6	337	2.1	156	1.5	18	0.2
18.5 - 24.9	1753	50.3	5316	45.6	8560	45.9	9059	46.7	4864	44.5	802	46.4
25.0 - 29.9	598	17.9	2558	21.7	4341	24.6	4206	23.2	2572	26.9	415	27.6
30.0 - 35.0	233	7.6	1096	10.0	1627	9.3	1399	8.8	769	8.9	109	8.1
Not recorded	581	18.1	1969	18.4	3091	17.6	3389	19.2	2000	18.3	329	17.7
Missing	5		30		59		63		36		8	
IMD quintile												
1st (Least deprived)	245	6.8	1102	8.5	2875	13.8	4255	20.5	2783	24.6	434	26.0
2nd	405	12.3	1521	13.3	3259	17.5	4114	21.7	2434	22.3	396	22.0
3rd	637	18.2	2115	18.0	3657	18.6	3759	19.7	2135	20.0	357	21.6
4th	827	25.3	2784	23.9	3957	22.7	3479	19.8	1765	17.9	291	16.9
5th (Most deprived)	1221	37.5	3821	36.2	4262	27.5	2759	18.4	1215	15.2	197	13.7
Missing	19		52		81		87		65		6	
Previous pregnancies ≥ 24 weeks												

0	2835	86.8	6341	62.0	8438	53.6	7307	46.7	2989	36.9	346	28.0
1	474	12.1	3772	29.4	5892	29.9	6963	33.9	3929	35.5	540	32.3
2	38	0.8	1006	6.8	2549	10.9	2779	12.2	2260	17.4	414	20.2
3-5	7	0.3	276	1.9	1212	5.6	1404	7.2	1219	10.2	381	19.5
Missing												
Gestation at delivery (completed weeks)												
37	119	4.1	351	3.5	530	3.6	534	3.5	275	3.1	52	3.2
38	305	11.0	1136	10.1	1743	9.9	1739	9.9	971	10.2	146	9.9
39	783	22.5	2788	24.4	4409	24.2	4439	23.5	2516	23.2	410	27.2
40	1292	36.7	4361	36.7	6970	36.2	7090	37.5	3933	35.9	639	35.0
41 - 42+0 days	855	25.7	2759	25.3	4439	26.1	4651	25.6	2702	27.7	434	24.7
Planned place of birth												
OU	1445	87.5	4150	84.9	5601	82.6	4946	80.7	2571	80.2	497	83.2
AMU	1038	8.5	3445	9.6	4958	10.1	4540	10.3	2212	9.6	294	7.9
FMU	661	3.2	2115	3.5	3242	3.8	3216	3.9	1674	3.8	249	3.0
Home	210	0.8	1685	2.0	4290	3.5	5751	5.1	3940	6.4	641	5.8
Birth weight (grams)												
< 2500	53	1.9	146	1.8	166	1.4	159	1.1	75	1.0	17	1.3
2500 - 2999	561	18.4	1728	16.4	2281	14.5	1924	12.7	1100	12.5	168	12.8
3000 - 3499	1502	44.6	4678	41.1	7171	39.3	6960	38.2	3644	36.5	596	37.1
3500 - 3999	977	28.4	3664	30.9	6256	33.4	6767	35.0	3888	35.3	617	36.9
4000 - 4499	233	6.0	1023	8.7	1926	10.0	2294	11.4	1432	12.5	239	9.9
≥ 4500	21	0.7	135	1.2	262	1.5	303	1.6	237	2.3	40	2.0
Missing	7		21		29		46		21		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	145	7.1	411	6.1	678	6.5	706	7.1	415	7.0	78	8.9
Meconium stained liquor	126	5.8	322	4.8	469	5.0	541	6.1	295	5.9	60	7.4
Proteinuria 1+ or more	79	2.3	203	1.7	261	1.9	226	1.6	109	1.7	20	1.6
Hypertension	55	2.6	160	2.2	232	2.4	207	2.0	102	2.1	17	2.0
Abnormal vaginal bleeding	16	0.7	57	0.9	79	0.9	119	1.5	77	2.1	16	2.1

Non-cephalic presentation	5	0.2	31	0.5	44	0.4	64	0.5	46	0.7	3	0.3
Abnormal fetal heart rate	41	1.5	106	1.7	162	1.8	143	1.7	82	1.7	27	3.0
Other complications	14	0.6	24	0.3	23	0.2	27	0.1	11	0.2	2	0.2
Any complicating condition	431	18.5	1175	16.1	1744	16.6	1829	18.0	1001	18.1	199	22.5

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 2 Association between maternal age (per 5-year increase) and maternal and perinatal outcomes in low risk women aged between 16 and 40 years old (inclusive)

	Nulliparous women				Multiparous women			
	Unadjusted[1]		Adjusted[1, 2]		Unadjusted[1]		Adjusted[1, 2]	
	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Maternal composite	1.13	(1.11-1.16)	1.13	(1.11-1.16)	1.07	(1.03-1.13)	1.08	(1.03-1.14)
OU	1.13	(1.11-1.16)	1.12	(1.10-1.15)				
Non-OU[1, 3]	1.22	(1.19-1.26)	1.21	(1.18-1.25)				
		Wald test for interaction		$P^{1,4}$ <0.001		Wald test for interaction		$P^{1,4}$ =0.34
Augmentation	1.13	(1.09-1.16)	1.12	(1.08-1.17)	1.00	(0.92-1.08)	1.01	(0.92-1.11)
OU	1.13	(1.09-1.17)	1.12	(1.07-1.17)				
Non- OU[1, 3]	1.25	(1.20-1.31)	1.23	(1.18-1.28)				
		Wald test for interaction		$P^{1,4}$<0.001		Wald test for interaction		$P^{1,4}$ =0.24
Instrumental delivery	1.20	(1.13-1.26)	1.18	(1.12-1.25)	1.14	(1.04-1.25)	1.15	(1.05-1.27)
		Wald test for interaction		$P^{1,4}$ =0.18		Wald test for interaction		$P^{1,4}$ =0.06
Intrapartum caesarean section	1.27	(1.23-1.31)	1.27	(1.23-1.32)	1.16	(1.07-1.26)	1.16	(1.06-1.28)
		Wald test for interaction		$P^{1,4}$ =0.26		Wald test for interaction		$P^{1,4}$ =0.50
General anaesthesia	1.06	(0.93-1.20)	1.06	(0.92-1.22)	1.05	(0.87-1.27)	1.09	(0.91-1.32)
		Wald test for interaction		$P^{1,4}$ =0.83		Wald test for interaction		$P^{1,4}$ =0.15
Maternal blood transfusion	1.09	(0.97-1.23)	1.13	(0.95-1.34)	1.23	(0.95-1.60)	1.24	(0.94-1.62)
		Wald test for interaction		$P^{1,4}$ =0.38		Wald test for interaction		$P^{1,4}$ =0.44
Third/fourth degree perineal tear	1.17	(1.09-1.27)	1.12	(1.02-1.23)	1.10	(0.98-1.23)	1.01	(0.89-1.15)
		Wald test for interaction		$P^{1,4}$ =0.43		Wald test for interaction		$P^{1,4}$ =0.29
Maternal admission for higher level care	1.28	(1.03-1.58)	1.46	(1.07-1.99)	1.40	(1.01-1.92)	1.49	(1.06-2.10)
		Wald test for interaction		$P^{1,4}$ =0.41		Wald test for interaction		$P^{1,4}$ =0.15
Perinatal composite	1.07	(0.97-1.17)	1.06	(0.95-1.17)	1.02	(0.87-1.19)	0.98	(0.84-1.15)
		Wald test for interaction		$P^{1,4}$ =0.92		Wald test for interaction		$P^{1,4}$ =0.66

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. AMU vs. FMU vs. home).

[3] Results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[4] P for interaction, results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. non-OU).

Table 3 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	480/1239	39.4	(35.6-43.3)	252/1553	17.5	(15.2-20.1)
20-24	1229/2577	47.9	(44.7-51.1)	886/3679	24.2	(21.8-26.8)
25-29	1670/3003	55.6	(53.4-57.9)	1680/5354	32.3	(29.5-35.2)
30-34	1402/2322	61.1	(57.3-64.8)	1730/4897	36.6	(34.2-39.1)
35-39	622/957	65.5	(61.8-69.1)	792/1995	39.9	(36.0-43.9)
40+	108/148	71.9	(63.0-79.3)	83/196	44.8	(35.2-54.7)
Total	5511/10246	54.4	(51.9-56.9)	5423/17674	31.3	(29.3-33.4)
Augmentation						
16-19	317/1245	25.9	(22.5-29.7)	141/1564	8.6	(7.0-10.5)
20-24	790/2584	30.7	(26.9-34.7)	489/3706	12.9	(11.1-14.9)
25-29	1079/3011	35.7	(33.4-38.1)	918/5372	17.4	(15.6-19.3)
30-34	867/2318	37.5	(34.1-41.1)	964/4921	19.9	(18.3-21.7)
35-39	402/955	42.2	(36.4-48.1)	473/2015	22.6	(19.8-25.7)
40+	71/149	47.6	(37.0-58.4)	44/196	23.7	(15.7-34.1)
Total	3526/10262	34.6	(31.9-37.4)	3029/17774	16.9	(15.7-18.1)
Instrumental delivery						
16-19	191/1266	15.1	(12.5-18.2)	99/1568	7.9	(6.2-10.2)
20-24	469/2618	17.9	(15.9-20.0)	392/3717	10.6	(8.9-12.5)
25-29	707/3039	23.4	(21.3-25.6)	772/5391	15.0	(13.1-17.0)
30-34	591/2349	26.3	(21.3-32.1)	795/4950	17.0	(15.2-19.1)
35-39	275/968	29.5	(25.0-34.4)	401/2018	19.4	(15.9-23.6)
40+	41/149	30.4	(20.0-43.2)	37/197	21.0	(13.3-31.5)
Total	2274/10389	22.5	(19.9-25.3)	2496/17841	14.5	(13.0-16.0)
Intrapartum caesarean section						
16-19	101/1266	8.3	(6.5-10.5)	55/1568	3.3	(2.5-4.2)
20-24	313/2618	12.2	(10.4-14.2)	194/3717	5.2	(4.2-6.5)
25-29	461/3039	15.2	(13.3-17.2)	408/5391	8.0	(6.9-9.3)
30-34	466/2349	19.8	(17.5-22.3)	452/4950	9.0	(7.9-10.4)
35-39	223/968	23.0	(19.8-26.5)	212/2018	11.2	(9.0-13.9)
40+	47/149	29.2	(20.9-39.3)	22/197	9.7	(5.2-17.2)
Total	1611/10389	15.7	(14.1-17.5)	1343/17841	7.6	(6.8-8.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 4 Relative risk for non-OU compared to OU by age groups in nulliparous women

Age (years)	Unadjusted RR[1] (95% CI)	Adjusted RR[1, 2] (95% CI)	Adjusted RR[1, 3] (95% CI)
Maternal composite			
16-19	0.44 (0.38-0.53)	0.45 (0.38-0.54)	0.49 (0.42-0.58)
20-24	0.51 (0.45-0.57)	0.51 (0.45-0.58)	0.55 (0.49-0.62)
25-29	0.58 (0.53-0.64)	0.59 (0.54-0.65)	0.63 (0.57-0.70)
30-34	0.60 (0.55-0.66)	0.61 (0.56-0.67)	0.66 (0.60-0.73)
35-39	0.61 (0.54-0.68)	0.62 (0.56-0.69)	0.68 (0.61-0.76)
40+	0.62 (0.49-0.80)	0.66 (0.51-0.87)	0.70 (0.53-0.93)
Augmentation			
16-19	0.33 (0.26-0.42)	0.34 (0.27-0.44)	0.37 (0.29-0.47)
20-24	0.42 (0.35-0.51)	0.43 (0.35-0.52)	0.47 (0.39-0.57)
25-29	0.49 (0.43-0.55)	0.50 (0.45-0.57)	0.56 (0.49-0.63)
30-34	0.53 (0.47-0.60)	0.55 (0.48-0.63)	0.61 (0.53-0.71)
35-39	0.54 (0.44-0.65)	0.54 (0.46-0.64)	0.61 (0.51-0.74)
40+	0.50 (0.32-0.78)	0.53 (0.33-0.84)	0.58 (0.36-0.94)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[3] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and complicating conditions identified at the start of care in labour.

Table 5 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	35/177	20.2	(14.1-28.0)	20/338	6.6	(4.1-10.6)
20-24	242/1506	16.2	(13.8-19.0)	146/3486	4.6	(3.6-5.8)
25-29	468/2504	18.9	(16.9-20.9)	297/6989	4.8	(4.1-5.7)
30-34	492/2548	19.2	(16.8-21.8)	418/8440	5.4	(4.7-6.2)
35-39	344/1575	21.9	(19.4-24.7)	273/5737	5.6	(4.8-6.6)
40+	82/340	24.1	(20.7-28.0)	65/975	7.4	(5.6-9.7)
Total	1663/8650	19.3	(17.6-21.1)	1219/25965	5.3	(4.7-5.9)
Augmentation						
16-19	19/178	10.5	(5.9-17.9)	11/340	3.8	(2.0-7.1)
20-24	144/1516	9.4	(7.5-11.8)	62/3520	2.0	(1.4-2.7)
25-29	247/2529	9.9	(8.2-12.0)	109/7077	1.8	(1.4-2.3)
30-34	255/2572	9.7	(8.0-11.7)	132/8535	1.6	(1.3-2.0)
35-39	156/1592	9.8	(8.2-11.6)	89/5796	1.8	(1.3-2.5)
40+	42/345	12.2	(9.5-15.5)	18/985	1.8	(1.1-3.2)
Total	863/8732	9.8	(8.5-11.4)	421/26253	1.8	(1.5-2.1)
Instrumental delivery						
16-19	12/179	7.5	(3.6-14.9)	7/340	3.1	(1.3-7.1)
20-24	55/1530	3.6	(2.7-4.9)	38/3520	1.4	(1.0-2.0)
25-29	139/2557	5.5	(4.6-6.5)	102/7092	1.8	(1.4-2.3)
30-34	159/2594	6.1	(5.0-7.5)	124/8544	1.6	(1.2-2.0)
35-39	102/1600	6.6	(5.0-8.6)	82/5802	1.8	(1.4-2.4)
40+	30/347	8.8	(5.5-13.8)	17/987	2.5	(1.3-4.7)
Total	497/8807	5.7	(4.9-6.7)	370/26285	1.7	(1.4-2.1)
Intrapartum caesarean section						
16-19	6/179	3.4	(1.4-7.7)	4/340	0.9	(0.3-2.5)
20-24	62/1530	4.1	(2.6-6.3)	21/3520	0.6	(0.3-1.1)
25-29	121/2557	4.8	(3.8-6.1)	48/7092	0.7	(0.5-0.9)
30-34	134/2594	5.1	(4.0-6.5)	70/8544	0.9	(0.6-1.2)
35-39	110/1600	6.8	(5.1-9.1)	53/5802	1.1	(0.8-1.5)
40+	16/347	4.8	(3.1-7.4)	15/987	1.5	(0.8-2.7)
Total	449/8807	5.1	(4.2-6.3)	211/26285	0.8	(0.7-1.1)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 6 Perinatal outcomes by maternal age in low risk women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Nulliparous						
16-19	39/1260	3.2	(2.2-4.5)	31/1553	2.9	(1.9-4.4)
20-24	89/2610	3.5	(2.5-5.0)	94/3700	2.4	(1.9-3.2)
25-29	92/3026	3.3	(2.6-4.0)	123/5357	2.1	(1.7-2.8)
30-34	101/2340	4.2	(3.1-5.6)	128/4918	3.0	(2.2-4.0)
35-39	37/962	3.9	(2.8-5.4)	65/1999	3.0	(2.1-4.1)
40+	10/149	7.5	(3.4-15.7)	8/195	3.9	(1.0-14.0)
Total	368/10347	3.7	(2.9-4.6)	449/17722	2.6	(2.2-3.1)
Multiparous						
16-19	6/179	3.0	(1.4-6.4)	5/337	1.7	(0.6-4.6)
20-24	26/1519	1.8	(1.2-2.7)	43/3489	1.3	(0.8-2.0)
25-29	41/2547	1.6	(1.2-2.3)	73/7032	1.1	(0.8-1.6)
30-34	50/2578	2.0	(1.5-2.6)	111/8468	1.2	(1.0-1.5)
35-39	33/1594	2.1	(1.3-3.3)	88/5761	1.6	(1.2-2.2)
40+	7/345	2.1	(0.9-4.6)	20/978	2.3	(1.3-4.1)
Total	163/8762	1.9	(1.5-2.4)	340/26065	1.3	(1.1-1.6)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

The effect of maternal age and planned place of birth on intrapartum outcomes in healthy women with straightforward pregnancies: secondary analysis of the Birthplace national prospective cohort study

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Keywords

Maternal age, parity, birthing centre, home birth, augmentation, instrumental delivery, caesarean section, adverse maternal outcomes, adverse perinatal outcomes

Word count

Main text 4,630 words

Abstract

Objectives

To describe the relationship between maternal age and intrapartum outcomes in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth

Design

Prospective cohort study

Setting

Obstetric units, midwifery units and planned home births in England

Participants

63,371 women aged over 16 without known medical or obstetric risk factors, with singleton pregnancies, planning vaginal birth

Methods

Log Poisson regression was used to evaluate the association between maternal age, modelled as a continuous and categorical variable, and risk of intrapartum interventions and adverse maternal and perinatal outcomes.

Main Outcome Measures

Intrapartum caesarean section, instrumental delivery, syntocinon augmentation and a composite measure of maternal interventions/adverse outcomes requiring obstetric care encompassing augmentation, instrumental delivery, intrapartum caesarean section, general anaesthesia, blood transfusion, 3rd/4th degree tear, maternal admission; adverse perinatal outcome (encompassing neonatal unit admission or perinatal death).

Results

Interventions and adverse maternal outcomes requiring obstetric care generally increased with age, particularly in nulliparous women. For nulliparous women aged 16-40, the risk of experiencing an intervention or adverse outcome requiring obstetric care increased more steeply with age in planned non-obstetric unit births than in planned obstetric unit births (adjusted RR 1.21 per 5-year

increase in age, 95% CI 1.18-1.25 vs. adjusted RR 1.12, 95% CI 1.10-1.15) but absolute risks were lower in planned non-OU births at all ages. The risk of neonatal unit admission or perinatal death was significantly raised in nulliparous women aged 40+ relative to women aged 25-29 (adjusted RR 2.29, 95% CI 1.28-4.09).

Conclusions

At all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Younger nulliparous women appear to benefit more from this reduction than older nulliparous women.

Article summary

Article focus

- Does increasing age in women without known medical or obstetric risk factors increase the risk of intrapartum interventions and adverse outcomes that might affect their choice of planned place of birth?

Key messages

- At all ages 'low risk' women who plan birth in a non-obstetric unit setting have lower intervention rates than comparable women who plan their birth in an obstetric unit
- ~~Older women having a first baby appear to benefit less than younger women from planned birth in a non-obstetric unit setting.~~
- The chances of experiencing an intervention or outcome that requires obstetric care increase with age, even in women who do not have known risk factors.
- Younger nulliparous women appear to benefit more than older nulliparous women from the reduction in interventions associated with planned birth in a non-obstetric unit setting
- ~~Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.~~

Strengths and weaknesses

Strengths

- The study was based on a large, nationally representative cohort of 'low risk' women, with high quality data collected prospectively.

Weaknesses

- The number of women over 40 was relatively small so the study had limited power to explore effects in women over 40, particularly in non-obstetric unit settings.
- Planned births in non-obstetric unit settings were combined; graphical plots indicated that this was reasonable but important differences between settings cannot be ruled out.

Background

The proportion of births in women aged 35 and over has been steadily rising in recent years in the UK and elsewhere.[1, 2] Currently approximately 16% of births in England and Wales are to women aged 35-39 and 4% of births are to women aged 40 and over.[1]

Advanced maternal age is associated with an increased risk of pregnancy complications including gestational diabetes,[3] pregnancy induced hypertension and preeclampsia,[4, 5] twin or higher order pregnancies,[3] breech presentation,[6] placenta praevia,[3, 7-9] preterm birth,[5, 10] post-term birth,[11], severe maternal morbidity,[12] and adverse perinatal outcomes including antepartum stillbirth,[13] intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission.[5] Older women also have an increased risk of interventions such as induction and caesarean section.[16-20] However, many age-related pregnancy complications are known risk factors for intrapartum complications or adverse perinatal outcomes and women with these risk factors would normally be advised to give birth in an obstetric unit (OU). Relatively little is known about the incidence of intrapartum interventions and adverse maternal and perinatal outcomes in older women who do not have known risk factors.[21]

The current clinical guideline in England[22] recommends that healthy women with straightforward pregnancies should be offered a choice of planned birth at home, in a midwife-led unit or in an obstetric unit, but also suggest individual assessment when planning place of birth for women over 40 at booking.[22] The evidence for 'low risk' women in general shows that planned birth in a non-OU setting is associated with a lower incidence of intrapartum interventions[22-28] and research has demonstrated that in 'low risk' women, after adjustment for maternal characteristics, planned birth in a midwifery unit and planned birth at home (multiparous women only) is not associated with an increased risk to the baby compared with planned birth in an OU.[25] However, rates of intrapartum transfer increase with age in nulliparous women[29] and, more generally, the risks that might affect the choice of planned place of birth (PPOB) by healthy older women are not well documented.

The aim of this study was to evaluate the association between maternal age and intrapartum interventions and adverse maternal and perinatal outcomes that may influence the choice of planned place of birth, in 'low risk' women with singleton, term pregnancies planning a vaginal birth.

The main objectives were to describe the relationship between maternal age and intrapartum interventions and adverse outcomes that indicate a need for obstetric or neonatal care in 'low risk' women; and to evaluate whether the relationship between maternal age and intrapartum interventions and adverse outcomes differs by planned place of birth.

Methods

Settings and participants

The study used data from the Birthplace in England national prospective cohort study which was designed to compare perinatal and maternal outcomes and interventions by planned place of birth at the start of care in labour.

The cohort study methods are described in full elsewhere.[25, 26] Briefly, the Birthplace cohort included a total of 79,774 births between April 2008 and April 2010, including 32,257 planned OU births from a stratified random sample of 36 OUs, 11,666 planned births in 53 freestanding midwifery units (FMUs), 17,582 planned births in 43 alongside midwifery units (AMUs) and 18,269 planned home births from 142 NHS trusts across England. Births were eligible for inclusion if the woman was planning a vaginal birth and received some labour care from an NHS midwife in her planned birth setting. Women who had an elective caesarean section or caesarean section before the onset of labour, presented in preterm labour (<37 weeks' gestation), had a multiple pregnancy, an unplanned home birth, or who were "unbooked" (received no antenatal care) were excluded. Stillbirths occurring before the start of care in labour were excluded. Women in the cohort were classified as 'low risk' if before the start of labour they were not known to have any of the medical or obstetric risk factors listed in national guidelines on intrapartum care[22] as "indicating increased risk suggesting planned birth in an obstetric unit". The study had a high response rate and low levels of missing data.[25, 26]

The study population for the analyses reported here was 'low risk' women in the Birthplace cohort aged 16 years or over at the time of birth, with a term (gestational age 37^{+0} weeks to 42^{+0} weeks inclusive) pregnancy and parity less than 6. In the NICE intrapartum care guideline individual assessment is recommended when planning place of birth for women with parity of 6 or more and many midwifery units restrict admission to women of parity 5 or less.[30] We additionally excluded women for whom age, parity or gestational age was not known.

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee and did not require consent to be sought from participants as no personally identifiable data were collected.

Data

As described elsewhere,[25] maternal characteristics, and medical or obstetric risk factors known prior to the onset of labour were extracted from the woman's medical records by the midwife

attending the birth. Complicating conditions identified by the midwife at the start of care in labour (for example prolonged rupture of membranes), intrapartum interventions and adverse maternal and perinatal outcomes were recorded by the attending midwife using a data collection form started during labour and completed on or after the fifth postnatal day.

Planned place of birth (OU, AMU, FMU or home) was based on the intended place of birth at the start of care in labour. Women were included in the group in which they planned to give birth at the start of care in labour regardless of whether they were transferred during labour care or immediately after the birth.

Outcomes

We focused on outcome measures that reflected interventions and adverse outcomes that indicated a need for obstetric and/or neonatal care, that is, outcomes that would require the woman and/or baby to be transferred to an obstetric or neonatal unit if labour care or birth took place elsewhere. For women, we considered the following outcomes both separately and as a combined maternal composite outcome ('interventions/adverse outcomes requiring obstetric care'): augmentation with syntocinon, instrumental delivery (ventouse or forceps), intrapartum caesarean section, general anaesthesia, maternal blood transfusion, 3rd/4th degree perineal tear, maternal admission for higher level care. The use of epidural/spinal analgesia was also considered as a secondary outcome. The main outcomes considered for women were the maternal composite outcome ('interventions and adverse outcomes requiring obstetric care'), augmentation, instrumental delivery, and intrapartum caesarean section.

For babies, we considered a single composite outcome measure largely reflecting admission to a neonatal unit. This 'perinatal composite outcome' encompassed one or more of the following events: admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death.

Statistical analysis

Analyses were conducted separately by parity. We modelled age at the time of delivery both as a categorical and continuous variable, using log Poisson regression to estimate relative risks adjusted for the following potential confounders: ethnic group, understanding of English, marital or partner status, body mass index (BMI), index of multiple deprivation (IMD) score, gestational age at birth and, where appropriate, planned place of birth (see supplementary Table S1 for categorisation). We also carried out sensitivity analyses in which we additionally adjusted for the presence of

complicating conditions identified at the start of care in labour (none, one or more) and for the use of epidural/spinal analgesia.

We fitted a series of models following a pre-specified, iterative strategy. In order to test our modelling assumptions regarding age and to determine whether it was appropriate to combine data for planned births in non-OU settings, we plotted outcomes by age and planned place of birth using polynomial smoothing.[31] Visual inspection of these plots (see Figure 1 and 2 for the main outcomes) indicated that it was reasonable to model age as a continuous variable within the age range 16-40 (inclusive) and further indicated that event rates were generally similar in the three non-OU settings, suggesting that it was reasonable to combine the non-OU settings for the purposes of exploring interactions between maternal age and planned place of birth. We did not model age as a continuous variable above the age of 40 because data were sparse, particularly for planned non-OU births to nulliparous women, and we could not be confident that the broadly linear trends seen at younger ages could be extrapolated above this age.

We initially modelled the effect of age on study outcomes separately by parity and for all planned places of birth combined. Models in which age was modelled as a continuous variable were restricted to the age range 16-40 inclusive. For each of the study outcomes, we tested for an interaction between age (as a continuous variable) and planned place of birth (OU vs. non-OU) using a Wald test, and where the interaction was significant at the 5% level, we modelled the effect of age on the outcome separately by planned place of birth. For outcomes where the interaction between age and planned place of birth was significant, we calculated crude and adjusted relative risks associated with planned non-OU birth separately for each age band.

In order to test whether the presence of complicating conditions at the start of care in labour (for example prolonged rupture of membranes) had an effect on the observed relationships, we fitted a further set of models in which we adjusted for both maternal characteristics and the presence of complicating conditions. Because previous analyses have shown that women planning birth in an OU have a higher prevalence of complicating conditions than in other settings[25] and this affects the magnitude of the difference in event rates between settings, we carried out further analyses of the main outcomes restricted to 'low risk' women without complicating conditions at the start of care in labour.

Robust variance estimation was used to allow for the clustered nature of the data and, as described elsewhere,[25, 26] probability weights were incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs. The

weighting is such that, when applied to the pooled data for all four settings, the weighted event rates represent the estimated average event rates for England as a whole.

For each outcome, we calculated the number of events, the number of births, the weighted incidence and 95% confidence intervals. We assessed statistical significance at the 5% level.

Results

Description of the study sample

From the 79,774 women in the Birthplace cohort we excluded 15,553 women who had pre-existing risk factors including 'NICE' medical and obstetric risk factors,[22] grand multiparity (parity 6 or over) and post-term pregnancy, 62 women who were aged under 16, 682 women who had missing data on risk factors, parity or gestational age, and 106 whose age was missing. The study population consisted of 63,371 eligible 'low risk' women. The proportion (weighted) of women who were ineligible because of pre-existing risk factors, increased from 31.9% in women aged 16-19 to 46.7% in women aged 40 and over.

Table 1 describes the characteristics of the sample by age. The percentages shown in the table are weighted so that they provide an estimate of the distribution of maternal characteristics that would apply to eligible 'low risk' births in England. Older women tended to be white, have a fluent understanding of English, and were more likely than younger women to live in a socioeconomically advantaged area. They were less likely than younger women to be nulliparous and more likely to have had multiple previous pregnancies. Planned home births were more common at older ages (Table 1 and supplementary Tables S2 and S3), particularly in multiparous women (supplementary Table S3). Older women were more likely to have complicating conditions, such as prolonged rupture of membranes, noted by the midwife at the start of care in labour (Table 1). Complicating conditions at start of care in labour were more common in nulliparous women (supplementary Tables S2 and S3).

[TABLE 1 HERE]

Maternal interventions and adverse outcomes

Descriptive plots of outcomes by age indicated that the incidence of most outcomes tended to increase steadily with age in the age range 16 to 40, and that incidence rates were generally lower in planned non-OU births (Figure 1 and supplementary Figure S1). Rates for planned OU and non-OU births tended to diverge above this age range, but rates were based on small numbers of older women (supplementary Table S4) particularly for planned AMU and FMU births and therefore these rates have wide confidence intervals.

For nulliparous women in the age range 16-40 (all PPOBs combined), the adjusted risk of having an intervention/ adverse outcome requiring obstetric care (maternal composite) increased significantly with age, as did the risk of augmentation with syntocinon, instrumental delivery, intrapartum

caesarean section, 3rd/4th degree perineal tear, or maternal admission for higher level care (Table 2). For augmentation with syntocinon and the maternal composite outcome, the effect of age differed by PPOB (Table 2). The risk of augmentation increased more steeply with age in non-OU settings (RR 1.23, 95% CI 1.18-1.28 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.07-1.17 for planned OU births). Nevertheless, the proportion of women receiving augmentation was lower in planned non-OU births at all ages (Table 3). For example, 42.2% (95% CI 36.4%-48.1%) of nulliparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 22.6% (95% CI 19.8%-25.7%) of nulliparous women of the same age who planned birth in a non-OU setting. A similar pattern was observed for the maternal composite outcome: the risk of an intervention/adverse outcome requiring obstetric care (maternal composite) increased slightly more steeply with age in the non-OU settings (RR 1.21, 95% CI 1.18-1.25 for every 5-year increase in age in planned non-OU births vs. 1.12, 95% CI 1.10-1.15 for planned OU births) but the absolute risk was lower in the planned non-OU birth at all ages (Table 3). For example, 65.5% (95% CI 61.8%-69.1%) of nulliparous women aged 35-39 who planned birth in an OU experienced an intervention/adverse outcome requiring obstetric care compared with 39.9% (95% CI 36.0%-43.9%) of nulliparous women of the same age who planned birth in a non-OU setting. In nulliparous women, the risk of instrumental delivery and intrapartum caesarean section increased significantly with age (RR 1.18, 95% CI 1.12-1.25 and RR 1.27, 95% CI 1.23-1.32) across all settings. Again, absolute risks were substantially lower in planned non-OU births (Table 3).

[TABLE 2 AND TABLE 3 HERE]

Similar patterns were observed when we adjusted for complicating conditions at the start of care in labour in order to take account of difference between settings in complicating conditions at the start of care in labour (23.9% in nulliparous planned OU births vs. 8.6% in nulliparous planned-non-OU births) (supplementary Table S5).

However, although the risk of intervention increased with age, at all ages, nulliparous women who planned birth in a non-OU setting had a significantly reduced risk of receiving augmentation or of experiencing an intervention/adverse outcome requiring obstetric care. Table 4 shows the adjusted risks by age for the two outcomes (maternal composite and augmentation) where the effect of planned place of birth differed by age.

[TABLE 4 HERE]

For multiparous women aged 16-40 (all PPOBs combined), the combined risk of having an intervention or adverse outcome requiring obstetric care (maternal composite) or of instrumental delivery, intrapartum caesarean section, and maternal admission for higher level care increased with

age (Table 2). Augmentation with syntocinon, general anaesthesia, blood transfusion, and 3rd/4th degree perineal tear were not associated with maternal age in multiparous women (Table 2). For all of the outcomes considered, the effect of age did not differ by PPOB in multiparous women (Table 2). Again, for the maternal composite outcome, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section, the absolute event rates were lower in planned non-OU births in most age categories (Table 5). For example, 9.8% (95% CI 8.2%-11.6%) of multiparous women aged 35-39 who planned birth in an OU received augmentation with syntocinon compared with 1.8% (95% CI 1.3%-2.5%) of women of the same age who planned birth in a non-OU setting.

Up to age 40, other less common outcomes did not increase significantly with maternal age in nulliparous or multiparous women with the exception of maternal admission to higher level care (Table 2 and supplementary Tables S6 and S7).

[TABLE 5 HERE]

Absolute event rates for the main outcomes (maternal composite, augmentation with syntocinon, instrumental delivery, intrapartum caesarean section and perinatal composite) were reduced when the analysis was restricted to women without complicating conditions identified at start of labour care (supplementary Tables S8 and S9). However, at all ages, nulliparous women without complicating conditions who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention/adverse outcome requiring obstetric care (maternal composite outcome) (Table S8 and S10).For example, 38.0% (95% CI 34.3%-41.9%) of nulliparous women aged 35-39 without complicating complications who planned birth in a non-OU setting experienced an intervention/adverse outcome requiring obstetric care, compared with 57.7% (95% CI 53.4%- 62.0%) of women of the same age without complicating conditions who planned birth in an OU.

The use of epidural/spinal analgesia increased significantly with maternal age and lower rates of use were observed in planned non-OU births (supplementary Figure S2). Adjustment for use of epidural in the multivariable models attenuated but did not change the results materially (data not shown).

Perinatal outcome

The perinatal composite outcome (admission to a neonatal unit within 48 hours of birth, stillbirth after the onset of labour or early neonatal death) showed a modest but not statistically significant increase with age in nulliparous women in the age range 16-40 (Table 2). The risk increased significantly in nulliparous women aged 40+ compared with women aged 25-29 (RR 2.29, 95%CI 1.28-4.09, adjusted for maternal characteristics and planned place of birth, all settings combined). Maternal age was not significantly associated with the risk of the perinatal composite outcome in

multiparous women in the age range 16-40 (Table 2) and the risk was not significantly increased in births to multiparous women aged 40+ compared with women aged 25-29 (RR 1.21, 95% CI 0.60-2.43, adjustment as before). Absolute event rates are shown in Table 6.

[TABLE 6 HERE]

Discussion

Principal findings

In women without known medical or obstetric risk factors prior to the onset of labour, interventions and adverse maternal outcomes requiring obstetric care generally increased with age, but there was no age at which there was a step-change in risk. For both nulliparous and multiparous women, maternal intervention rates were lower in births planned in non-OU settings compared with planned OU births at all ages. For nulliparous women the overall risk of experiencing an intervention or adverse outcome requiring obstetric care, and in particular of augmentation with syntocinon, increased more steeply with age in planned non-OU births than in planned OU births. As a consequence, although nulliparous women of all ages who planned birth in a non-OU setting had a significantly reduced risk of experiencing an intervention or adverse outcome requiring obstetric care, the benefit of planned non-OU birth was greatest at younger ages.

In low risk women up to the age of 40, the risk of neonatal unit admission or intrapartum stillbirth/early neonatal death did not show a statistically significant upward trend with age in either nulliparous or multiparous women. In planned OU births, the risk of neonatal unit admission or perinatal death was significantly higher in nulliparous women aged 40+ relative to women aged 25-29.

Strengths and limitations

A strength of the study is that we were able to evaluate the effect of age on intrapartum outcomes by planned birth setting in a nationally representative sample of 'low risk' women. In order to strengthen the evidence supporting clinical guidelines on planned place of birth, the study specifically focused on outcomes that reflect need for obstetric or neonatal care in a sample of women who meet the current criteria for planned birth in a non-OU setting.[22] To our knowledge, this is the first study to investigate the effect of increasing maternal age in different birth settings with a focus on outcomes that would require transfer to an OU and hence may affect the choice of planned place of birth.

Despite the large overall sample size, the number of older women was relatively small, so we had limited ability to explore effects above age 40 or to separate results of individual non-OU birth settings. We combined data for the non-OU settings, having first explored the data to check that this was reasonable. This increased our statistical power to evaluate the association between maternal age and the study outcomes (maternal and perinatal), but we still lacked the statistical power to evaluate uncommon outcomes. It is important to note that previous analyses[25] have shown that

planned home births are associated with a significantly increased risk of adverse perinatal outcomes in nulliparous women.

The risk of bias due to missing data and non-response was low: the study had a low level of missing data, a high response rate[25, 26] and, because consent was not required, there was no self-selection bias due to non-consent. We addressed potential differences in risk between groups in a number of ways. First, we controlled for important potential confounders such as body mass index. Second, we focused on a relatively homogeneous population of women without known medical or obstetric risk factors prior to the onset of labour. Third, because previous analyses[25] identified that the prevalence of complicating conditions at the start of care in labour was higher in the planned OU birth group, we conducted two additional analyses in which we controlled for complicating conditions and restricted the analysis to women without complicating conditions. Differences in the clinical characteristics of the OU and non-OU groups therefore seem unlikely to explain the age related trends observed or the significant reductions in risks observed in non-OU births. Nevertheless, women self-select their birth setting and it may be that some of the differences in outcomes that we observed between settings may have been due to unmeasured differences in the characteristics of women opting for OU and non-OU births, rather than to differences attributable to the birth setting.

Comparison with the existing literature

Older women have been shown to have an increased risk of intrapartum intervention,[6, 32] but many studies include women known to be at higher risk who would normally be advised to give birth in an obstetric unit. Evidence relating to 'low risk' women[17] or from studies that have controlled for pre-existing risk factors or complications[33] is more limited but is generally consistent with our finding that intervention rates increase with age in 'low risk' women.

There is extensive evidence that 'low risk' women who plan birth in a non-OU setting have a reduced risk of a range of intrapartum interventions, including augmentation, instrumental delivery and intrapartum caesarean section, and are more likely to have a spontaneous vaginal birth.[22-24, 27, 28] Our study found that, ~~across the age range 16-40~~at all ages, women who plan birth in a non-OU setting experience substantially lower intervention rates and are less likely to experience an outcome requiring obstetric care than women of the same age who plan birth in an obstetric unit.

In nulliparous women we found that rates of augmentation of labour with syntocinon increased more steeply with maternal age in planned non-OU births compared with planned OU births, although absolute rates of augmentation were substantially lower in planned non-OU births at all ages. An age-related increase in augmentation is consistent with evidence of poorer uterine function

at older ages,[34] longer labours[34] and an increased incidence of prolonged labour,[35, 36] but the reasons for a steeper increase in augmentation with age in non-OU settings is unclear. It has been suggested that labelling of older women as 'higher risk' and/or heightened concern about the safety of older nulliparous women, particularly those who have required fertility treatment, may result in increased rates of caesarean section for non-medical reasons,[20, 32, 33, 37] and it is possible that similar factors affect midwives' decision making regarding transfer for failure to progress, or for other reasons. Intrapartum transfers from midwifery units in the Birthplace study have been shown to increase significantly with age in nulliparous women[29] and, once transferred, women are 'exposed' to the higher intervention rates found in obstetric units.

It is also possible that age-related differences in women's expectations and expressed preferences may contribute to the pattern of intervention observed in our study. Older nulliparous women have been found to have a more positive attitude towards caesarean section,[38] for example, and also to have a higher perception of pregnancy risk, even in older women without known risk factors.[39] The significant positive association between maternal age and epidural use observed in our study (seen most strongly in nulliparous women planning a non-OU birth), would be consistent with a greater willingness of older women to consider interventions.

We found a significantly increased risk of maternal admission to higher level care at older ages in both nulliparous and multiparous women. The number of events was small and this could be a chance finding but an increase in serious obstetric complications at older ages observed in some studies[3, 6, 12] cannot be ruled out.

Although studies including women with known risk factors have reported increased risks in women aged over 35,[3, 6, 35] our analysis shows that up to the age of 40, risks tend to increase in a broadly linear manner in healthy women with straightforward pregnancies, with no evidence of a step-change in risk below the age of 40. Other studies have similarly concluded that the association of adverse outcomes with maternal age is a continuum,[3] with the increase in adverse perinatal outcomes possibly gaining momentum above the age of 40.[40] Because of the small number of births to mothers aged over 40 in our sample we had limited power to evaluate risks at older ages and other evidence relating to older 'low risk' women is sparse.[21]

There is some evidence that the babies of older women are at increased risk of serious adverse outcomes, including intrapartum-related perinatal death,[14] early neonatal death[15] and neonatal unit admission,[5, 33] but these outcomes would be expected to be substantially reduced in 'low risk' women who, by definition, do not have medical or obstetric risk factors such as severe obesity, diabetes or previous caesarean section. Furthermore, the poorer outcomes associated with the

increased risk of pre-term birth at older ages do not apply to women giving birth at term. In our 'low risk' cohort, we did not observe a significant increase with age in our composite measure of neonatal unit admission/perinatal death within the age range 16-40, but graphical plots for nulliparous women suggested a possible upturn in neonatal unit admission/perinatal death around the age of 40 in nulliparous women. Further research evaluating perinatal outcomes in 'low risk' women aged over 40 is needed.

Conclusions and policy implications

The incidence of intrapartum interventions and adverse outcomes requiring obstetric care increases with maternal age, but at all ages 'low risk' women who plan birth in a non-obstetric unit setting tend to experience lower intervention rates than comparable women who plan birth in an OU. Amongst nulliparous women, younger women appear to benefit more from the reduction in interventions associated with planned birth in a non-OU setting. Increased intervention rates at older ages may partly reflect women's expectations and preferences and possibly 'higher risk' labelling by clinicians.

All women, irrespective of age and parity, should be given information about the risks and benefits of different birth settings. Nulliparous women planning birth in non-OU setting should be informed that the risk of interventions that require transfer to an OU increases with age. Further research is required to evaluate adverse perinatal outcomes in 'low risk' women aged over 40.

Acknowledgements

We thank Xiaosi Wang for conducting initial literature searches and statistical analysis.

Competing interests

None.

Contribution to authorship

JH conceived and developed the study outline with input from PB; YL developed the protocol and analysis plan with input from JH, JT and MK; YL conducted the analysis; JT provided statistical advice; YL and JH drafted the manuscript with input from RR, MK and PB. All authors were involved in interpretation of data, review and revision of the draft manuscript and approval of the final version.

Ethics Approval

Research ethics committee approval for the Birthplace study was obtained from the Berkshire Research Ethics Committee (MREC ref 07/H0505/151).

Funding

This paper reports on an independent study which is funded by the Policy Research Programme in the Department of Health. The views expressed are not necessarily those of the Department.

Birthplace combines the Evaluation of Maternity Units in England study funded in 2006 by the National Institute for Health Research Service Delivery and Organisation (NIHR SDO) programme, and the Birth at Home in England study funded in 2007 by the Department of Health Policy Research Programme (DH PRP). From January 2012, the NIHR SDO programme merged with the NIHR Health Services Research programme to establish the new NIHR health Services and Delivery Research (NIHR HS&DR) programme. The views and opinions expressed by the authors do not necessarily reflect those of the HS&DR Programme, NIHR, NHS, DH PRP or the Department of Health.

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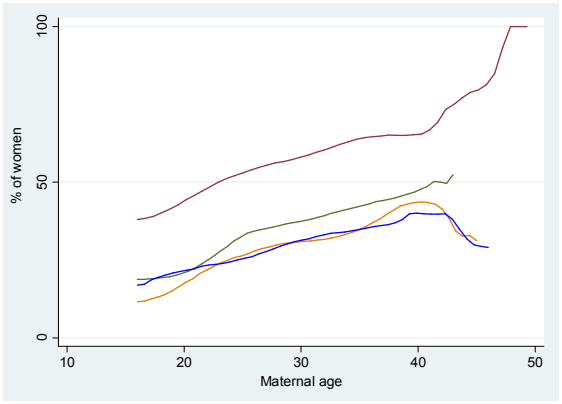
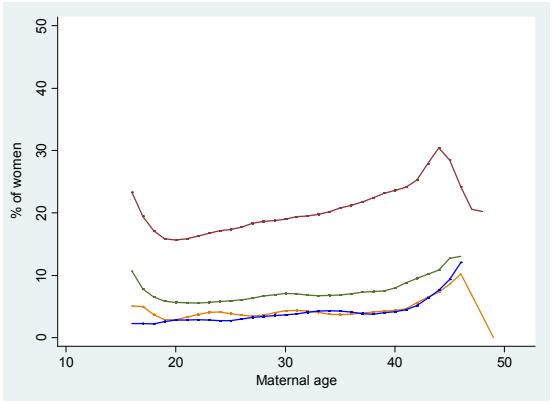


(a) Maternal composite, nulliparous women



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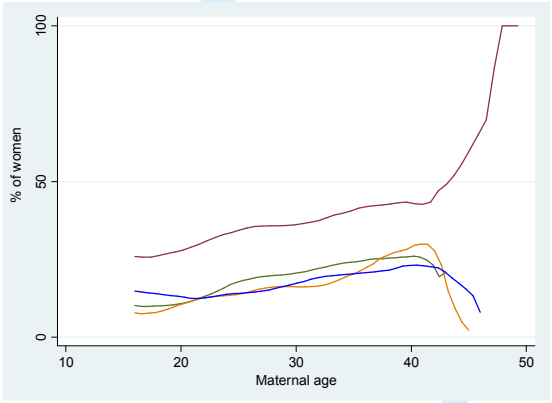

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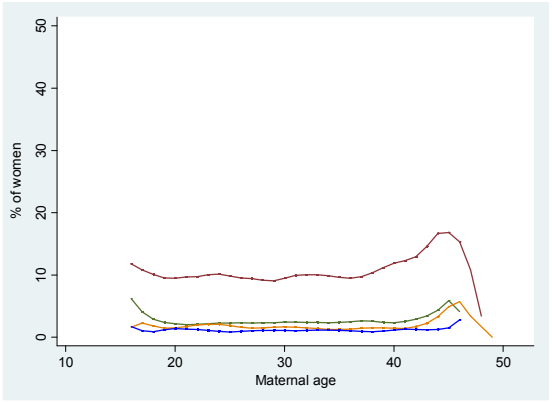
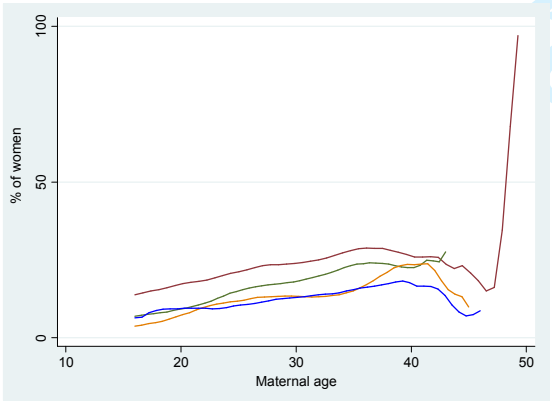
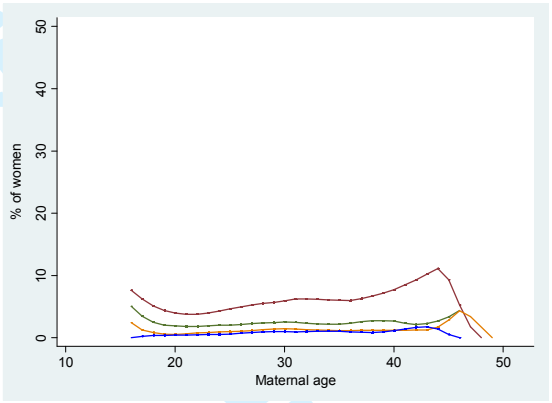


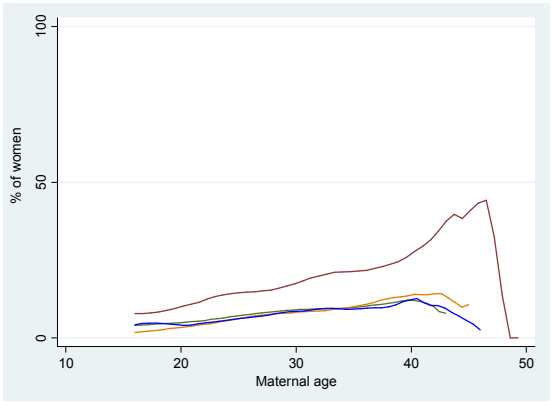
(f) Augmentation, multiparous women



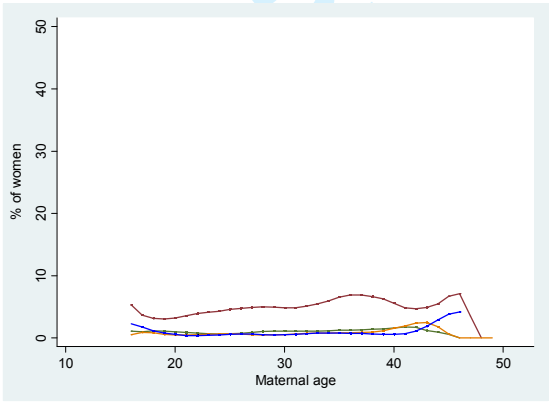
(c) Instrumental delivery, nulliparous women



(g) Instrumental delivery, multiparous women



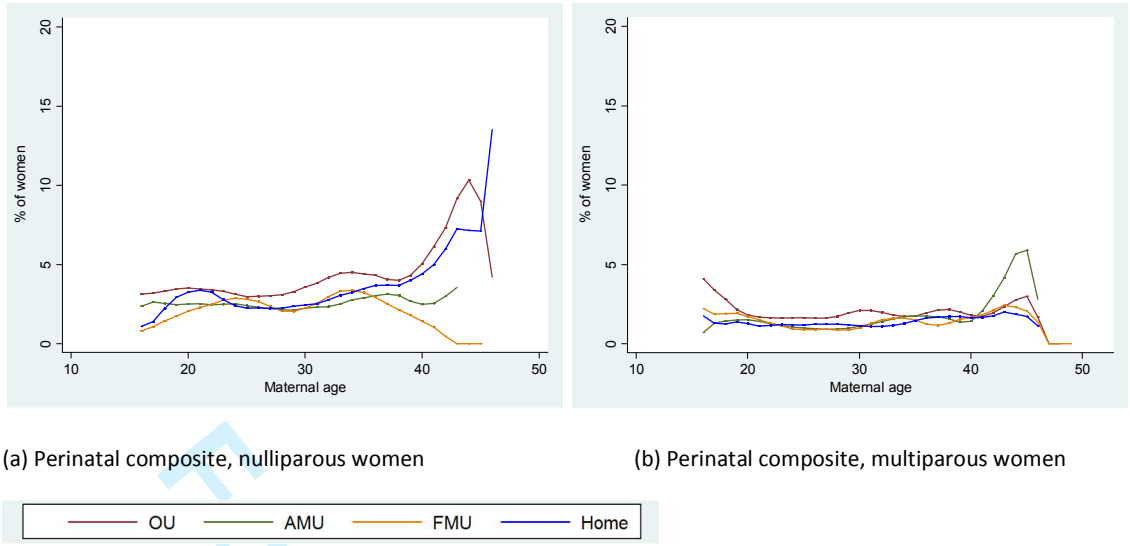
(d) Intrapartum caesarean section, nulliparous



(h) Intrapartum caesarean section, multiparous

Figure 1 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over[1]

[1] NOTE THAT scales for nulliparous women and multiparous women are different.



(a) Perinatal composite, nulliparous women

(b) Perinatal composite, multiparous women

Figure 2 Association between maternal age and perinatal composite outcome in low risk women aged 16 and over

Table 1 Characteristics of low risk women aged 16 and over by maternal age category

	16 - 19 years n=3354		20 - 24 years n=11395		25 - 29 years n=18091		30 - 34 years n=18453		35 - 39 years n=10397		≥ 40 years n=1681	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	3078	90.1	9685	81.2	15146	77.5	16052	80.7	9339	84.3	1527	86.6
Non-white	275	9.9	1697	18.8	2920	22.5	2375	19.3	1044	15.8	153	13.4
Missing	1		13		25		26		14		1	
Understanding of English												
Fluent	3254	96.7	10394	89.6	16757	90.0	17605	92.9	10155	96.3	1638	96.7
Not fluent	94	3.3	948	10.4	1251	10.0	776	7.1	214	3.7	36	3.4
Missing	6		53		83		72		28		7	
Marital/partner status												
Married/living with partner	1836	51.9	9550	81.8	16868	92.1	17782	96.1	10004	95.4	1591	94.4
Single/unsupported by partner	1440	48.1	1677	18.2	1010	7.9	493	3.9	293	4.7	68	5.7
Missing	78		168		213		178		100		22	
BMI in pregnancy (kg/m^2)												
< 18.5	184	6.2	426	4.2	413	2.6	337	2.1	156	1.5	18	0.2
18.5 - 24.9	1753	50.3	5316	45.6	8560	45.9	9059	46.7	4864	44.5	802	46.4
25.0 - 29.9	598	17.9	2558	21.7	4341	24.6	4206	23.2	2572	26.9	415	27.6
30.0 - 35.0	233	7.6	1096	10.0	1627	9.3	1399	8.8	769	8.9	109	8.1
Not recorded	581	18.1	1969	18.4	3091	17.6	3389	19.2	2000	18.3	329	17.7
Missing	5		30		59		63		36		8	
IMD quintile												
1st (Least deprived)	245	6.8	1102	8.5	2875	13.8	4255	20.5	2783	24.6	434	26.0
2nd	405	12.3	1521	13.3	3259	17.5	4114	21.7	2434	22.3	396	22.0
3rd	637	18.2	2115	18.0	3657	18.6	3759	19.7	2135	20.0	357	21.6
4th	827	25.3	2784	23.9	3957	22.7	3479	19.8	1765	17.9	291	16.9
5th (Most deprived)	1221	37.5	3821	36.2	4262	27.5	2759	18.4	1215	15.2	197	13.7
Missing	19		52		81		87		65		6	
Previous pregnancies ≥ 24 weeks												
0	2835	86.8	6341	62.0	8438	53.6	7307	46.7	2989	36.9	346	28.0

1	474	12.1	3772	29.4	5892	29.9	6963	33.9	3929	35.5	540	32.3
2	38	0.8	1006	6.8	2549	10.9	2779	12.2	2260	17.4	414	20.2
3-5	7	0.3	276	1.9	1212	5.6	1404	7.2	1219	10.2	381	19.5
Missing												
Gestation at delivery (completed weeks)												
37	119	4.1	351	3.5	530	3.6	534	3.5	275	3.1	52	3.2
38	305	11.0	1136	10.1	1743	9.9	1739	9.9	971	10.2	146	9.9
39	783	22.5	2788	24.4	4409	24.2	4439	23.5	2516	23.2	410	27.2
40	1292	36.7	4361	36.7	6970	36.2	7090	37.5	3933	35.9	639	35.0
41 - 42+0 days	855	25.7	2759	25.3	4439	26.1	4651	25.6	2702	27.7	434	24.7
Planned place of birth												
OU	1445	87.5	4150	84.9	5601	82.6	4946	80.7	2571	80.2	497	83.2
AMU	1038	8.5	3445	9.6	4958	10.1	4540	10.3	2212	9.6	294	7.9
FMU	661	3.2	2115	3.5	3242	3.8	3216	3.9	1674	3.8	249	3.0
Home	210	0.8	1685	2.0	4290	3.5	5751	5.1	3940	6.4	641	5.8
Birth weight (grams)												
< 2500	53	1.9	146	1.8	166	1.4	159	1.1	75	1.0	17	1.3
2500 - 2999	561	18.4	1728	16.4	2281	14.5	1924	12.7	1100	12.5	168	12.8
3000 - 3499	1502	44.6	4678	41.1	7171	39.3	6960	38.2	3644	36.5	596	37.1
3500 - 3999	977	28.4	3664	30.9	6256	33.4	6767	35.0	3888	35.3	617	36.9
4000 - 4499	233	6.0	1023	8.7	1926	10.0	2294	11.4	1432	12.5	239	9.9
≥ 4500	21	0.7	135	1.2	262	1.5	303	1.6	237	2.3	40	2.0
Missing	7		21		29		46		21		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	145	7.1	411	6.1	678	6.5	706	7.1	415	7.0	78	8.9
Meconium stained liquor	126	5.8	322	4.8	469	5.0	541	6.1	295	5.9	60	7.4
Proteinuria 1+ or more	79	2.3	203	1.7	261	1.9	226	1.6	109	1.7	20	1.6
Hypertension	55	2.6	160	2.2	232	2.4	207	2.0	102	2.1	17	2.0
Abnormal vaginal bleeding	16	0.7	57	0.9	79	0.9	119	1.5	77	2.1	16	2.1

Non-cephalic presentation	5	0.2	31	0.5	44	0.4	64	0.5	46	0.7	3	0.3
Abnormal fetal heart rate	41	1.5	106	1.7	162	1.8	143	1.7	82	1.7	27	3.0
Other complications	14	0.6	24	0.3	23	0.2	27	0.1	11	0.2	2	0.2
Any complicating condition	431	18.5	1175	16.1	1744	16.6	1829	18.0	1001	18.1	199	22.5

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 2 Association between maternal age (per 5-year increase) and maternal and perinatal outcomes in low risk women aged between 16 and 40 years old (inclusive)

	Nulliparous women				Multiparous women			
	Unadjusted[1]		Adjusted[1, 2]		Unadjusted[1]		Adjusted[1, 2]	
	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Maternal composite	1.13	(1.11-1.16)	1.13	(1.11-1.16)	1.07	(1.03-1.13)	1.08	(1.03-1.14)
OU	1.13	(1.11-1.16)	1.12	(1.10-1.15)				
Non-OU[1, 3]	1.22	(1.19-1.26)	1.21	(1.18-1.25)				
		Wald test for interaction	$P^{1,4}$ <0.001			Wald test for interaction	$P^{1,4}$ =0.34	
Augmentation	1.13	(1.09-1.16)	1.12	(1.08-1.17)	1.00	(0.92-1.08)	1.01	(0.92-1.11)
OU	1.13	(1.09-1.17)	1.12	(1.07-1.17)				
Non- OU[1, 3]	1.25	(1.20-1.31)	1.23	(1.18-1.28)				
		Wald test for interaction	$P^{1,4}$<0.001			Wald test for interaction	$P^{1,4}$ =0.24	
Instrumental delivery	1.20	(1.13-1.26)	1.18	(1.12-1.25)	1.14	(1.04-1.25)	1.15	(1.05-1.27)
		Wald test for interaction	$P^{1,4}$ =0.18			Wald test for interaction	$P^{1,4}$ =0.06	
Intrapartum caesarean section	1.27	(1.23-1.31)	1.27	(1.23-1.32)	1.16	(1.07-1.26)	1.16	(1.06-1.28)
		Wald test for interaction	$P^{1,4}$ =0.26			Wald test for interaction	$P^{1,4}$ =0.50	
General anaesthesia	1.06	(0.93-1.20)	1.06	(0.92-1.22)	1.05	(0.87-1.27)	1.09	(0.91-1.32)
		Wald test for interaction	$P^{1,4}$ =0.83			Wald test for interaction	$P^{1,4}$ =0.15	
Maternal blood transfusion	1.09	(0.97-1.23)	1.13	(0.95-1.34)	1.23	(0.95-1.60)	1.24	(0.94-1.62)
		Wald test for interaction	$P^{1,4}$ =0.38			Wald test for interaction	$P^{1,4}$ =0.44	
Third/fourth degree perineal tear	1.17	(1.09-1.27)	1.12	(1.02-1.23)	1.10	(0.98-1.23)	1.01	(0.89-1.15)
		Wald test for interaction	$P^{1,4}$ =0.43			Wald test for interaction	$P^{1,4}$ =0.29	
Maternal admission for higher level care	1.28	(1.03-1.58)	1.46	(1.07-1.99)	1.40	(1.01-1.92)	1.49	(1.06-2.10)
		Wald test for interaction	$P^{1,4}$ =0.41			Wald test for interaction	$P^{1,4}$ =0.15	
Perinatal composite	1.07	(0.97-1.17)	1.06	(0.95-1.17)	1.02	(0.87-1.19)	0.98	(0.84-1.15)
		Wald test for interaction	$P^{1,4}$ =0.92			Wald test for interaction	$P^{1,4}$ =0.66	

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. AMU vs. FMU vs. home).

[3] Results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[4] P for interaction, results in these rows were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and planned place of birth (OU vs. non-OU).

Table 3 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	480/1239	39.4	(35.6-43.3)	252/1553	17.5	(15.2-20.1)
20-24	1229/2577	47.9	(44.7-51.1)	886/3679	24.2	(21.8-26.8)
25-29	1670/3003	55.6	(53.4-57.9)	1680/5354	32.3	(29.5-35.2)
30-34	1402/2322	61.1	(57.3-64.8)	1730/4897	36.6	(34.2-39.1)
35-39	622/957	65.5	(61.8-69.1)	792/1995	39.9	(36.0-43.9)
40+	108/148	71.9	(63.0-79.3)	83/196	44.8	(35.2-54.7)
Total	5511/10246	54.4	(51.9-56.9)	5423/17674	31.3	(29.3-33.4)
Augmentation						
16-19	317/1245	25.9	(22.5-29.7)	141/1564	8.6	(7.0-10.5)
20-24	790/2584	30.7	(26.9-34.7)	489/3706	12.9	(11.1-14.9)
25-29	1079/3011	35.7	(33.4-38.1)	918/5372	17.4	(15.6-19.3)
30-34	867/2318	37.5	(34.1-41.1)	964/4921	19.9	(18.3-21.7)
35-39	402/955	42.2	(36.4-48.1)	473/2015	22.6	(19.8-25.7)
40+	71/149	47.6	(37.0-58.4)	44/196	23.7	(15.7-34.1)
Total	3526/10262	34.6	(31.9-37.4)	3029/17774	16.9	(15.7-18.1)
Instrumental delivery						
16-19	191/1266	15.1	(12.5-18.2)	99/1568	7.9	(6.2-10.2)
20-24	469/2618	17.9	(15.9-20.0)	392/3717	10.6	(8.9-12.5)
25-29	707/3039	23.4	(21.3-25.6)	772/5391	15.0	(13.1-17.0)
30-34	591/2349	26.3	(21.3-32.1)	795/4950	17.0	(15.2-19.1)
35-39	275/968	29.5	(25.0-34.4)	401/2018	19.4	(15.9-23.6)
40+	41/149	30.4	(20.0-43.2)	37/197	21.0	(13.3-31.5)
Total	2274/10389	22.5	(19.9-25.3)	2496/17841	14.5	(13.0-16.0)
Intrapartum caesarean section						
16-19	101/1266	8.3	(6.5-10.5)	55/1568	3.3	(2.5-4.2)
20-24	313/2618	12.2	(10.4-14.2)	194/3717	5.2	(4.2-6.5)
25-29	461/3039	15.2	(13.3-17.2)	408/5391	8.0	(6.9-9.3)
30-34	466/2349	19.8	(17.5-22.3)	452/4950	9.0	(7.9-10.4)
35-39	223/968	23.0	(19.8-26.5)	212/2018	11.2	(9.0-13.9)
40+	47/149	29.2	(20.9-39.3)	22/197	9.7	(5.2-17.2)
Total	1611/10389	15.7	(14.1-17.5)	1343/17841	7.6	(6.8-8.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 4 Relative risk for non-OU compared to OU by age groups in nulliparous women

Age (years)	Unadjusted RR[1] (95% CI)	Adjusted RR[1, 2] (95% CI)	Adjusted RR[1, 3] (95% CI)
Maternal composite			
16-19	0.44 (0.38-0.53)	0.45 (0.38-0.54)	0.49 (0.42-0.58)
20-24	0.51 (0.45-0.57)	0.51 (0.45-0.58)	0.55 (0.49-0.62)
25-29	0.58 (0.53-0.64)	0.59 (0.54-0.65)	0.63 (0.57-0.70)
30-34	0.60 (0.55-0.66)	0.61 (0.56-0.67)	0.66 (0.60-0.73)
35-39	0.61 (0.54-0.68)	0.62 (0.56-0.69)	0.68 (0.61-0.76)
40+	0.62 (0.49-0.80)	0.66 (0.51-0.87)	0.70 (0.53-0.93)
Augmentation			
16-19	0.33 (0.26-0.42)	0.34 (0.27-0.44)	0.37 (0.29-0.47)
20-24	0.42 (0.35-0.51)	0.43 (0.35-0.52)	0.47 (0.39-0.57)
25-29	0.49 (0.43-0.55)	0.50 (0.45-0.57)	0.56 (0.49-0.63)
30-34	0.53 (0.47-0.60)	0.55 (0.48-0.63)	0.61 (0.53-0.71)
35-39	0.54 (0.44-0.65)	0.54 (0.46-0.64)	0.61 (0.51-0.74)
40+	0.50 (0.32-0.78)	0.53 (0.33-0.84)	0.58 (0.36-0.94)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.

[3] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, and complicating conditions identified at the start of care in labour.

Table 5 Intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	35/177	20.2	(14.1-28.0)	20/338	6.6	(4.1-10.6)
20-24	242/1506	16.2	(13.8-19.0)	146/3486	4.6	(3.6-5.8)
25-29	468/2504	18.9	(16.9-20.9)	297/6989	4.8	(4.1-5.7)
30-34	492/2548	19.2	(16.8-21.8)	418/8440	5.4	(4.7-6.2)
35-39	344/1575	21.9	(19.4-24.7)	273/5737	5.6	(4.8-6.6)
40+	82/340	24.1	(20.7-28.0)	65/975	7.4	(5.6-9.7)
Total	1663/8650	19.3	(17.6-21.1)	1219/25965	5.3	(4.7-5.9)
Augmentation						
16-19	19/178	10.5	(5.9-17.9)	11/340	3.8	(2.0-7.1)
20-24	144/1516	9.4	(7.5-11.8)	62/3520	2.0	(1.4-2.7)
25-29	247/2529	9.9	(8.2-12.0)	109/7077	1.8	(1.4-2.3)
30-34	255/2572	9.7	(8.0-11.7)	132/8535	1.6	(1.3-2.0)
35-39	156/1592	9.8	(8.2-11.6)	89/5796	1.8	(1.3-2.5)
40+	42/345	12.2	(9.5-15.5)	18/985	1.8	(1.1-3.2)
Total	863/8732	9.8	(8.5-11.4)	421/26253	1.8	(1.5-2.1)
Instrumental delivery						
16-19	12/179	7.5	(3.6-14.9)	7/340	3.1	(1.3-7.1)
20-24	55/1530	3.6	(2.7-4.9)	38/3520	1.4	(1.0-2.0)
25-29	139/2557	5.5	(4.6-6.5)	102/7092	1.8	(1.4-2.3)
30-34	159/2594	6.1	(5.0-7.5)	124/8544	1.6	(1.2-2.0)
35-39	102/1600	6.6	(5.0-8.6)	82/5802	1.8	(1.4-2.4)
40+	30/347	8.8	(5.5-13.8)	17/987	2.5	(1.3-4.7)
Total	497/8807	5.7	(4.9-6.7)	370/26285	1.7	(1.4-2.1)
Intrapartum caesarean section						
16-19	6/179	3.4	(1.4-7.7)	4/340	0.9	(0.3-2.5)
20-24	62/1530	4.1	(2.6-6.3)	21/3520	0.6	(0.3-1.1)
25-29	121/2557	4.8	(3.8-6.1)	48/7092	0.7	(0.5-0.9)
30-34	134/2594	5.1	(4.0-6.5)	70/8544	0.9	(0.6-1.2)
35-39	110/1600	6.8	(5.1-9.1)	53/5802	1.1	(0.8-1.5)
40+	16/347	4.8	(3.1-7.4)	15/987	1.5	(0.8-2.7)
Total	449/8807	5.1	(4.2-6.3)	211/26285	0.8	(0.7-1.1)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table 6 Perinatal outcomes by maternal age in low risk women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Nulliparous						
16-19	39/1260	3.2	(2.2-4.5)	31/1553	2.9	(1.9-4.4)
20-24	89/2610	3.5	(2.5-5.0)	94/3700	2.4	(1.9-3.2)
25-29	92/3026	3.3	(2.6-4.0)	123/5357	2.1	(1.7-2.8)
30-34	101/2340	4.2	(3.1-5.6)	128/4918	3.0	(2.2-4.0)
35-39	37/962	3.9	(2.8-5.4)	65/1999	3.0	(2.1-4.1)
40+	10/149	7.5	(3.4-15.7)	8/195	3.9	(1.0-14.0)
Total	368/10347	3.7	(2.9-4.6)	449/17722	2.6	(2.2-3.1)
Multiparous						
16-19	6/179	3.0	(1.4-6.4)	5/337	1.7	(0.6-4.6)
20-24	26/1519	1.8	(1.2-2.7)	43/3489	1.3	(0.8-2.0)
25-29	41/2547	1.6	(1.2-2.3)	73/7032	1.1	(0.8-1.6)
30-34	50/2578	2.0	(1.5-2.6)	111/8468	1.2	(1.0-1.5)
35-39	33/1594	2.1	(1.3-3.3)	88/5761	1.6	(1.2-2.2)
40+	7/345	2.1	(0.9-4.6)	20/978	2.3	(1.3-4.1)
Total	163/8762	1.9	(1.5-2.4)	340/26065	1.3	(1.1-1.6)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

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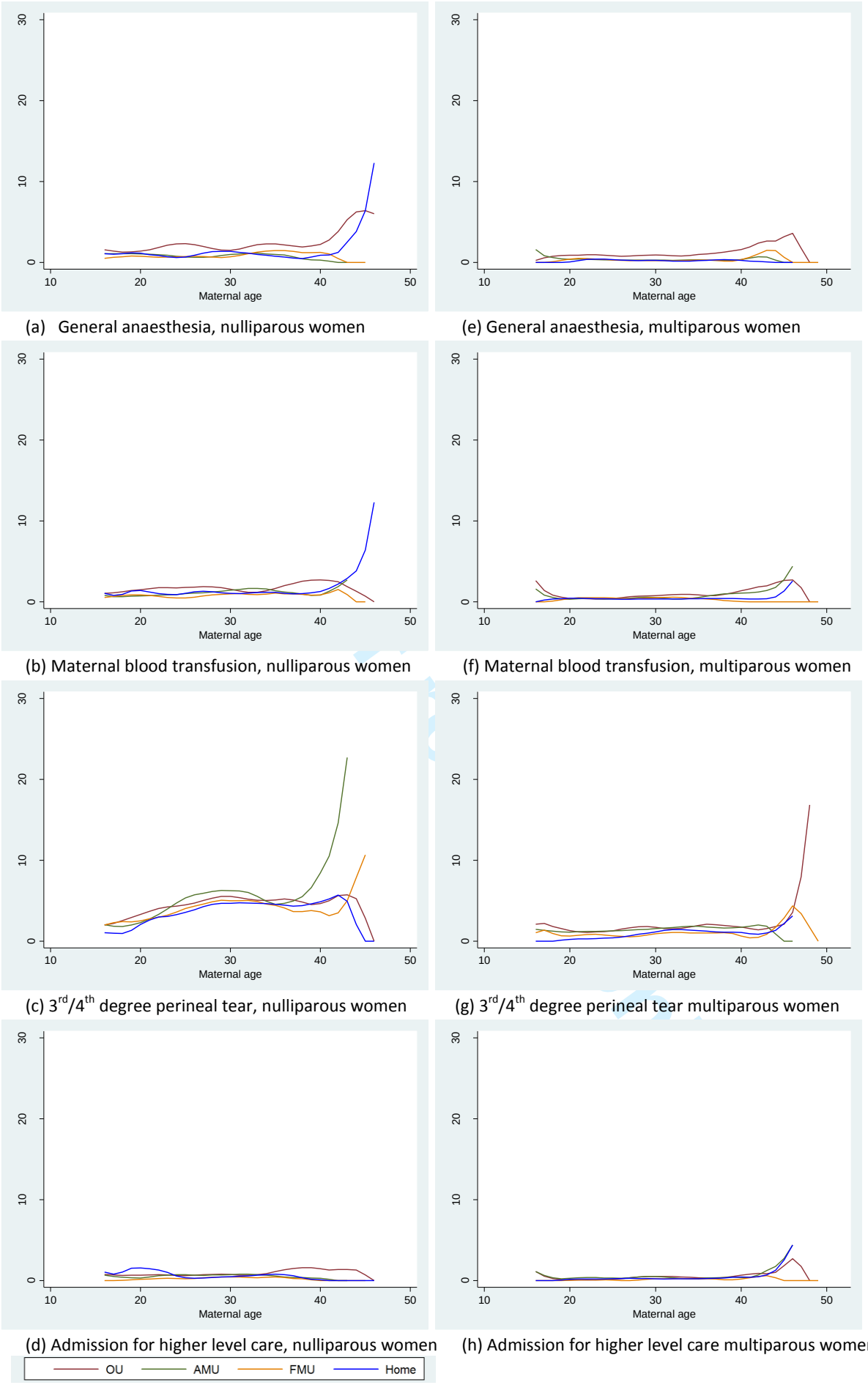


(a) General anaesthesia, nulliparous women

(e) General anaesthesia, multiparous women

(b) Maternal blood transfusion, nulliparous women

(f) Maternal blood transfusion, multiparous women

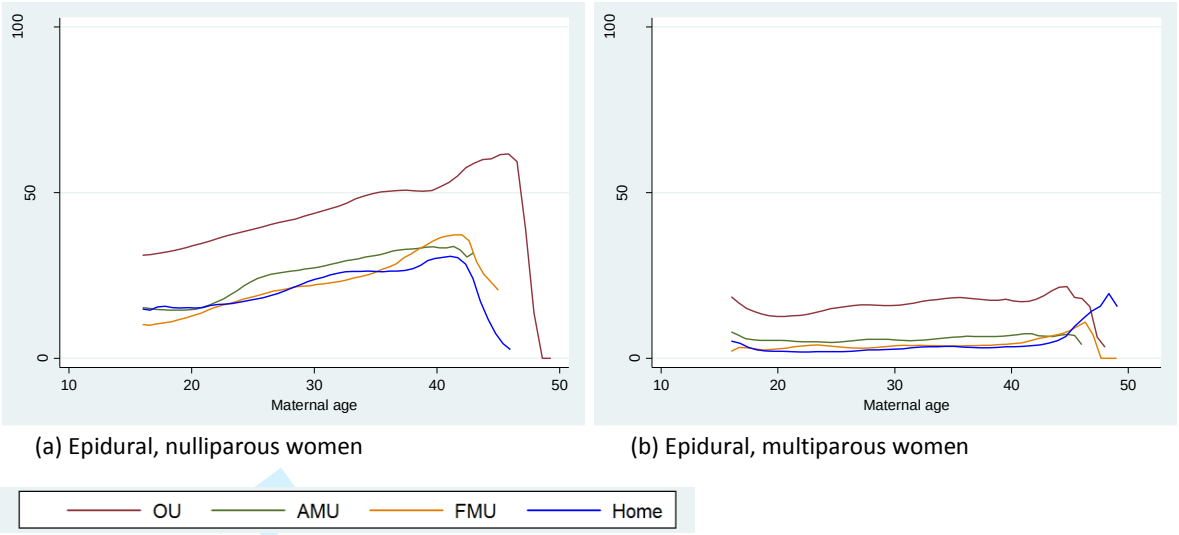
(c) 3rd/4th degree perineal tear, nulliparous women

(g) 3rd/4th degree perineal tear multiparous women

(d) Admission for higher level care, nulliparous women

(h) Admission for higher level care multiparous women

Figure S1 Association between maternal age and less common intrapartum interventions and adverse maternal outcomes in low risk women aged 16 and over



(a) Epidural, nulliparous women (b) Epidural, multiparous women

Figure S2 Association between maternal age and epidural in low risk women aged 16 and over

Table S1 Categorisation of potential confounders

Covariate	Response categories	Alternative categories in case of few events
Ethnic group	1 White 2 Non-white	
Understanding of English	1 Fluent 2 Not fluent (some/none)	
Marital/partner status	1 Married/living with partner 2 Single/unsupported by partner	
BMI in pregnancy (kg/m^2)	1 Less than 18.5 2 18.5 to 24.9 3 25.0 to 29.9 4 30.0 to 35.0 5 Not recorded	
Index of Multiple Deprivation (IMD) quintile	1 1st quintile (least deprived) 2 2nd quintile 3 3rd quintile 4 4th quintile 5 5th quintile (most deprived)	1 1st to 3rd quintile 2 4th to 5th quintile
Previous pregnancies ≥24 weeks	1 0 Nulliparous 2 1 previous 3 2 previous 4 3 or more previous	1 Nulliparous 2 Multiparous
Gestation at delivery (completed weeks)	1 37 weeks 2 38 weeks 3 39 weeks 4 40 weeks 5 41 weeks to 42 weeks+0 days	1 37 - 39 weeks 2 ≥ 40 weeks
Planned place of birth	1 Obstetric unit 2 Alongside midwifery unit 3 Freestanding midwifery unit 4 Home	
Complicating conditions identified at the start of care in labour	1 No complicating conditions 2 One or more complicating conditions	

Table S2 Characteristics of low risk nulliparous women aged 16 and over by maternal age category

	16 - 19 years n=2835		20 - 24 years n=6341		25 - 29 years n=8438		30 - 34 years n=7307		35 - 39 years n=2989		≥ 40 years n=346	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	2600	90.4	5329	80.6	7085	78.5	6434	82.7	2686	86.0	314	86.1
Non-white	234	9.6	1004	19.4	1340	21.5	859	17.3	298	14.0	31	13.9
Missing	1		8		13		14		5		1	
Understanding of English												
Fluent	2749	96.8	5709	88.6	7757	89.8	6999	94.4	2931	97.5	341	98.7
Not fluent	81	3.2	602	11.4	636	10.2	276	5.7	48	2.5	3	1.3
Missing	5		30		45		32		10		2	
Marital/partner status												
Married/living with partner	1484	50.2	5171	80.1	7869	92.2	7015	95.9	2854	94.9	320	92.8
Single/unsupported by partner	1284	49.8	1072	19.9	474	7.8	217	4.1	97	5.1	23	7.3
Missing	67		98		95		75		38		3	
BMI in pregnancy (kg/m^2)												
< 18.5	163	6.2	237	3.9	183	2.6	140	2.2	49	1.6	0	0.0
18.5 - 24.9	1510	51.0	3136	47.8	4216	47.2	3813	48.7	1441	46.0	170	44.8
25.0 - 29.9	494	18.1	1358	20.9	1897	23.6	1528	21.7	682	25.6	74	24.3
30.0 - 35.0	189	7.1	535	9.0	641	8.3	438	7.6	192	8.1	21	8.0
Not recorded	477	17.7	1059	18.4	1477	18.3	1363	19.9	616	18.8	80	22.9
Missing	2		16		24		25		9		1	
IMD quintile												
1st (Least deprived)	212	7.2	670	9.2	1475	14.5	1667	21.4	741	22.8	89	26.9
2nd	356	12.6	940	14.5	1690	19.7	1641	22.1	689	22.0	89	23.8
3rd	538	17.7	1239	18.9	1769	19.3	1544	20.7	633	21.1	69	20.0
4th	689	25.3	1525	23.6	1808	22.7	1455	20.7	558	20.3	56	16.9
5th (Most deprived)	1025	37.2	1932	33.8	1663	23.7	972	15.2	353	13.9	40	12.5
Missing	15		35		33		28		15		3	
Gestation at delivery (completed weeks)												
37	93	3.7	189	3.4	275	4.0	243	3.7	90	3.2	9	2.4
38	255	10.9	631	10.1	813	9.8	717	9.6	287	9.3	29	6.0
39	649	21.9	1462	23.5	1989	23.3	1652	22.2	700	23.3	76	23.6
40	1075	36.5	2393	36.3	3107	34.3	2688	36.6	1076	35.0	132	36.5
41 - 42+0 days	763	27.1	1666	26.8	2254	28.6	2007	27.9	836	29.2	100	31.6

Planned place of birth												
OU	1266	88.0	2620	86.6	3043	85.0	2351	83.5	968	84.4	149	89.2
AMU	882	8.4	2040	9.3	2535	9.7	1984	10.0	752	9.2	56	5.9
FMU	564	3.2	1235	3.3	1531	3.3	1302	3.4	456	2.7	47	2.0
Home	123	0.5	446	0.8	1329	2.0	1670	3.2	813	3.7	94	3.0
Birth weight (grams)												
< 2500	46	2.0	105	2.1	88	1.4	87	1.3	43	1.5	6	1.9
2500 - 2999	470	17.8	1053	17.4	1209	16.0	914	14.1	453	16.2	48	10.9
3000 - 3499	1286	44.7	2709	43.0	3536	41.1	3053	41.0	1167	38.8	139	43.0
3500 - 3999	826	28.8	1913	28.9	2782	31.8	2481	33.4	997	32.1	110	32.3
4000 - 4499	185	6.0	487	7.6	734	8.5	669	8.7	282	10.0	38	9.2
≥ 4500	15	0.7	64	0.9	77	1.1	82	1.5	40	1.5	5	2.7
Missing	7		10		12		21		7		0	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	130	7.2	293	7.4	457	8.7	466	10.6	209	10.8	34	14.7
Meconium stained liquor	112	5.9	220	5.6	285	6.0	286	7.4	127	7.6	16	6.1
Proteinuria 1+ or more	73	2.4	150	2.1	161	2.4	129	2.0	49	2.5	8	3.5
Hypertension	51	2.8	128	2.9	156	3.2	127	2.8	48	3.6	10	5.0
Abnormal vaginal bleeding	16	0.8	38	1.0	54	1.2	66	1.8	42	3.3	7	2.9
Non-cephalic presentation	5	0.2	20	0.5	29	0.4	38	0.7	18	0.7	1	0.5
Abnormal fetal heart rate	35	1.5	79	2.1	108	2.3	83	2.1	41	2.6	9	3.7
Other complications	14	0.6	15	0.3	16	0.2	14	0.2	5	0.3	0	0.0
Any complicating conditions	390	19.0	825	19.1	1112	21.0	1073	24.1	465	25.7	73	32.2

[1]Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S3 Characteristics of low risk multiparous women aged 16 and over by maternal age category

	16-19 years n=519		20 - 24 years n=5054		25 - 29 years n=9653		30 - 34 years n=11146		35 - 39 years n=7408		≥ 40 years n=1335	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]
Ethnic group												
White	478	88.2	4356	82.1	8061	76.3	9618	78.9	6653	83.2	1213	86.8
Non-white	41	11.8	693	17.9	1580	23.7	1516	21.1	746	16.8	122	13.2
Missing	0		5		12		12		9		0	
Understanding of English												
Fluent	505	96.3	4685	91.3	9000	90.3	10606	91.7	7224	95.6	1297	95.9
Not fluent	13	3.8	346	8.8	615	9.7	500	8.3	166	4.5	33	4.1
Missing	1		23		38		40		18		5	
Marital/partner status												
Married/living with partner	352	63.0	4379	84.5	8999	92.0	10767	96.3	7150	95.6	1271	95.0
Single/unsupported by partner	156	37.1	605	15.5	536	8.0	276	3.7	196	4.4	45	5.0
Missing	11		70		118		103		62		19	
BMI in pregnancy (kg/m^2)												
< 18.5	21	5.9	189	4.6	230	2.6	197	2.0	107	1.5	18	0.3
18.5 - 24.9	243	45.8	2180	42.2	4344	44.4	5246	45.0	3423	43.7	632	47.0
25.0 - 29.9	104	17.2	1200	23.1	2444	25.7	2678	24.6	1890	27.6	341	28.9
30.0 - 35.0	44	10.4	561	11.7	986	10.5	961	10.0	577	9.3	88	8.1
Not recorded	104	20.7	910	18.5	1614	16.9	2026	18.5	1384	17.9	249	15.7
Missing	3		14		35		38		27		7	
IMD quintile												
1st (Least deprived)	33	3.6	432	7.4	1400	13.0	2588	19.6	2042	25.7	345	25.6
2nd	49	10.0	581	11.4	1569	15.0	2473	21.4	1745	22.4	307	21.3
3rd	99	21.2	876	16.4	1888	17.7	2215	19.0	1502	19.4	288	22.2
4th	138	25.6	1259	24.6	2149	22.6	2024	18.9	1207	16.5	235	16.8
5th (Most deprived)	196	39.6	1889	40.2	2599	31.7	1787	21.1	862	16.0	157	14.1
Missing	4		17		48		59		50		3	
Previous pregnancies ≥ 24 weeks												
1	474	91.6	3772	77.1	5892	64.5	6963	63.6	3929	56.3	540	44.9
2	38	6.3	1006	17.9	2549	23.4	2779	22.9	2260	27.5	414	28.0
3-5	7	2.2	276	5.0	1212	12.1	1404	13.5	1219	16.2	381	27.1

Gestation at delivery (completed weeks)												
37	26	6.9	162	3.8	255	3.2	291	3.4	185	3.0	43	3.6
38	50	12.3	505	10.0	930	10.0	1022	10.3	684	10.8	117	11.4
39	134	26.5	1326	26.0	2420	25.2	2787	24.5	1816	23.1	334	28.6
40	217	37.7	1968	37.4	3863	38.4	4402	38.2	2857	36.3	507	34.4
41 - 42+0 days	92	16.7	1093	22.8	2185	23.2	2644	23.6	1866	26.8	334	22.0
Planned place of birth												
OU	179	84.6	1530	82.2	2558	79.8	2595	78.3	1603	77.7	348	80.9
AMU	156	9.6	1405	10.0	2423	10.6	2556	10.5	1460	9.8	238	8.7
FMU	97	3.4	880	3.9	1711	4.4	1914	4.4	1218	4.5	202	3.4
Home	87	2.5	1239	3.9	2961	5.3	4081	6.7	3127	8.0	547	6.9
Birth weight (grams)												
< 2500	7	0.8	41	1.3	78	1.3	72	1.0	32	0.7	11	1.1
2500 - 2999	91	22.7	675	14.6	1072	12.7	1010	11.5	647	10.3	120	13.5
3000 - 3499	216	44.0	1969	37.9	3635	37.3	3907	35.8	2477	35.2	457	34.9
3500 - 3999	151	26.0	1751	34.0	3474	35.2	4286	36.3	2891	37.1	507	38.7
4000 - 4499	48	6.1	536	10.6	1192	11.6	1625	13.8	1150	14.0	201	10.1
≥ 4500	6	0.5	71	1.7	185	1.9	221	1.6	197	2.8	35	1.8
Missing	0		11		17		25		14		4	
Complicating conditions identified at the start of care in labour												
Prolonged rupture of membranes > 18 hours	15	6.1	118	4.0	221	4.0	240	4.0	206	4.8	44	6.6
Meconium stained liquor	14	5.6	102	3.7	184	3.8	255	4.9	168	4.9	44	7.9
Proteinuria 1+ or more	6	1.9	53	0.9	100	1.3	97	1.2	60	1.2	12	0.9
Hypertension	4	1.6	32	0.9	76	1.5	80	1.4	54	1.2	7	0.8
Abnormal vaginal bleeding	0	0.0	19	0.8	25	0.5	53	1.2	35	1.4	9	1.8
Non-cephalic presentation	0	0.0	11	0.4	15	0.3	26	0.4	28	0.8	2	0.3
Abnormal fetal heart rate	6	1.9	27	1.0	54	1.2	60	1.3	41	1.2	18	2.8
Other complications	0	0.0	9	0.3	7	0.2	13	0.1	6	0.2	2	0.3
Any complicating conditions	41	15.5	350	11.2	632	11.5	756	12.7	536	13.6	126	18.7

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S4 Sample size of low risk women aged 40 and over by planned place of birth and parity

Age (years)	Nulliparous women				Multiparous women			
	OU	AMU	FMU	Home	OU	AMU	FMU	Home
40	64	32	24	38	157	103	93	242
41	31	17	11	26	86	63	47	147
42	24	6	3	13	53	39	25	83
43	12	1	2	10	29	18	22	37
44	14	0	4	4	12	10	10	23
45	2	0	3	2	4	4	2	9
46	1	0	0	1	5	1	1	5
47	0	0	0	0	1	0	1	0
48	0	0	0	0	1	0	0	0
49	0	0	0	0	0	0	1	0
50	1	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	1
Total	**149**	**56**	**47**	**94**	**348**	**238**	**202**	**547**

Table S5 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted‡ %	(95% CI)	Events / Births n/N	Weighted‡ %	(95% CI)
General anaesthesia						
16-19	17/1251	1.4	(0.8-2.4)	14/1562	0.8	(0.4-1.5)
20-24	47/2587	1.8	(1.4-2.4)	31/3698	0.9	(0.6-1.4)
25-29	58/2984	1.9	(1.5-2.5)	41/5349	0.8	(0.5-1.3)
30-34	44/2312	1.8	(1.3-2.7)	57/4900	1.3	(0.9-1.9)
35-39	20/949	2.0	(1.2-3.5)	16/2001	0.9	(0.4-1.9)
40+	5/143	3.0	(1.2-7.6)	2/195	0.6	(0.1-2.5)
Total	191/10226	1.9	(1.5-2.3)	161/17705	1.0	(0.8-1.2)
Maternal blood transfusion						
16-19	13/1260	1.1	(0.7-1.9)	10/1555	0.6	(0.3-1.2)
20-24	47/2606	1.8	(1.4-2.5)	29/3697	0.8	(0.6-1.2)
25-29	57/3024	1.8	(1.2-2.6)	54/5359	1.0	(0.8-1.3)
30-34	27/2335	1.2	(0.8-1.8)	64/4923	1.7	(1.2-2.5)
35-39	21/961	2.3	(1.3-3.9)	21/2002	1.2	(0.7-2.1)
40+	4/149	2.8	(1.1-6.8)	5/196	1.6	(0.5-4.6)
Total	169/10335	1.6	(1.3-2.0)	183/17732	1.1	(1.0-1.4)
3rd/4th degree perineal tear						
16-19	25/1259	2.0	(1.2-3.2)	30/1567	1.9	(1.2-2.8)
20-24	107/2609	4.1	(3.3-5.3)	118/3709	3.2	(2.5-4.1)
25-29	153/3030	4.8	(3.9-5.8)	274/5389	5.4	(4.7-6.3)
30-34	121/2343	5.1	(4.3-6.1)	267/4942	5.8	(5.0-6.7)
35-39	49/968	5.0	(3.4-7.2)	85/2007	4.1	(3.2-5.2)
40+	9/149	5.3	(2.9-9.6)	17/196	11.1	(5.0-22.7)
Total	464/10358	4.4	(3.8-5.1)	791/17810	4.6	(4.1-5.2)
Maternal admission for higher level care						
16-19	9/1266	0.7	(0.3-1.6)	5/1569	0.3	(0.1-0.8)
20-24	18/2620	0.7	(0.4-1.2)	22/3721	0.8	(0.4-1.5)
25-29	22/3043	0.7	(0.4-1.3)	24/5395	0.7	(0.4-1.3)
30-34	16/2351	0.7	(0.4-1.3)	31/4956	1.3	(0.5-3.1)
35-39	14/968	1.9	(0.7-4.8)	10/2021	0.5	(0.2-1.1)
40+	2/149	1.5	(0.3-6.8)	0/197	0	-
Total	81/10397	0.8	(0.5-1.4)	92/17859	0.8	(0.4-1.5)

‡Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S6 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted‡ %	(95% CI)	Events / Births n/N	Weighted‡ %	(95% CI)
General anaesthesia						
16-19	1/177	0.7	(0.1-4.3)	1/339	0.5	(0.1-3.6)
20-24	15/1516	1.0	(0.6-1.7)	15/3518	0.4	(0.2-0.8)
25-29	19/2528	0.8	(0.5-1.2)	18/7072	0.3	(0.1-0.5)
30-34	21/2569	0.8	(0.5-1.3)	17/8526	0.2	(0.1-0.4)
35-39	19/1584	1.1	(0.7-1.7)	16/5790	0.3	(0.1-0.5)
40+	9/343	2.6	(1.5-4.6)	5/985	0.5	(0.2-1.6)
Total	84/8717	0.9	(0.7-1.2)	72/26230	0.3	(0.2-0.4)
Maternal blood transfusion						
16-19	3/179	1.7	(0.4-6.4)	1/339	0.5	(0.1-3.6)
20-24	6/1519	0.4	(0.2-0.9)	15/3495	0.5	(0.2-0.9)
25-29	16/2544	0.6	(0.3-1.0)	26/7024	0.4	(0.3-0.6)
30-34	23/2575	0.9	(0.5-1.6)	35/8478	0.4	(0.3-0.5)
35-39	11/1593	0.6	(0.3-1.1)	30/5759	0.6	(0.4-1.0)
40+	7/345	2.2	(1.1-4.3)	6/979	0.8	(0.3-1.8)
Total	66/8755	0.7	(0.6-1.0)	113/26074	0.5	(0.4-0.6)
3rd/4th degree perineal tear						
16-19	5/179	2.7	(1.2-5.9)	4/340	0.9	(0.3-2.4)
20-24	15/1529	1.1	(0.6-1.8)	29/3518	1.0	(0.7-1.4)
25-29	44/2550	1.8	(1.3-2.3)	60/7075	1.0	(0.7-1.3)
30-34	42/2588	1.6	(1.1-2.3)	123/8531	1.6	(1.3-2.1)
35-39	32/1600	2.0	(1.3-3.1)	71/5792	1.3	(1.0-1.7)
40+	5/345	1.4	(0.6-3.3)	12/985	1.2	(0.6-2.2)
Total	143/8791	1.7	(1.3-2.1)	299/26241	1.3	(1.1-1.5)
Maternal admission for higher level care						
16-19	1/179	0.5	(0.1-3.6)	1/340	0.5	(0.1-3.6)
20-24	1/1530	0.1	(0.0-0.5)	8/3524	0.2	(0.1-0.5)
25-29	9/2558	0.3	(0.2-0.7)	17/7095	0.3	(0.2-0.5)
30-34	13/2595	0.5	(0.2-1.1)	22/8551	0.3	(0.2-0.5)
35-39	4/1603	0.3	(0.1-0.7)	16/5805	0.3	(0.2-0.5)
40+	4/348	1.2	(0.5-3.1)	7/987	0.7	(0.3-1.6)
Total	32/8813	0.4	(0.2-0.6)	71/26302	0.3	(0.2-0.4)

‡ Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table ~~S7~~ S5 Association between maternal age and intrapartum interventions and adverse maternal outcomes in low risk women aged between 16 and 40 years old (inclusive) additionally adjusted for complicating conditions

	Nulliparous women Adjusted[1] RR	(95% CI)	Multiparous women Adjusted[1] RR	(95% CI)
Maternal composite	1.12	(1.09-1.15)	1.07	(1.02-1.12)
OU[2]	1.11	(1.08-1.14)		
Non-OU[2]	1.21	(1.18-1.24)		
	Wald test for interaction	P^3 <0.001	Wald test for interaction	P^3 =0.50
Augmentation	1.11	(1.06-1.15)	0.98	(0.90-1.07)
OU[2]	1.10	(1.05-1.15)		
Non-OU[2]	1.22	(1.17-1.28)		
	Wald test for interaction	P^3 <0.001	Wald test for interaction	P^3 =0.33
Instrumental delivery	1.18	(1.11-1.25)	1.14	(1.04-1.25)
	Wald test for interaction	P^3 =0. 17	Wald test for interaction	P^3 =0.08
Intrapartum caesarean section	1.25	(1.20-1.30)	1.13	(1.03-1.23)
	Wald test for interaction	P^3 =0.12	Wald test for interaction	P^3 =0.40
General anaesthesia	1.04	(0.91-1.19)	1.07	(0.89-1.29)
	Wald test for interaction	P^3 =0.71	Wald test for interaction	P^3 =0.17
Maternal blood transfusion	1.13	(0.95-1.33)	1.21	(0.93-1.59)
	Wald test for interaction	P^3 =0.38	Wald test for interaction	P^3 =0.50
3rd /4th degree perineal tear	1.12	(1.02-1.23)	1.01	(0.89-1.15)
	Wald test for interaction	P^3 =0.41	Wald test for interaction	P^3 =0.30
Maternal admission for higher level care	1.45	(1.07-1.96)	1.47	(1.04-2.08)
	Wald test for interaction	P^3 =0.43	Wald test for interaction	P^3 =0.16
Neonatal composite	1.04	(0.94-1.16)	0.97	(0.83-1.13)
	Wald test for interaction	P^3 =0.78	Wald test for interaction	P^3 =0.66

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs. Models were adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, gestation at delivery, planned place of birth (OU/AMU/FMU/home), and complicating conditions identified at the start of care in labour.

[2] Results in these rows were weighted and adjusted as in footnote 1, with the exception of planned place of birth.

[3] *P* for interaction, results in these rows were weighted and adjusted as in footnote 1 except that planned place of birth was included as a binary variable (OU vs. non-OU).

Table ~~S5~~ S6 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk nulliparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	17/1251	1.4	(0.8-2.4)	14/1562	0.8	(0.4-1.5)
20-24	47/2587	1.8	(1.4-2.4)	31/3698	0.9	(0.6-1.4)
25-29	58/2984	1.9	(1.5-2.5)	41/5349	0.8	(0.5-1.3)
30-34	44/2312	1.8	(1.3-2.7)	57/4900	1.3	(0.9-1.9)
35-39	20/949	2.0	(1.2-3.5)	16/2001	0.9	(0.4-1.9)
40+	5/143	3.0	(1.2-7.6)	2/195	0.6	(0.1-2.5)
Total	191/10226	1.9	(1.5-2.3)	161/17705	1.0	(0.8-1.2)
Maternal blood transfusion						
16-19	13/1260	1.1	(0.7-1.9)	10/1555	0.6	(0.3-1.2)
20-24	47/2606	1.8	(1.4-2.5)	29/3697	0.8	(0.6-1.2)
25-29	57/3024	1.8	(1.2-2.6)	54/5359	1.0	(0.8-1.3)
30-34	27/2335	1.2	(0.8-1.8)	64/4923	1.7	(1.2-2.5)
35-39	21/961	2.3	(1.3-3.9)	21/2002	1.2	(0.7-2.1)
40+	4/149	2.8	(1.1-6.8)	5/196	1.6	(0.5-4.6)
Total	169/10335	1.6	(1.3-2.0)	183/17732	1.1	(1.0-1.4)
$3^{rd}/4^{th}$ degree perineal tear						
16-19	25/1259	2.0	(1.2-3.2)	30/1567	1.9	(1.2-2.8)
20-24	107/2609	4.1	(3.3-5.3)	118/3709	3.2	(2.5-4.1)
25-29	153/3030	4.8	(3.9-5.8)	274/5389	5.4	(4.7-6.3)
30-34	121/2343	5.1	(4.3-6.1)	267/4942	5.8	(5.0-6.7)
35-39	49/968	5.0	(3.4-7.2)	85/2007	4.1	(3.2-5.2)
40+	9/149	5.3	(2.9-9.6)	17/196	11.1	(5.0-22.7)
Total	464/10358	4.4	(3.8-5.1)	791/17810	4.6	(4.1-5.2)
Maternal admission for higher level care						
16-19	9/1266	0.7	(0.3-1.6)	5/1569	0.3	(0.1-0.8)
20-24	18/2620	0.7	(0.4-1.2)	22/3721	0.8	(0.4-1.5)
25-29	22/3043	0.7	(0.4-1.3)	24/5395	0.7	(0.4-1.3)
30-34	16/2351	0.7	(0.4-1.3)	31/4956	1.3	(0.5-3.1)
35-39	14/968	1.9	(0.7-4.8)	10/2021	0.5	(0.2-1.1)
40+	2/149	1.5	(0.3-6.8)	0/197	0	-
Total	81/10397	0.8	(0.5-1.4)	92/17859	0.8	(0.4-1.5)

[1]Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table ~~S6~~ S7 Less common intrapartum interventions and adverse maternal outcomes by maternal age in low risk multiparous women aged 16 and over

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
General anaesthesia						
16-19	1/177	0.7	(0.1-4.3)	1/339	0.5	(0.1-3.6)
20-24	15/1516	1.0	(0.6-1.7)	15/3518	0.4	(0.2-0.8)
25-29	19/2528	0.8	(0.5-1.2)	18/7072	0.3	(0.1-0.5)
30-34	21/2569	0.8	(0.5-1.3)	17/8526	0.2	(0.1-0.4)
35-39	19/1584	1.1	(0.7-1.7)	16/5790	0.3	(0.1-0.5)
40+	9/343	2.6	(1.5-4.6)	5/985	0.5	(0.2-1.6)
Total	84/8717	0.9	(0.7-1.2)	72/26230	0.3	(0.2-0.4)
Maternal blood transfusion						
16-19	3/179	1.7	(0.4-6.4)	1/339	0.5	(0.1-3.6)
20-24	6/1519	0.4	(0.2-0.9)	15/3495	0.5	(0.2-0.9)
25-29	16/2544	0.6	(0.3-1.0)	26/7024	0.4	(0.3-0.6)
30-34	23/2575	0.9	(0.5-1.6)	35/8478	0.4	(0.3-0.5)
35-39	11/1593	0.6	(0.3-1.1)	30/5759	0.6	(0.4-1.0)
40+	7/345	2.2	(1.1-4.3)	6/979	0.8	(0.3-1.8)
Total	66/8755	0.7	(0.6-1.0)	113/26074	0.5	(0.4-0.6)
3rd/4th degree perineal tear						
16-19	5/179	2.7	(1.2-5.9)	4/340	0.9	(0.3-2.4)
20-24	15/1529	1.1	(0.6-1.8)	29/3518	1.0	(0.7-1.4)
25-29	44/2550	1.8	(1.3-2.3)	60/7075	1.0	(0.7-1.3)
30-34	42/2588	1.6	(1.1-2.3)	123/8531	1.6	(1.3-2.1)
35-39	32/1600	2.0	(1.3-3.1)	71/5792	1.3	(1.0-1.7)
40+	5/345	1.4	(0.6-3.3)	12/985	1.2	(0.6-2.2)
Total	143/8791	1.7	(1.3-2.1)	299/26241	1.3	(1.1-1.5)
Maternal admission for higher level care						
16-19	1/179	0.5	(0.1-3.6)	1/340	0.5	(0.1-3.6)
20-24	1/1530	0.1	(0.0-0.5)	8/3524	0.2	(0.1-0.5)
25-29	9/2558	0.3	(0.2-0.7)	17/7095	0.3	(0.2-0.5)
30-34	13/2595	0.5	(0.2-1.1)	22/8551	0.3	(0.2-0.5)
35-39	4/1603	0.3	(0.1-0.7)	16/5805	0.3	(0.2-0.5)
40+	4/348	1.2	(0.5-3.1)	7/987	0.7	(0.3-1.6)
Total	32/8813	0.4	(0.2-0.6)	71/26302	0.3	(0.2-0.4)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S8 Event rates in restricted sample of nulliparous women aged 16 and over without complicating conditions identified at the start of care in labour

Age (years)	OU			Non-OU		
	Events / Births	Weighted[1]		Events / Births	Weighted[1]	
	n/N	%	(95% CI)	n/N	%	(95% CI)
Maternal composite						
16-19	335/985	34.4	(30.9-38.1)	221/1418	16.9	(14.6-19.4)
20-24	861/2039	42.3	(38.9-45.9)	768/3382	22.7	(20.6-25.0)
25-29	1160/2302	50.1	(47.4-52.7)	1453/4929	30.2	(27.5-33.0)
30-34	902/1680	54.5	(49.8-59.1)	1524/4442	35.4	(33.2-37.6)
35-39	391/680	57.7	(53.4-62.0)	685/1800	38.0	(34.3-41.9)
40+	67/98	66.1	(53.7-76.6)	70/173	42.4	(32.9-52.5)
Total	3716/7784	48.1	(45.5-50.8)	4721/16144	29.7	(27.8-31.6)
Augmentation						
16-19	224/991	23.0	(19.9-26.4)	119/1428	8.0	(6.5-9.9)
20-24	527/2044	25.8	(22.0-30.0)	417/3406	12.0	(10.5-13.8)
25-29	701/2305	30.0	(27.5-32.6)	777/4944	15.8	(14.1-17.7)
30-34	523/1678	31.4	(27.5-35.6)	838/4462	18.8	(17.2-20.5)
35-39	239/676	34.8	(28.3-42.0)	402/1817	21.1	(18.2-24.3)
40+	41/99	40.2	(27.9-53.9)	37/173	22.6	(14.3-33.8)
Total	2255/7793	29.0	(26.2-32.0)	2590/16230	15.7	(14.5-16.9)
Instrumental delivery						
16-19	139/1008	13.6	(10.8-16.9)	92/1432	8.2	(6.4-10.5)
20-24	354/2073	17.0	(14.9-19.4)	350/3418	10.0	(8.5-11.8)
25-29	512/2328	22.2	(19.9-24.6)	672/4962	14.0	(12.2-16.0)
30-34	411/1700	25.3	(20.0-31.4)	713/4487	16.8	(15.0-18.9)
35-39	191/686	28.9	(24.2-34.1)	353/1819	19.3	(15.8-23.4)
40+	26/99	26.9	(17.8-38.5)	31/174	20.7	(12.8-31.6)
Total	1633/7894	21.2	(18.7-23.9)	2211/16292	14.0	(12.6-15.5)
Intrapartum caesarean section						
16-19	65/1008	6.8	(4.9-9.4)	45/1432	2.7	(2.0-3.7)
20-24	194/2073	9.4	(7.8-11.3)	156/3418	4.6	(3.6-5.8)
25-29	308/2328	13.0	(11.2-15.1)	343/4962	7.3	(6.3-8.5)
30-34	267/1700	15.8	(13.2-18.9)	382/4487	8.3	(7.2-9.6)
35-39	125/686	18.3	(13.9-23.9)	177/1819	10.1	(8.1-12.5)
40+	27/99	25.6	(16.1-38.2)	18/174	8.8	(4.8-15.4)
Total	986/7894	12.6	(11.0-14.5)	1121/16292	6.9	(6.2-7.6)
Perinatal composite						
16-19	26/1003	2.6	(1.8-3.8)	23/1419	2.5	(1.6-4.0)
20-24	58/2064	2.9	(1.9-4.3)	87/3402	2.4	(1.9-3.1)
25-29	57/2319	2.7	(2.0-3.5)	104/4932	2.0	(1.5-2.6)
30-34	67/1694	3.7	(2.6-5.2)	108/4459	2.9	(2.1-4.0)
35-39	14/682	1.8	(1.0-3.4)	56/1804	2.5	(1.8-3.4)
40+	7/99	7.8	(3.8-15.6)	4/172	2.1	(0.5-8.5)
Total	229/7861	2.9	(2.3-3.7)	382/16188	2.4	(2.0-2.9)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S9 Event rates in restricted sample of multiparous women aged 16 and over without complicating conditions identified at the start of care in labour

Age (years)	OU			Non-OU		
	Events / Births n/N	Weighted[1] %	(95% CI)	Events / Births n/N	Weighted[1] %	(95% CI)
Maternal composite						
16-19	23/149	14.2	(8.7-22.1)	18/323	6.2	(3.8-10.0)
20-24	183/1311	14.1	(11.9-16.8)	130/3320	4.3	(3.4-5.5)
25-29	334/2159	15.5	(13.8-17.3)	272/6663	4.7	(3.9-5.6)
30-34	342/2155	15.7	(13.3-18.5)	376/8033	5.1	(4.4-5.9)
35-39	232/1316	17.8	(15.4-20.3)	242/5421	5.3	(4.5-6.2)
40+	54/265	20.3	(16.4-24.8)	55/917	6.8	(5.1-9.1)
Total	1168/7355	15.9	(14.2-17.8)	1093/24677	5.0	(4.5-5.6)
Augmentation						
16-19	11/150	6.8	(3.5-12.8)	9/324	3.2	(1.7-6.0)
20-24	101/1321	7.6	(6.0-9.6)	53/3352	1.8	(1.3-2.5)
25-29	155/2179	7.2	(5.7-9.0)	94/6743	1.6	(1.2-2.1)
30-34	165/2175	7.5	(5.9-9.6)	112/8118	1.5	(1.2-1.9)
35-39	93/1331	6.9	(5.5-8.7)	80/5476	1.7	(1.2-2.3)
40+	22/268	8.3	(5.0-13.3)	12/927	1.2	(0.6-2.3)
Total	547/7424	7.3	(6.1-8.8)	360/24940	1.6	(1.4-1.9)
Instrumental delivery						
16-19	7/151	4.2	(1.9-9.1)	7/324	3.3	(1.4-7.4)
20-24	45/1334	3.4	(2.4-4.8)	33/3352	1.3	(0.9-1.9)
25-29	111/2205	5.1	(4.3-6.0)	95/6757	1.7	(1.3-2.3)
30-34	126/2194	5.8	(4.7-7.1)	119/8126	1.6	(1.2-2.0)
35-39	80/1338	6.1	(4.7-8.0)	73/5482	1.7	(1.3-2.3)
40+	20/269	7.2	(4.5-11.3)	15/929	2.3	(1.1-4.9)
Total	389/7491	5.3	(4.5-6.2)	342/24970	1.7	(1.4-2.0)
Intrapartum caesarean section						
16-19	4/151	2.5	(0.9-7.2)	4/324	1.0	(0.3-2.7)
20-24	48/1334	3.6	(2.2-6.1)	17/3352	0.5	(0.2-1.0)
25-29	79/2205	3.6	(2.7-4.7)	42/6757	0.6	(0.4-0.9)
30-34	80/2194	3.6	(2.6-4.9)	54/8126	0.7	(0.5-1.1)
35-39	64/1338	4.8	(3.4-6.7)	41/5482	0.9	(0.6-1.4)
40+	11/269	4.0	(2.2-7.4)	14/929	1.4	(0.7-2.6)
Total	286/7491	3.8	(2.9-5.0)	172/24970	0.7	(0.6-0.9)
Perinatal composite						
16-19	4/151	2.2	(0.8-5.7)	4/322	1.5	(0.5-4.5)
20-24	19/1325	1.5	(0.9-2.5)	39/3323	1.2	(0.8-1.7)
25-29	34/2199	1.6	(1.1-2.2)	61/6701	1.0	(0.7-1.6)
30-34	30/2182	1.4	(0.9-2.0)	97/8058	1.1	(0.9-1.4)
35-39	26/1334	2.0	(1.2-3.4)	82/5445	1.6	(1.2-2.1)
40+	6/268	2.2	(0.9-5.1)	17/920	2.1	(1.1-4.0)
Total	119/7459	1.6	(1.2-2.1)	300/24769	1.2	(1.0-1.5)

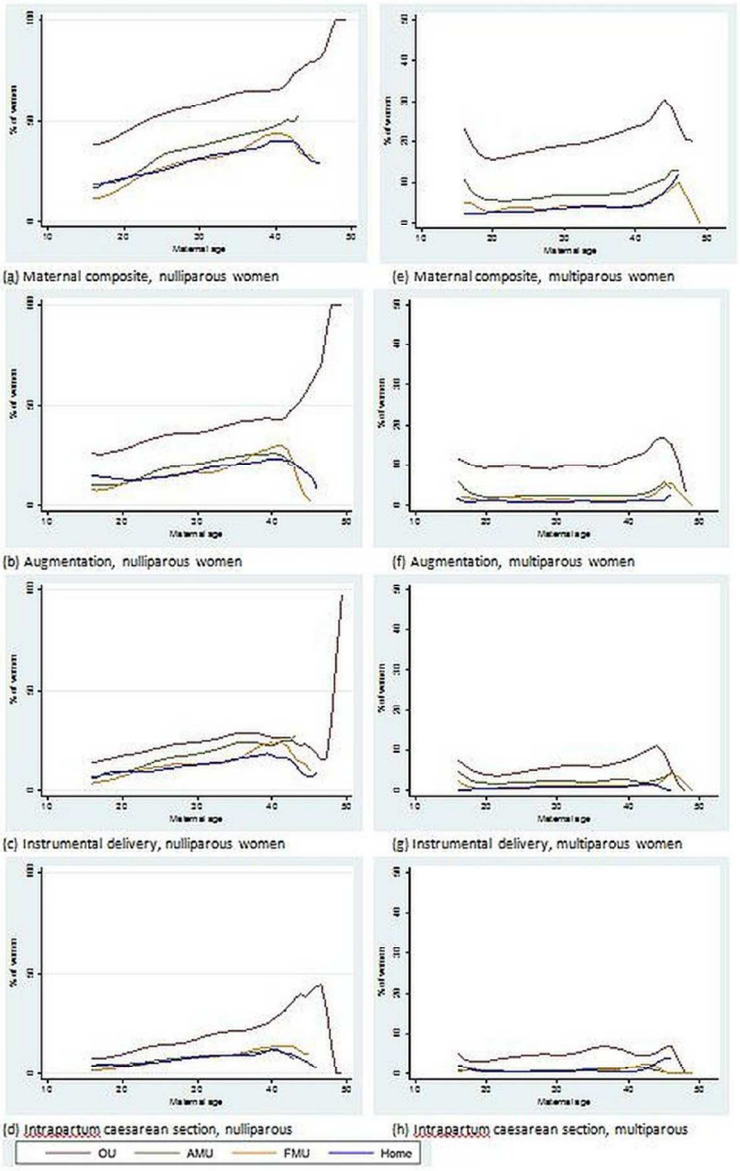
[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

Table S10 Relative risk for non-OU compared to OU by age groups in nulliparous women without complicating conditions

Age (years)	Unadjusted RR[1] (95% CI)	Adjusted RR[1, 2] (95% CI)
Maternal composite		
16-19	0.49 (0.41-0.59)	0.52 (0.43-0.62)
20-24	0.54 (0.47-0.61)	0.54 (0.48-0.61)
25-29	0.60 (0.54-0.67)	0.61 (0.55-0.68)
30-34	0.65 (0.58-0.72)	0.67 (0.61-0.74)
35-39	0.66 (0.58-0.75)	0.67 (0.60-0.76)
40+	0.64 (0.48-0.86)	0.67 (0.48-0.92)
Augmentation		
16-19	0.35 (0.27-0.45)	0.37 (0.29-0.47)
20-24	0.47 (0.38-0.57)	0.47 (0.39-0.57)
25-29	0.53 (0.46-0.61)	0.54 (0.47-0.61)
30-34	0.60 (0.52-0.70)	0.63 (0.53-0.74)
35-39	0.61 (0.48-0.77)	0.61 (0.49-0.75)
40+	0.56 (0.33-0.97)	0.56 (0.33-0.95)

[1] Probability weights are incorporated to account for differences in the probability of a woman being selected for inclusion in the study arising from differences in each unit/trust's period of participation and the stratum specific probabilities of selection of OUs.

[2] Adjusted for ethnic group, understanding of English, marital/partner status, BMI in pregnancy, index of multiple deprivation score quintile, and gestation at delivery.



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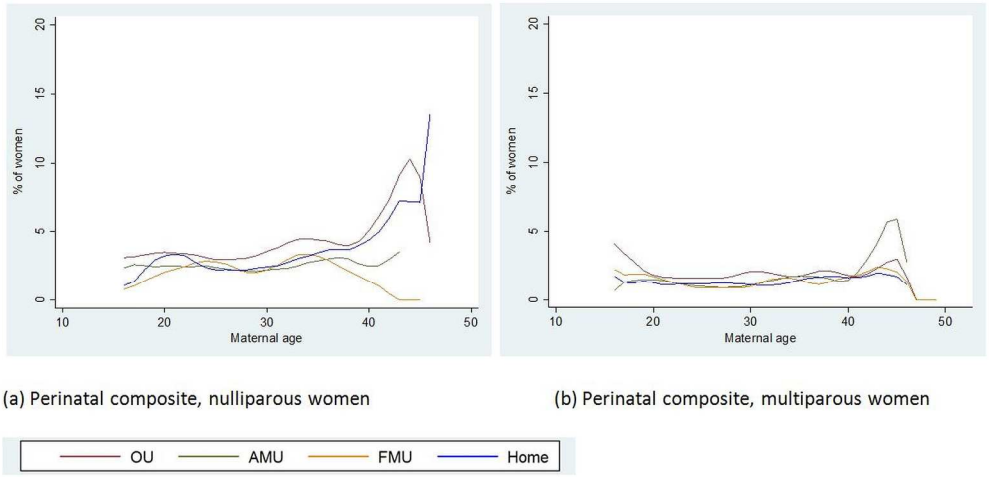

(a) Perinatal composite, nulliparous women

(b) Perinatal composite, multiparous women

Figure 2 Association between maternal age and perinatal composite outcome in low risk women aged 16 and over

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Please NOTE that the pages have been updated to be related to **the revised version with "track changes"**.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes – title and abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes, p2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes, p5
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes, p5
Methods			
Study design	4	Present key elements of study design early in the paper	Yes, p6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes, p6-7. References also given to other publications providing more details
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes, p7-8 and Table S1
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	Yes, p8, more details in cited reports.
Bias	9	Describe any efforts to address potential sources of bias	Cohort study methods to minimise bias addressed elsewhere – ref 26.
Study size	10	Explain how the study size was arrived at	N/A. Secondary analysis of existing data. Original power calculations described in ref 26.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes, p7-9.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes, p7-9
		(*b*) Describe any methods used to examine subgroups and interactions	Yes, interactions p8
		(*c*) Explain how missing data were addressed	N/A. Low level of missing data
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	Yes, p8

Results			
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	P10 for current study; refs given for 'recruitment' into main study
		(b) Give reasons for non-participation at each stage	Ditto
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes, Tables 1, S2 and S3
		(b) Indicate number of participants with missing data for each variable of interest	Yes, Tables 1, S2 and S3
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes, fully reported in tables
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	Yes, unadjusted & adjusted estimates and 95% CIs reported in tables; adjustment variables described (Table S1)
		(*b*) Report category boundaries when continuous variables were categorized	Yes. Maternal age – Table 1; confounders Table S1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Absolute event rates reported in tables
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	All analyses reported in manuscript or supplementary tables
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes, p14
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	Yes, p14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Other evidence comprehensively summarised p15-17; cautious interpretation p17
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes, p14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes, p18

*Give information separately for exposed and unexposed groups.