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Use of induction of labour and emergency caesarean section and perinatal outcomes in English maternity services: a national hospital-level study

Short title: Hospital-level interventions and perinatal outcomes

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ABSTRACT

Objectives: To assess the association between hospital-level rates of induction of labour and emergency caesarean section, as measures of "practice style", and rates of adverse perinatal outcomes.

Design: National study using electronic maternity records.

Setting: English National Health Service.

Participants: Hospitals providing maternity care to women between April 2015 and March 2017.

Main outcome measures: Stillbirth, admission to a neonatal unit, and babies receiving mechanical ventilation.

Results: Among singleton term births, the risk of stillbirth was 0.15%; of admission to a neonatal unit 5.4%; and of mechanical ventilation 0.54%. There was considerable between-hospital variation in the induction of labour rate (minimum 17.5%, maximum 40.7%) and the emergency caesarean section rate (minimum 5.6%, maximum 17.1%). Women who gave birth in hospitals with a higher induction of labour rate had better perinatal outcomes. For each 5%-point increase in induction, there was a decrease in the risk of term stillbirth by 9% (OR 0.91; 95% CI 0.85 to 0.97) and mechanical ventilation by 14% (OR 0.86; 95% CI 0.79 to 0.94). There was no significant association between hospital-level induction of labour rates and neonatal unit admission at term ($p>0.05$). There was no significant association between hospital-level emergency caesarean section rates and adverse perinatal outcomes (p always >0.05).

Conclusions: There is considerable between-hospital variation in the use of induction of labour and emergency caesarean section. Hospitals with a higher induction rate had a lower risk of adverse birth outcomes. A similar association was not found for caesarean section.

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Keywords: induction, caesarean, intervention, stillbirth, quality, labour, pregnancy

INTRODUCTION

The care that maternity services provide to women giving birth needs to be finely balanced between supporting the physiological process of birth and intervening when required. This is the fundamental principle underpinning clinical guidelines on care of women during pregnancy and birth, all aiming to ensure that giving birth is a safe and joyful experience and that women and their families are treated with dignity and respect.[1 2]

At the same time, there is ample evidence that maternity care varies widely between and within countries.[3 4] For example, in England, Scotland and Wales, the National Maternity and Perinatal Audit (NMPA), a national initiative to assess and improve the quality of maternity services, found that the induction of labour rate varied between 16% and 44% and the overall caesarean section rate between 17% and 35% in singleton babies born at term in 149 hospital organisations in the National Health Service (NHS) that provided maternity services between April 2016 and March 2017.[5]

This between-hospital variation reflects the lack of consensus about the indications for interventions such as induction of labour and emergency caesarean section. Positions in this debate are often based on arguments that focus either on the safety of childbirth or on the women's experience.[6] Some organisations supporting families are concerned that an emphasis on numerical targets related to safety may lead to poorer birth experiences, and increases in rates of induction of labour and caesarean section.[7] Conversely, a recent high-profile independent review of potentially avoidable harm in births occurring at an NHS hospital in England between 2000 and 2019 reported, after having reviewed the first 250 cases, that "there was a culture […] to keep caesarean section rates low, because this was not perceived as the essence of good maternity care".[8]

In response to this debate, we investigated the association of the rates of induction of labour and emergency caesarean section in each hospital in England with the risks of stillbirth, admission to a neonatal unit, and use of mechanical ventilation in babies born at term. We considered these two intervention rates as complementary measures of a hospital's culture, or more accurately "practice style", with the induction of labour rate reflecting how hospitals provide proactive care for women with term pregnancies and the emergency caesarean section rate reflecting how hospitals respond to acute situations that may need immediate preventive action or rescue.

METHODS

Data Sources

We used a patient-level dataset compiled by the NMPA, based on records of each birth from routinely collected maternity information systems (MIS) used in NHS hospitals to record care throughout pregnancy linked to data from the Hospital Episode Statistics (HES), the database that contains administrative data for all admissions to NHS hospitals.[5 9] The MIS databases include data items that typically cover antenatal booking through to birth and immediate postnatal care, entered by midwives and support staff in the antenatal clinic or labour ward. Although there were 20 different systems in use, each of which collects slightly different information in sometimes different formats, there was sufficient similarity between systems to allow a single dataset to be developed from which comparative measures can be derived.

This NMPA dataset was also linked to the National Neonatal Research Dataset (NNRD), which contains information on admissions to neonatal care.[10] Information was available on births between 1st April 2015 and 31st March 2017. The resulting linked dataset, including 131 NHS hospitals, or more precisely NHS "hospital trusts" which are NHS organisations with one or more sites providing secondary health services in a geographical area, with 1,253,847 births, captures approximately 94% of births that occurred in England during the study period.[5 10] Further details about the datasets and linkage process are available elsewhere.[5 10] Details of the datasets used to derive each variable in the analyses are available in Supplementary Table 1.

Population

This study examined the association between hospital-level rates of induction of labour and emergency caesarean section and the patient-level risk of adverse perinatal outcomes in singleton pregnancies at term. Births were eligible for inclusion if they occurred between 1st April 2015 and 31st March 2017 in an NHS hospitals providing maternity care in England. Overall, we included only those hospitals in the analyses where at least 70% of birth records within a hospital had information about the specific intervention and outcome. In addition, for each analysis of a specific association between a hospital-level intervention rate and a perinatal adverse outcome, we only included births with complete information on both the specific intervention and outcome measure that were being studied.

Perinatal outcomes, interventions, and maternal and pregnancy characteristics

The adverse perinatal outcome measures were stillbirth, according to the NMPA dataset, and admission to a neonatal unit at term, and mechanical ventilation of the baby, according to the NNRD.[11] These outcomes cover three of the eight core outcomes recommended by the Core Outcome Measure In Effectiveness Trials Initiative.[12] It should be noted that the recommended core outcomes include "death of the baby" defined as "intrapartum/neonatal/perinatal death", whereas we included all antepartum and intrapartum stillbirth, irrespective of gestational age. Antepartum stillbirth was included, because we consider that a relevant outcome when studying the association between the use of interventions and perinatal outcomes. We did not include neonatal death or perinatal death other than stillbirth because these outcomes were not fully covered in our linked datasets.

Information about induction of labour, emergency caesarean section (defined as a caesarean sections that is not planned and/or prelabour), was obtained from the NMPA dataset.[5]

Information about maternal characteristics, including age, obstetric history (parity and previous caesarean birth), body mass index (BMI), and comorbidities, including pre-eclampsia/eclampsia, pre-existing hypertensive disease and pre-existing or gestational diabetes, was available in the NMPA dataset. Women were assumed not to have a comorbid condition, if relevant diagnostic codes were not present.[13] If information about a woman's obstetric history was missing in the birth record, a 'look-back' approach in HES was used where all previous records for the woman since 2000 in English NHS hospitals were considered.[14] Maternal ethnicity was coded using the Office for National Statistics categorisation system from the 2001 Census, collapsed into five groups: White, South-Asian, Black, Mixed, and Other (including Chinese).[15] Socio-economic status was evaluated using the Index of Multiple Deprivation (IMD), an area-level measure of deprivation identified by the woman's recorded postcode in the NMPA dataset, and grouped into quintiles according to the national distribution.[14 16]

Statistical analysis

First, we determined for each hospital the rate of induction of labour and emergency caesarean section. In a second step, we included these hospital-level induction of labour and emergency caesarean section rates as risk factors in multilevel regression models with stillbirth, admission to a neonatal unit, or mechanical ventilation as outcomes.

The multilevel models were used to test whether differences in the hospital-level intervention rates were associated with the risk of an adverse outcome using odds ratios. A p value lower than 0.05 was considered to indicate a statistically significant association. Given that stillbirth, neonatal admission, and mechanical ventilation of the baby are rare events from an epidemiological perspective, odds ratios can be interpreted as measures of relative risk.[17]

The hospital-level rates of induction of labour and emergency caesarean section were recoded, so that the odds ratios estimated by the models represent relative differences in the risk (or more precisely in the "odds") of the perinatal adverse outcomes associated with a 5%-point increase in these intervention rates to make the results easier to interpret. In other words, the hospital-level intervention rates were multiplied by 20 so that a 5%-point increase was transformed into a one-unit increase (20 x 5% = 1).

We also estimated odds ratios with adjustment for individual maternal characteristics, including age (grouped as < 20, 20 to 34, 35 to 39 and (≥40 years of age), parity and previous caesarean birth, BMI (grouped as <18.5, 18.5 to 24.9, 25.0 to 29.9, 30.0 to 34.9, 35.0 to 39.9, and ≥ 40 kg/m^2), pre-eclampsia, pre-existing hypertensive disease, pre-existing or gestational diabetes, maternal ethnicity ,and socioeconomic deprivation, which were chosen as they are known to be strongly associated with adverse perinatal outcomes.[18 19] For each maternal characteristic, missing values were assigned to a separate "missing" category, so that all included births with complete information on the specific intervention and outcome measures could be retained in the regression analyses.

We carried out two supplementary analyses. First, we investigated the association between the hospitals' intervention rates and the proportion of term babies born before 39 completed weeks of gestation. We performed this supplementary analysis because increased use of induction of labour may be associated with an increase in the proportion of babies born before 39 weeks.[20 21] A second supplementary analysis was carried out, only including primiparous women, given that our previous work has highlighted that parity is a considerably stronger risk factor than other risk factors for adverse perinatal outcomes.[19]

All analyses were performed in Stata 16, StataCorp, College Station, Texas, USA.

Patient and Public Involvement:

This study was motivated by the public debate triggered by the publication of the Ockenden report in 2020 and the consultation of draft guideline on induction of labour of the National Institute of Health and Clinical Excellence.[8 22] Women and families were not directly involved in the design of the study, the data analysis or the interpretation of the results.

Role of the funding source:

The National Maternity and Perinatal Audit is commissioned by the Healthcare Quality Improvement Partnership (HQIP; www.hqip.org.uk) as part of the National Clinical Audit and Patient Outcomes Programme and funded by NHS England and the Scottish and Welsh governments. Neither HQIP nor the funders had any involvement in designing the study; collecting, analysing, and interpreting the data; writing the report; or the decision to submit the article for publication.

RESULTS

The dataset included 131 hospitals and 1,131,719 singleton term births. The number of hospitals included in the analyses varied between 92 to 109, depending on the specific intervention and the outcome measure that were analysed (Supplementary Figure 1, see Methods). Hospitals that were excluded due to data quality were more likely to have a lower number of births (fewer than 4000 per annum) than included hospitals. Characteristics of women in included and excluded units were similar. A detailed description of the maternal characteristics of the included and excluded births can be found in Supplementary Tables 2a for the induction of labour analysis and in Supplementary Table 2b for the emergency caesarean section analysis. Overall, the risk of stillbirth at term was 0.15% (in 101 hospitals and 935,053 births), the risk of admission to a neonatal unit 5.4% (in 112 hospitals and 998,933 births), and the risk of mechanical ventilation of the baby 0.54% (in 112 hospitals and 998,933 births).

Figure 1 presents plots of the observed risks of the three perinatal outcomes according to the hospitals' induction of labour and emergency caesarean section rates as well as the predicted risks. These plots show the between-hospital variation in the induction of labour rate (minimum 17.5%, maximum 40.7%, and interquartile range 24.6% and 32.1%) and in the emergency caesarean section rate (minimum 5.6%, maximum 17.1%, and interquartile range 9.4% and 11.8%).

Figure 1 also demonstrates that the risk of adverse perinatal outcomes tends to be lower in hospitals with higher intervention rates, but only the associations between the induction of labour rate and stillbirth and mechanical ventilation rate were statistically significant (p = 0.002 and p = 0.001, respectively).

Table 1 demonstrates a similar pattern of results with adjustment for maternal characteristics. These adjusted results show that a 5%-point increase in a hospital's induction of labour rate was associated with a 9%-reduction (95% CI 3% to 15%, corresponding to an OR of 0.91) in the risk of stillbirth in term pregnancies and a 14%-reduction (95% CI 6% to 21%, corresponding to an OR of 0.86) in the risk of a baby requiring mechanical ventilation. No corresponding association was found between rates of emergency caesarean section and risk of stillbirth, neonatal admission or mechanical ventilation of the baby. Full model results are described in Supplementary Tables 3a and 3b.

In the first supplementary analysis, we found evidence that hospitals with higher induction of labour rates had more term babies born before 39 completed weeks of gestation, without and with adjustment for maternal characteristics (Supplementary Table 4). In the second supplementary analysis, including only primiparous women, the pattern of results was very similar (Supplementary Table 5), but the association between induction of labour rates and stillbirth was no longer statistically significant.

DISCUSSION

Main findings

Hospitals with a higher induction of labour rate had a lower risk of stillbirth and mechanical ventilation of babies born after 37 completed weeks of gestation. There was no evidence of an association between the hospitals' emergency caesarean section rate and risk of adverse perinatal outcome.

Strengths and limitations

The key strengths of our study are its size and design. First, this study uses data from births in at least 92 of the 134 hospitals in the English NHS providing maternity services between 2015 and 2017. Second, unlike many other studies in this area that report solely on stillbirth, we could report on a wider range of perinatal outcomes, such as neonatal admission and mechanical ventilation of the baby. Third, data completeness in the hospitals included in the analyses was high, so that

meaningful adjustments could be made at individual patient level for a wide range of maternal characteristics.

A first limitation is that we did not have information about the indications for the interventions which limits the exploration of the reasons for the observed variation. Second, a higher induction of labour rate may be linked to other differences in the care delivered to women with pregnancies beyond 37 weeks. For example, we did not have data about screening for fetal growth restriction, fetal monitoring, or one-on-one continuous care from a primary midwife through pregnancy and birth. Therefore, residual confounding cannot be fully excluded, despite adjustments for the most important maternal risk factors,[19 23] However, residual confounding does not explain our findings because both the rate of interventions and the rate of adverse perinatal outcomes are likely to be higher in women with an increased risk profile.

Third, not all hospitals could be included because of a high level of missing data about the specific intervention and outcome. The characteristics of women in included and excluded units were similar and therefore it is unlikely that a particular pattern of missingness can explain our results (Supplementary Tables 2a and 2b).

Interpretation [in light of other evidence]

The variation observed in the induction of labour and emergency caesarean section rates suggests that there are marked differences in the practice style of hospitals providing maternity services in the English health service. However, only higher induction rates were found to be associated with a slightly lower risk of adverse perinatal outcomes, both when all births were considered and when only births in primiparous women were included. As expected, the results for neonatal admissions were very similar to those for mechanical ventilation, but this association was not found to be significant. This may reflect that admission to a neonatal unit reflects a wider range of less specific adverse outcomes than those that trigger an induction of labour.

At a risk of over-interpreting the results, one could argue that the results for induction of labour indicate that hospitals with a practice style which includes a lower threshold for induction of labour in women with pregnancies at term seem to have better outcomes but that the results for emergency caesarean section suggest that there is no – or at best little – evidence that the risks of poor perinatal outcomes are linked to how teams of midwives and obstetricians in English NHS hospitals use caesarean section in emergency situations.

This reduction in the risk of adverse birth outcomes with higher hospital-level induction rates may come at a price. We found that an increased induction of labour rate increased the rate of births before 39 weeks. This is a potential concern as long-term studies of childhood outcomes have shown that neurocognitive and health outcomes may improve with each week of gestation up to 40 weeks.[24 25] Also, it has been shown that an emergency caesarean section in the first pregnancy is associated with a shorter length of gestation, increased rate of repeat caesarean section, and increased rates of neonatal admissions in the next pregnancy.[26]

Clinical and research Implications

Intervention rates in maternity services are difficult to target. For example, reported caesarean for European countries vary widely, for example from 16.5% in Norway to 35.4% in Italy.[27] There is no consensus about the optimal population-level caesarean section rate.[28] Similarly, an overview of four major international guidelines found considerable variation in the recommendation on the timing and as a consequence the overall frequency of induction of labour,[29] but there is growing evidence for the clinical and cost-effectiveness of induction of labour beyond 41 weeks of gestation.[30]

This lack of consensus is not surprising because midwives and obstetricians are guided by imprecise evidence about relatively low risks of serious outcomes, when they help women to choose where and how to give birth to their baby. In line with the longstanding dichotomies in this debate, a focus on safety may lead to doing "too much, too soon" whereas a focus on the women's experience may lead to doing "too little, too late".[1]

Our results provide important background information for the independent reviews of cases of potentially avoidable harm in births in specific hospitals in England.[8 31 32] These reviews often have little or no access to comparative data from births without adverse outcomes or from hospitals with different intervention rates or with different risks of adverse perinatal outcome. It has been argued that these reviews without being nested in larger epidemiological studies, such as the one described in this paper, are only appropriate for hypothesis generation, but they are frequently used to make high-profile recommendations.[33]

In the United Kingdom, national guidelines for induction of labour have just been updated.[34] This followed a national debate regarding the appropriateness of draft recommendations, which

recommended an offer of induction of labour at 41 completed weeks to all women, and from 39 completed weeks of gestation to women with uncomplicated pregnancies who are at increased risk of stillbirth because of their clinical profile.[22] Women's advocacy and support groups, as well as organisations representing healthcare professionals, expressed concern that increased use of induction of labour would harm maternal experience, and that "singling out" women based on their age, ethnic background, or body mass may be considered discriminatory, if not fully backed up by evidence.[35] These recommendations have therefore not been included in the final version of the national guidelines, and more research is recommended to establish if, and at what gestational age, induction of labour should be offered.

This research needs to include large numbers given that the risk of adverse outcomes is low, which makes it unlikely that randomised controlled trials can be designed with adequate statistical power.[36] Non-randomised studies, using routinely collected clinical data, provide an alternative approach to fill this evidence gap, provided that the level of data completeness and quality is sufficiently high so that adjustments can be made for differences in the characteristics of the women who do and do not have the intervention. Therefore, our study reiterates the need to have more complete and accurate maternity data at national level than are currently available.[37]

Conclusions

There was considerable between-hospital variation in the use of induction of labour and emergency caesarean section in singleton term births. Hospitals with a higher induction rate had a lower risk of adverse birth outcomes but a similar association was not found for emergency caesarean section. This suggests that a more proactive practice style with an increased use of induction of labour, rather than an increased use of caesarean section in emergency situations, seems to be linked to safer childbirth at term. Our results also demonstrate that independent reviews investigating concerns about safety of maternity services in a specific hospital might benefit from being nested in larger epidemiological studies.

ADDITIONAL STATEMENTS

Author contribution: JvdM, IGU, PM, and AK conceived the study. IGU conducted the analysis. All authors contributed to the interpretation of the results. JJ wrote the first draft of the paper that was reviewed and revised by all authors. JvdM edited the final manuscript. IGU is guarantor and confirms that this manuscript is an accurate reflection of the results.

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Competing interest declaration: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: all individuals, apart from JvdM, are or have been partially or wholly funded by the Healthcare Quality Improvement Partnership for their contribution to the submitted work. All authors also declare no financial relationships with any organisation that might have an interest in the submitted work in the previous three years. The authors report no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: This study used data routinely collected in clinical care to evaluate service provision and performance and therefore individual consent was not sought. Permission to access the data was provided by the NHS Health Research Authority Confidentiality Advisory Group, approval number 16/CAG/0058. The data were used to evaluate service provision and performance and therefore was exempt from ethical review by the NHS Health Research Authority.

Data sharing: The data are available for further research and service evaluation after approval from the data controller, which is the Healthcare Quality Improvement Partnership.

Dissemination to participants and related patient and public communities: We disseminate results through patient organisations and representative groups of women giving birth in the UK.

Transparency statement: Ipek Gurol-Urganci affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned have been explained.

Figure 1. Risks observed in hospitals (dots) and predicted* risks (line) of the three perinatal outcomes according to the hospitals' induction of labour and emergency caesarean section rates.

Table 1. Odds ratios corresponding to a 5%-point increase in the induction of labour or in the emergency caesarean section rate.

	Odds ratio (95% confidence interval)	p-value	Odds ratio (95% confidence interval) adjusted for maternal characteristics*	p-value
Stillbirth rate				
Induction of labour (92 hospitals with 842,737 births)	0.89 (0.83 – 0.94)	<0.001	0.91 (0.85 – 0.97)	0.002
Emergency caesarean section (99 hospitals with 905,081 births)	0.86 (0.73 – 1.01)	0.07	0.96 (0.82 – 1.13)	0.66
Neonatal admission rate				
Induction of labour (101 hospitals with 839,754 births)	0.94 (0.88 – 1.01)	0.11	0.94 (0.87 – 1.01)	0.09
Emergency caesarean section (109 hospitals with 964,353 births)	0.94 (0.79 – 1.13)	0.52	0.94 (0.79 – 1.13)	0.53
Mechanical ventilation rate				
Induction of labour (101 hospitals with 839,754 births)	0.87 (0.80 – 0.94)	0.001	0.86 (0.79 - 0.94)	0.001
Emergency caesarean section (109 hospitals with 964,353 births)	0.92 (0.74 – 1.15)	0.47	0.93 (0.74 – 1.17)	0.53

* Maternal characteristics included age, maternal ethnicity, BMI, socioeconomic status, parity, previous caesarean birth, maternal hypertensive disease, and maternal diabetes.

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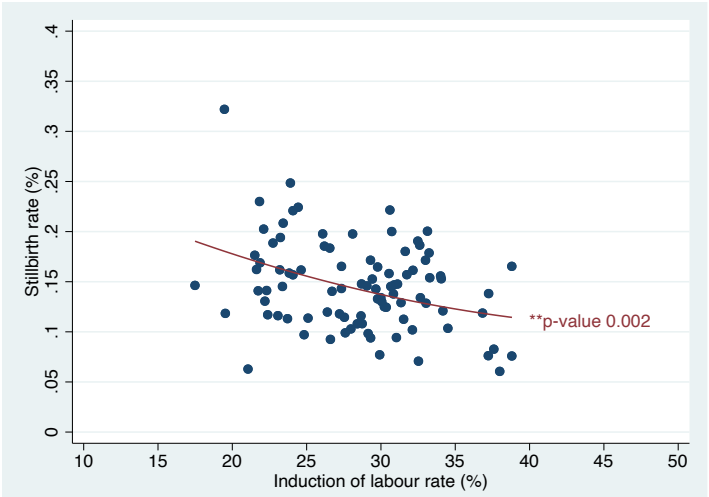

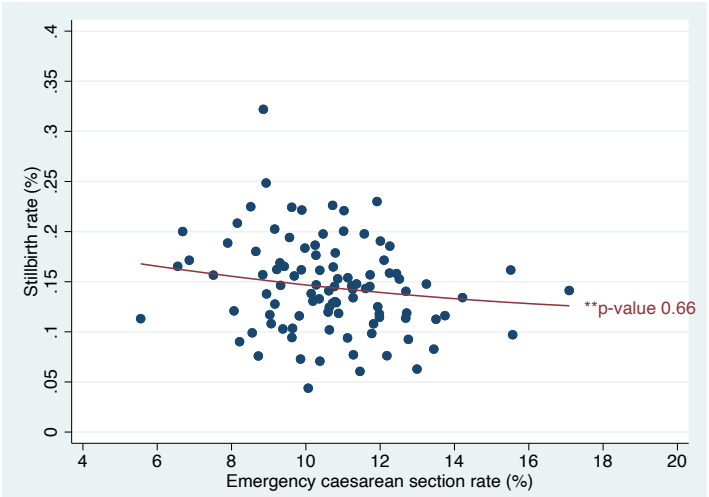

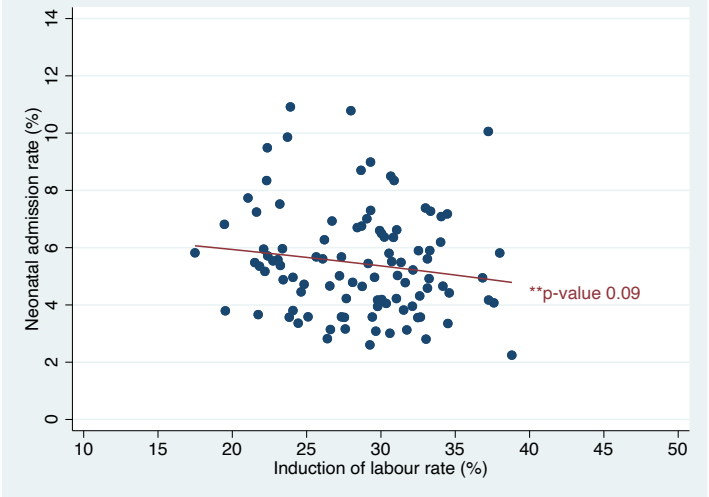

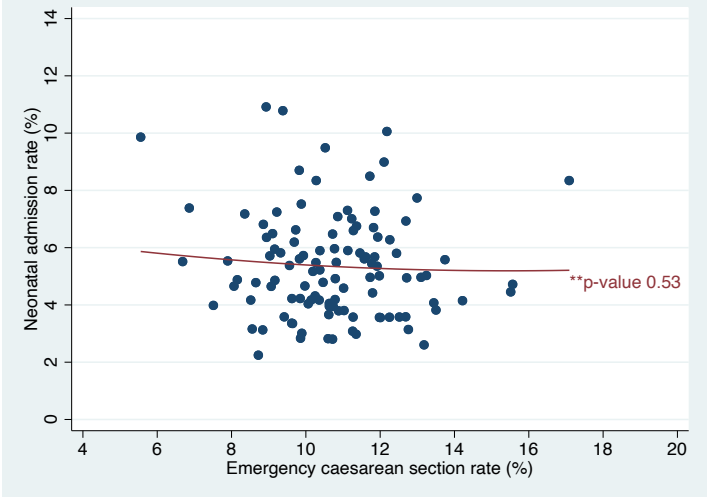

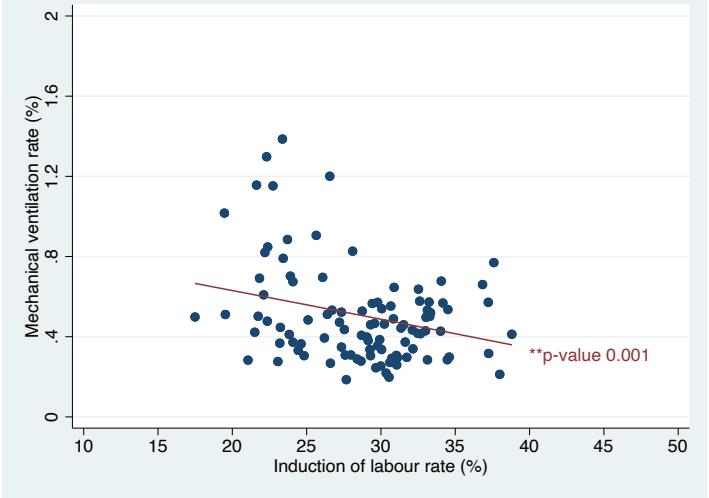

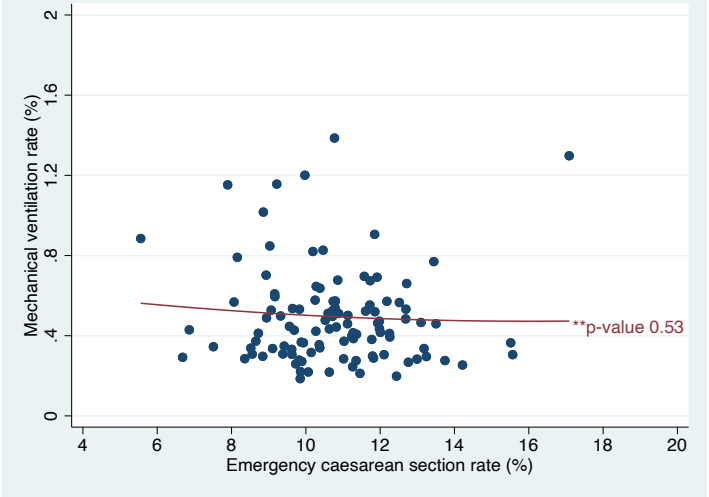

* Predictions of the multilevel logistic regression model described in the Methods section with adjustment for maternal characteristics.

** P value of the association between the perinatal outcome and the hospital-level intervention rate with adjustment for maternal characteristics.