The effect of senior obstetric presence on maternal and neonatal outcomes in UK NHS maternity units

DOI:
10.1111/1471-0528.14649

Document Version
Accepted author manuscript

Citation for published version (APA):
Reid, H., Hayes, D., Wittkowski, A., Vause, S., Whitcombe, J., & Heazell, A. (2017). The effect of senior obstetric presence on maternal and neonatal outcomes in UK NHS maternity units: A systematic review and meta-analysis. *BJOG: an international journal of obstetrics and gynaecology* . https://doi.org/10.1111/1471-0528.14649

Published in:
BJOG: an international journal of obstetrics and gynaecology

Full title: The effect of senior obstetric presence on maternal and neonatal outcomes in UK NHS maternity units: A systematic review and meta-analysis

Running title: A meta-analysis of the impact of senior obstetric presence

Holly E Reid[1,3], Dexter JL Hayes[1], Anja Wittkowski[2,3], Sarah Vause[1,4], Jo Whitcombe[4], Alexander EP Heazell[1,4]

[1]Maternal and Fetal Health Research Centre, Division of Developmental Biology and Medicine, School of Medical Sciences, Faculty of Biology, Medicine and Health, University of Manchester, 5th Floor Research, St. Mary's Hospital, Oxford Road, Manchester, UK M13 9WL

[2]Division of Psychology and Mental Health, School of Health Sciences, Faculty of Biology, Medicine and Health, University of Manchester, 2nd Floor, Zochonis Building, Brunswick Street, Manchester, UK M13 9PL

Greater Manchester Mental Health NHS Foundation Trust, Wythenshawe Hospital, Southmoor Road, Wythenshawe, Manchester, UK M23 9LT

[4]Central Manchester University Hospitals NHS Foundation Trust, St. Mary's Hospital, Oxford Road, Manchester, UK M13 9WL

Correspondence to: HE Reid holly.reid@manchester.ac.uk, +44 (0)161 701 0889

Full Abstract

Background

There is little consensus regarding the hypothesised link between obstetric consultant presence and maternal and neonatal outcomes.

Objectives

To pool existing data on the impact of consultant presence on the outcomes of women who have given birth in UK NHS maternity units.

Search strategy

Twelve databases, grey literature and reference lists were searched.

Selection criteria

Studies conducted in UK NHS maternity units comparing outcomes during lesser consultant presence versus increased consultant presence that reported mode of delivery and adverse maternal or neonatal outcomes.

Data collection and analysis

Studies were divided into three groups by type of comparison: 1) hours of rostered consultant presence during the weekend versus hours of rostered consultant presence during the week; 2) hours per week of rostered consultant presence pre-increase versus hours per week of rostered consultant presence post-increase; 3) no rostered consultant presence versus rostered consultant presence. A random effects meta-analysis was performed.

Main results

Fifteen studies fulfilled the inclusion criteria, presenting data from 125,856 births. Overall, there was no significant difference between lesser and increased consultant presence for any outcome. When data were stratified by comparison type, the likelihood of emergency caesarean section was significantly lower (OR 0.91; 95% CI 0.86-0.96) and non-instrumental vaginal delivery was significantly higher (OR 1.07; 95% CI 1.02-1.12) when rostered hours of consultant presence per week were increased.

Conclusions

Increased consultant presence has some effect on mode of delivery, but evidence for a benefit for adverse outcomes was not identified.

Keywords

Obstetrics; meta-analysis; consultants; maternal outcomes; neonatal outcomes

Tweetable Abstract

Increasing hours of NHS obstetric consultant presence may increase chance of non-instrumental vaginal delivery

Introduction

Organisations in the UK have recommended increasing the number of hours consultant obstetricians are present on the maternity unit.[1–6] Consultant obstetricians, who have completed all specialist training and examinations in obstetrics, have ultimate responsibility for patients; equivalent to an attending physician in the USA. Recently, guidelines have shifted focus to ensure consultant presence during working hours Monday to Friday with an aim to extend this to seven days a week.[7] The drivers for this increase in consultant presence include rising birth rate, increasing case complexity and cost of litigation claims.[8,9]

However, these recommendations lack a robust evidence base to support the notion that increased consultant presence translates into better outcomes. Observational studies have evaluated outcomes for mothers and babies depending on time of birth. One such study in Scotland found that the risk of neonatal death from intrapartum hypoxia was greater outside the normal working week (5.6 per 10,000 births versus 4.2 per 10,000 births; odds ratio (OR) 1.30; 95% CI 1.10-1.60).[10] This could be explained by the level of staffing at different times of day. However, another similar UK multi-centre study of 87,501 births found no difference in neonatal morbidity, but demonstrated that obstetric intervention was less likely outside of scheduled consultant presence.[11] Critically, analysis of rotas or time periods rather than actual consultant presence may overlook consultant presence when consultants have been called in.[12] The presumed link between consultant presence and an improvement in outcome is far from established.

Nevertheless, many units have made significant moves towards fulfilment of the Royal College of Obstetricians and Gynaecologists' (RCOG) earlier recommendations[3-6] to increase the number of hours of consultant presence,[13] albeit through different approaches, with some units investigating the impact through observational studies. However, single unit studies are under-powered to identify differences in rare but serious outcomes. Amalgamation of data would increase the ability to determine whether consultant presence affects perinatal outcomes and understand sources of variation. A meta-analysis comparing the impact of continuous resident consultant cover to other models of cover found that instrumental deliveries decreased when consultants were resident.[14] However, this meta-analysis only included studies if they measured outcomes during a period of continuous consultant presence and provided adequate information in the title and abstract. Furthermore, limits were applied to study design, which resulted in only six included studies.

We conducted a systematic review and meta-analysis to compare and pool the effects of increased consultant presence across NHS maternity units and understand the determinants of these effects, using an updated and more inclusive search strategy than previously employed.[14]

Methods

Protocol

The systematic review and meta-analysis were reported in accordance with the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines.[15] The review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 26 February 2016 (registration number CRD42016035455). After the search had been completed it was apparent that inclusion of qualitative outcomes was not feasible because very few studies included these outcomes, and often authors used a closed-question survey and reported numeric results which did not allow for synthesis of qualitative findings.

Population studied and study inclusion criteria

Studies that examined women of any age who gave birth in a UK NHS maternity unit were included as the RCOG recommendations were primarily intended for UK NHS units, not privately funded units or those abroad adopt different staffing models. We planned that this would include secondary maternity units that offer routine and specialised care to women with low-moderate-risk pregnancies and tertiary units that carry out highly specialised care in addition to secondary care (although definitions of secondary and tertiary maternity units can vary). The search only included studies reported in the English language because it was assumed that studies conducted in UK NHS hospitals would be reported in English only. There were no restrictions on date of publication or study design.

Study exclusion criteria

Any studies that focused on non-NHS maternity units or places of birth not normally attended to by consultant obstetricians (e.g., midwifery-led unit or home) were excluded.

Intervention

Exposures of interest included any increase in obstetric consultant presence; thus, any studies that involved a comparison of outcomes during lesser consultant presence versus increased consultant presence were included (e.g., outcomes during a nightshift covered by a registrar only with a consultant off-site versus a nightshift covered by a resident consultant).

Outcome measures

Outcomes of interest included emergency caesarean section rate, non-instrumental vaginal delivery rate, instrumental delivery rate, stillbirth rate, neonatal death rate, perinatal mortality rate, maternal death rate, and admission to a neonatal intensive care unit (NICU admission). Mode of delivery was chosen as a primary outcome because this was the most reported outcome in prior studies investigating consultant presence. Other secondary outcomes included rate of postpartum haemorrhage (PPH) and 3rd and 4th degree tears.

Information sources and search

The literature searches were conducted by HR (a research assistant) and JW (a clinical librarian) in EMBASE, MEDLINE, PsycINFO, CINAHL, Web of Science, Health Management Information Consortium, Applied Social Sciences Index and Abstracts, and Google Scholar. In order to uncover any relevant unpublished studies and grey literature the Centre for Reviews and Dissemination databases, ProQuest Dissertations and Theses: UK and Ireland: Health and Medicine, and EThOS were searched. Publications identified in the searches were published between 1969 and 2016. Furthermore, reference lists of relevant studies were also examined. See Appendix S1 for the EMBASE search strategy.

Study selection and data collection

Duplicates were removed and the most recent and complete version of the studies were reviewed for eligibility. All relevant studies were assessed for eligibility by two reviewers (HR and DH) independently according to the pre-specified inclusion and exclusion criteria. A proforma was developed a priori for extracting the data from each study. The data extraction was performed by HR and DH and if a disagreement occurred a third reviewer (AH) was consulted to resolve the issue. In the event of missing data or identification of an eligible abstract, authors were contacted by email, telephone, and post to obtain the unpublished information in writing. If data were inconsistent, clarification was sought, or the data were excluded from the analysis if the authors were uncontactable. All studies were required to report at least one mode of delivery outcome, as well as the unit delivery volume (average number of deliveries per year), the cohort sizes, the study design, the duration of the study, and comparison hours of consultant presence.

Risk of bias

The studies included in the review were subjected to a risk of bias assessment using the Newcastle-Ottawa Quality Assessment Scale (NOS)[16] by HR and DH independently. The NOS, designed to assess the quality of non-randomised studies included in meta-analyses, comprises of eight items categorised into themes of *selection*, *comparability*, and *outcome*. It uses a nine-point rating system; where the higher the score the lower the risk of bias. The *selection* criterion assesses the representativeness of the exposed cohort, selection of the non-exposed cohort, how exposure was ascertained and the demonstration that the outcome(s) of interest was not present prior to the study. The *comparability* criterion assesses the number of variables controlled for, and the *outcome* criterion assesses how the outcome(s) of interest was reported, whether the follow-up was long enough for the outcome(s) to occur and whether all participants were accounted for. If a study's risk of bias was categorised as high (score of six or fewer)[17], the effect of removing this study from the meta-analysis was tested.

Statistical analyses

Meta-analysis was conducted using STATA (Version 14).[18] Random effects meta-analysis was performed in anticipation of heterogeneity between studies due to study design. The I^2 statistic, derived from Cochran's chi-squared statistic Q, was calculated to describe the percentage of between-study variation attributable to variability in the true exposure effect.[19] Heterogeneity was classified as low (I^2=0-40%), moderate (I^2=30-60%), substantial (I^2=50-90%), or considerable (I^2=75-100%).[20] Meta-regression was undertaken to test the effect of unit delivery volume and the period of the study. All studies were categorised into three groups depending on the comparison adopted: 1) hours of rostered consultant presence during the weekend versus hours of rostered consultant presence during the week; 2) hours per week of rostered consultant presence pre-increase versus hours per week of rostered consultant presence post increase; and 3) no rostered consultant presence versus rostered consultant presence. Rostered consultant presence describes the period in which a consultant is physically present and immediately available on the labour ward with no other duties.[4] Forest plots were constructed to show whether differences within the three groups or type of maternity unit had any significant effect on each outcome. Funnel plots were created to test for small-study effects.

Results

Study characteristics

Our systematic search strategy identified 412 titles (see Figure 1). After removal of duplicates and screening of abstracts, 33 publications were fully evaluated. After removal of publications that did not meet inclusion criteria and/or lacked relevant data, 15 titles that all reported single-centre studies related to consultant presence and perinatal outcomes were included in the final analysis.[21–35] Thirteen studies reported births for all modes of delivery (emergency caesarean sections, instrumental deliveries, and non-instrumental vaginal deliveries),[21–24,26,27,29–35] one study included elective caesarean sections and therefore data for caesarean sections were excluded.[25] Inductions of labour (IOLs) were only mentioned in six studies (five included IOLs,[22,25,26,33,34] one excluded IOLs[35]). Although, IOLs are more likely to occur during ‘office hours’ and are directed to higher-risk pregnancies, we could not conduct a sensitivity analysis due to the small number of studies providing information on IOLs in their datasets. Another study reported both instrumental and non-instrumental vaginal deliveries as a single outcome;[28] thus, data for those outcomes were excluded. Ten studies reported data for other outcomes, such as stillbirth, neonatal death, NICU admission, 3rd and 4th degree tears, and postpartum haemorrhage. Nine studies were conducted in secondary maternity units and six were conducted in tertiary units (see Table S1 for study characteristics). The majority of studies had a low risk of bias in the assessed domains, with the exception of the Fleming et al.[25] study which was assessed as having a high risk of bias (see Figure S1; Table S2). The following analyses were also conducted with the exclusion of this study; however, this did not change the findings, therefore the meta-analysis results presented include all studies.

Consultant presence and emergency caesarean section rate

All studies included in the analysis, except for one,[25] excluded elective caesarean sections. This was important because elective caesarean sections are more likely to occur during ‘office hours’ and carry a lower risk of adverse outcomes. The 14 studies that reported emergency caesarean sections recorded the outcome of 119,397 births (94.9% of births in the whole analysis). There was no significant difference in emergency caesarean section rates between lesser consultant presence and increased consultant presence (OR 0.98; 95% CI 0.92 to 1.05). Table 1.

There was substantial heterogeneity within the data (I^2=68.2%). Firstly, the data were stratified by comparison group and inspection of the forest plot (see Figure 2) suggested that the likelihood of emergency caesarean section was significantly lower during an increase in rostered consultant presence hours per week versus pre-increase consultant presence (Group 2) (OR 0.91; 95% CI 0.86 to 0.96). Secondly, when data were stratified by type of unit (secondary or tertiary), inspection of the forest plot (see Figure S2) indicated that this did not have a significant effect on emergency caesarean section rates.

Meta-regression was performed to search for any associations between unit delivery volume and study period in months, which showed no evidence for an association of any covariates with the size of the exposure effect (R^2=0.21). A contour enhanced funnel plot demonstrated that small study effects did not have an influence on the significance of this result (see Figure S3; Harbord's test, p=0.74); this is also supported by the similarity between the output of random and fixed effects meta-analyses.

Consultant presence and non-instrumental vaginal delivery rate

The 14 studies that reported non-instrumental vaginal deliveries recorded the outcome of 117,684 births (93.5% of births in the whole analysis). Overall, there was no significant difference in non-instrumental vaginal deliveries between lesser consultant presence and increased consultant presence (OR 1.00; 95% CI 0.95 to 1.06). There was substantial heterogeneity within the data (I^2=71.7%). Following inspection of the forest plot for data stratified by comparison group (see Figure 3), non-instrumental vaginal deliveries were significantly more likely to occur during increased hours per week of rostered consultant presence when compared to pre-increase hours per week of rostered consultant presence (Group 2) (OR 1.07; 95% CI 1.02-1.12). When the data were stratified by type of unit, again no significant difference was observed with regard to non-instrumental vaginal deliveries.

Consultant presence and instrumental delivery rate

The studies that reported instrumental delivery rates were identical to those that reported non-instrumental vaginal deliveries (93.5% of births in the whole analysis). Overall, there was no significant difference in instrumental deliveries between lesser consultant presence and increased consultant presence (OR 1.04; 95% CI 0.98 to 1.10). There was moderate heterogeneity within the data (I^2=46.0%). Stratification of the data by comparison group (see Figure S4) and by type of unit did not demonstrate any differences.

Consultant presence and maternal and neonatal outcomes

A summary of the meta-analysis of all outcomes is shown in Table 1. Two studies recorded the frequency of maternal death, Freites et al.[26] reported one death and Mackie et al.[29] reported two deaths; due to the low incidence they were not included in the analysis. There were no significant differences in NICU admission, neonatal death, stillbirth, PPH or tears. All studies that reported NICU admission were hospitals with a level 3 NICU, except one unit which was level 2,[33] and therefore data could not be stratified by level of NICU. Outcomes showed heterogeneity ranging I^2=0.0-83.8%.

Discussion

Main findings

The review consolidates research investigating the effect of consultant presence on maternal and neonatal outcomes, but also identifies that three different methods of comparing obstetric consultant presence in UK NHS maternity units have been employed yielding different results. The meta-analysis of 15 studies found no overall significant difference between prior levels of consultant presence and increased consultant presence with regards to mode of delivery or maternal and neonatal outcomes. However, when data were stratified by comparison group, findings indicated that increased hours per week of rostered consultant presence significantly reduced the likelihood of emergency caesarean sections and significantly increased the likelihood of non-instrumental vaginal deliveries. Meta-regression indicated that unit delivery volume and study period were not associated with the exposure effect. Furthermore, two-thirds of studies were assessed as having a low risk of bias and removal of the study with the highest risk of bias[25] did not change the results, suggesting the quality of studies did not affect the findings. Overall, the data indicate that increasing consultant presence had an impact on the mode of delivery, rather than maternal and neonatal morbidity or mortality.

Strengths and Limitations

This comprehensive review was strengthened by the use of a prospective protocol, with specified eligibility criteria and adherence to published guidelines. Furthermore, the analysis included a varied range of maternity units with regards to unit location, unit type, and unit delivery volume, suggesting a population of high- and low-risk women, which increases the generalisability of the findings. However, there were limitations that constrain the conclusions of this meta-analysis. There was a lack of information available regarding midwifery or anaesthetic staff during the studies, and whether their numbers and level of experience changed in line with the changes to consultant cover. This presents a confounder that could not be investigated fully. Some of the outcomes, such as late intrauterine fetal death and NICU admissions, do not reflect intrapartum management; thus, the possible effect of consultant presence is reduced. The most serious intrapartum outcomes, intrapartum stillbirth and maternal death from direct causes, are rarely reported or are such a rare occurrence that any analysis would have to be enormous (i.e. nationwide) to demonstrate a statistically significant difference. Furthermore, we identified that the arbitrariness of categorisation and labels played a role in this review. Firstly, there was no definitive method or resource to help categorise maternity units as secondary or tertiary. Secondly, the career labels themselves, ‘consultant’ and ‘registrar’, pose a limitation, as a consultant is not necessarily better than an experienced trainee who is nearly a consultant.

Interpretation

The involvement of consultants in obstetric care is considered important in providing safer intrapartum outcomes.[3–6] The present study clarifies the currently conflicting results regarding a link between obstetric consultant presence and maternal and neonatal outcomes.

The findings suggest that increasing rostered consultant presence would reduce emergency caesarean section rates and increase non-instrumental vaginal deliveries. This would have a number of benefits including reduced recovery time postpartum, reduced risk of maternal infection and thrombosis, and reduced risk of neonatal complications.[36] Although the reasons for the reduction in caesarean section rate during periods of consultant presence in this meta-analysis are not clear, consultant presence may increase junior doctors' clinical judgement, confidence, and skills to allow a woman to give birth vaginally rather than performing an emergency caesarean section prematurely. The reduction in caesarean sections did not seem to be associated with instrumental birth. The present study found no difference in instrumental vaginal delivery, which was not in agreement with previous observations that women who gave birth during periods of no rostered consultant presence were less likely to have an instrumental delivery. These contradictory observations may reflect controversy surrounding certain instrumental procedures (e.g., rotation of the fetal head)[37,38] and variability between trainee doctors in performing instrumental deliveries,[39] exerting a greater influence over rates than consultant presence alone.

We did not observe an effect of obstetric consultant presence on NICU admissions or stillbirths. One possible explanation is that senior input in labour is not a preventative measure in the majority of these occurrences. NICU admissions may include very preterm babies or babies with known structural anomalies that cannot be improved by an obstetric consultant, and 86% of stillbirths occur prior to the onset of labour.[40] The results also demonstrated no effect on the other outcomes of PPH, neonatal death, and 3rd and 4th degree tears. The most likely reason for this would be lack of data; despite combining studies within a meta-analysis, the cumulative data are still under-powered to detect the frequency of rare but serious events such as neonatal death due to intrapartum anoxia. Using previously reported incidences,[10] over 392,000 women would be required in each group to detect a statistically significant difference ($p<0.05$) in neonatal death due to intrapartum anoxia with 80% power.

Statistically significant differences were only found for studies of increased hours per week of rostered consultant presence (Group 2). A number of reasons may explain why this statistically significant difference was found in the stratified analyses only. Firstly, this may reflect statistical power as studies in Group 2 included a greater number of births. Secondly, studies from Groups 1 and 3 compared rostered consultant presence during time of the week and specific shifts, respectively. These comparisons rely on the assumption that consultants are not present when they are on-call, however in an emergency situation the consultants would be called in. This may have resulted in consultants being present on the ward during times of no rostered consultant presence and this may explain why consultant presence was not seen to impact any outcomes in these groups.[12]Alternatively, there may be other interventions introduced concurrently with increased consultant presence which also affect mode of delivery, including increase of midwife or anaesthetist presence. For example in one included study, the midwife to antenatal patient ratio increased from 1:35 to 1:28 due to amalgamation of units,[29] which could contribute to the increased likelihood of a non-instrumental vaginal delivery.[41] Another possibility could be increased cohesiveness of the obstetric and midwifery team, which could result in stronger working relationships and better management of the team by consultants, which offers another possibility for the different findings observed in the overall analysis and the stratified analyses. To contextualise our findings we attempted to find international studies comparing the effects of increased senior obstetric presence on perinatal outcome, but we could find no directly comparable studies.

Consultant presence may deliver a cost saving because non-instrumental vaginal deliveries cost considerably less than caesarean sections.[42] However, our findings also imply that consultant presence may not reduce maternal and neonatal mortality and morbidity, the predominant cause of medicolegal cases (which totalled £3.1 billion between 2000-2010)[43], a number of issues must be considered by healthcare-providers and policy-makers when increasing consultant presence, including the financial repercussions (to employ a full-time consultant for one year costs approximately £125,000). Further large scale studies, which can adequately assess the frequency of these rare and serious outcomes, are needed to evaluate the cost-effectiveness of increased consultant presence. Numerical analysis should also be supported by other methodologies, such as Confidential Enquiries,[44] to determine whether consultant presence would have made a difference to perinatal outcome.

Conclusion

In conclusion, this meta-analysis suggests that consultant presence reduced the likelihood of emergency caesarean sections and increased non-instrumental vaginal deliveries. The findings shed some light on the relationship between obstetric consultant presence and perinatal outcomes in UK NHS maternity units, providing further evidence that consultant presence has an effect but evidence for an effect on more serious outcome including mortality and morbidity was not identified.

Acknowledgements

We would like to thank the study authors who provided additional information regarding their research to aid this meta-analysis.

Disclosure of interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that

could appear to have influenced the submitted work. The ICMJE disclosure forms are available as online supporting information.

Contribution to authorship

All authors had full access to all of the data and can take responsibility for the integrity of the data and accuracy of the data analysis. HR, DH, AW, SV, and AH contributed to the study concept and design. HR and AH wrote the protocol. HR and JW developed the search strategy. HR, DH, SV, and JW acquired the data for the study. HR, DH, and AH contributed to the analysis and interpretation of the data. HR developed the first draft of the manuscript and DH, AW, SV, JW, and AH revised all manuscript drafts and approved the final version. HR is the study guarantor.

Details of ethical approval

Ethical approval was not required because the systematic review did not involve human or animal subjects, nor did it involve collecting data from patients' medical records.

Patient Involvement

Patients were not involved in the design or conduct of this study.

Funding

The study was funded by Central Manchester University Hospitals NHS Foundation Trust Charity. The funding source had no role in study design, data collection, data analysis, data interpretation or preparation of the manuscript. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Transparency

The lead author (HR) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported. No important aspect of the study has been omitted and discrepancies from the registered protocol have been explained.

Data sharing

Additional data and the study reports can be obtained from the corresponding author on request.

References

1. Healthcare Commission. *Towards better births: a review of maternity services in England*. London: Commission for Healthcare Audit and Inspection, 2008.
2. National Health Service Litigation Authority. *Clinical Negligence Scheme for Trusts. Maternity. Clinical Risk Management Standards.* London: National Health Service Litigation Authority, 2013.
3. Royal College of Obstetricians and Gynaecologists. *The future role of the consultant: a working party report*. London: Royal College of Obstetricians and Gynaecologists, 2005.
4. Royal College of Obstetricians and Gynaecologists, Royal College of Midwives, Royal College of Anaesthetists, Royal College of Paediatrics and Child Health. *Safer childbirth: minimum standards for the organisation and delivery of care in labour*. London: RCOG Press, 2007.
5. Royal College of Obstetricians and Gynaecologists. *Responsibility of consultant on-call.* London: Royal College of Obstetricians and Gynaecologists, 2009.
6. Royal College of Obstetricians and Gynaecologists. *Labour ward solutions.* London: Royal College of Obstetricians and Gynaecologists, 2010.

7. Royal College of Obstetricians and Gynaecologists. *Providing quality care for women: Obstetrics and gynaecology workforce*. London: Royal College of Obstetricians and Gynaecologists, 2016.
8. Sandall J, Homer C, Sadler E, Rudsill C, Bourgeault IL, Bewley S, et al. *Staffing in maternity units: getting the right people in the right place at the right time*. London: The King's Fund, 2011.
9. National Audit Office. *Maternity service in England*. London: National Audit Office, 2013.
10. Pasupathy D, Wood AM, Pell JP, Mechan H, Fleming M, Smith GCS. Time of birth and risk of neonatal death at term: retrospective cohort study. *BMJ*. 2010; 341: c3498. doi: 10.1136/bmj.c3498
11. Knight HE, van der Meulen JH, Gurol-Urganci I, Smith CG, Kiran A, Thornton S, et al. Birth "Out-of-Hours": an evaluation of obstetric practice and outcome according to the presence of senior obstetricians on the labour ward. *PLoS Med*. 2016; 13: e1002000. doi:10.1371/journal.pmed.1002000
12. Myers JE, Johnstone ED. Is there evidence of poorer birth outcomes for mothers and babies when the most senior obstetrician is not on site? *PLoS Med*. 2016; 13: e1002001. doi: 10.1371/journal.pmed.1002001
13. Royal College of Obstetricians and Gynaecologists. *RCOG Census Report 2013*. London: Royal College of Obstetricians and Gynaecologists, 2015.
14. Knight M, Henderson J, Kurinczuk JJ. Evidence review to support the National Maternity Review 2015; Report 3: systematic review and case studies to assess models of consultant resident cover and the outcomes of intrapartum care; and two international case studies of the delivery of maternity care. Oxford: National Perinatal Epidemiology Unit, University of Oxford, 2015.

15. Stroup DF, Berlin JA, Morton SC, Ingram Olkin G, Williamson D, Rennie D, et al. Meta-analysis of observational studies in epidemiology (MOOSE): a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) Group. *JAMA*. 2000; 283: 2008-12. doi: 10.1001/jama.283.15.2008

16. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses [Internet]. 2014 [cited 1st April 2016]. Available from: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.

17. Lo CK, Mertz D, Loeb M. Newcastle-Ottawa scale: Comparing reviewers' to authors' assessments. *BMC Med Res Methodol*. 2014; 14: 45. doi: 10.1186/1471-2288-14-45

18. StataCorp. STATA Statistical Software, release 14. College Station, TX: StataCorp LP, 2015.

19. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003; 327: 557–60. doi: 10.1136/bmj.327.7414.557

20. Deeks JJ, Higgins JPT, Altman DG. Chapter 9: analysing data and undertaking meta-analyses [Internet]. In: Higgins JPT, Green S, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. 2011 [cited 17th June 2016]. Available from: www.cochrane-handbook.org.

21. Ahmed I, Wyldes MP, Chong HP, Barber KJ, Tan BK. 24/7 consultant presence in a UK NHS tertiary maternity unit. *Lancet*. 2015; 386: 951–2. doi: 10.1016/S0140-6736(15)00058-6

22. Aiken CE, Aiken AR, Scott JG, Brockelsby JT. Weekend working: a retrospective cohort study of maternal and neonatal outcomes in a large NHS delivery unit. *Eur J Obstet Gynecol Reprod Biol*. 2016; 199: 5–10. doi: 10.1016/j.ejogrb.2016.01.034

23. Albury C, Ashelby L, Basude S. Resident consultant on-call: 6 month evaluation of service. Does resident consultant presence change outcomes in a tertiary maternity unit? *BJOG*. 2015; 122(S2): 78–9. doi: 10.1111/1471-0528.13387

24. Ballal A, Dawood F, Scholefield H. Resident consultant versus on call cover on delivery suite: are outcomes better? *Arch Dis Child Fetal Neonatal Ed*. 2012; 97(S1): A78. doi: 10.1136/fetalneonatal-2012-301809.256

25. Fleming A, Martindale EA, Schram CMH. Reducing caesarean section rates through choice and collaboration. *Arch Dis Child Fetal Neonatal Ed*. 2013; 98(S1): A55–A56. doi: 10.1136/archdischild-2013-303966.189

26. Freites J, Ruprai C, Paul H, Lindow SW. Resident consultant presence in labour ward after midnight – a retrospective cohort study of 5318 deliveries. *J Perinat Med*. 2012; 40: 615–8. doi: 10.1515/jpm-2012-0060

27. Katakam N, Chan D, Rockett T, Wong S, Das S. Does consultant obstetrician presence on the labour ward improve quality of patient care? A review of quality indicators at Royal Bolton Hospital. *Arch Dis Child Fetal Neonatal Ed*. 2012; 97(S1): A111. doi: 10.1136/fetalneonatal-2012-301809.362

28. Khalil A, Suff N, Blott M, O’Brien P. Does the presence of a consultant on the delivery suite reduce the emergency caesarean section rate? *Arch Dis Child Fetal Neonatal Ed*. 2011; 96(S1): Fa10. doi: 10.1136/adc.2011.300160.30

29. Mackie FL, Afadapa F, Moise J, Amu O. Maternal and neonatal outcomes after the amalgamation of two maternity units and consequent increased consultant labour ward presence: a retrospective population-cased study. *Arch Dis Child Fetal Neonatal Ed*. 2014; 99(S1): A21–A22. doi: 10.1136/archdischild-2014-306576.60

30. Nunes N, Rogers C, Johnston T. Impact of overnight consultant presence – outcomes and attitudes. *Arch Dis Child Fetal Neonatal Ed*. 2014; 99(S1): A22. doi: 10.1136/archdischild-2014-306576.62

31. Rajesh U, Merrick K. Impact of resident consultants on call at night in York Teaching Hospital. *Arch Dis Child Fetal Neonatal Ed*. 2014; 99(S1): A28. doi: 10.1136/archdischild-2014-306576.79

32. Siddiqui F, Green A, Moore J, Kean L. Resident obstetric consultant cover: does it make a difference to vaginal delivery rates or perinatal morbidity? *Arch Dis Child Fetal Neonatal Ed*. 2008; 93(S1), Fa11.

33. Tang JWY, Dwyer JP, Rajesh U. Impact of introducing consultant resident on-call in a District General Hospital. *J Obstet Gynaecol*. 2012; 32: 736–9. doi: 10.3109/01443615.2012.717992

34. Woodhead N, Lindow S. Time of birth and delivery outcomes: a retrospective cohort study. *J Obstet Gynaecol*. 2012; 32: 335–7.

35. Woods CFG, Manohar S, Lindow SW. Obstetric consultant weekend on-call shift patterns have no effect on the management of spontaneous labour in a large maternity hospital. *J Obstet Gynaecol*. 2013; 33: 802-5.

36. Bragg F, Cromwell DA, Edozien LC, Gurol-Urganci I, Mahmood TA, Templeton A, et al. Variation in rates of caesarean section among English NHS trusts after accounting for maternal and clinical risk: cross sectional study. *BMJ*. 2010; 341: c5065. doi: 10.1136/bmj.c5065

37. Al-Suhel R, Gill S, Robson S, Shadbolt B. Kjelland's forceps in the new millennium. Maternal and neonatal outcomes of attempted rotational forceps delivery. *Aust N Z J Obstet Gynaecol*. 2009; 49: 510–4. doi: 10.1111/j.1479-828X.2009.01060.x.

38. Tempest N, Hart A, Walkinshaw S, Hapangama DK. A re-evaluation of the role of rotational forceps: retrospective comparison of maternal and perinatal outcomes following different methods of birth for malposition in the second stage of labour. *BJOG*. 2013; 120: 1277–84. doi: 10.1111/1471-0528.12199

39. Aiken CE, Park H, Brockelsby J, Prentice A. Operative skills training in obstetrics – identification of increased training needs for junior doctors. *Arch Dis Child Fetal* Neonatal Ed. 2014; 99: A17. doi: 10.1136/archdischild-2014-306576.47

40. Manktelow BM, Smith LK, Evans TA, Hyman-Taylor P, Kurinczuk JJ, Field DJ, et al. *Perinatal Mortality Surveillance Report: UK Perinatal Deaths for births from January to December 2013*. Leicester: The Infant Mortality and Morbidity Group, Department of Health Sciences, University of Leicester, 2015.

41. Sandall J, Soltani H, Gates S, Shennan A, Devane D. Midwife-led continuity models versus other models of care for childbearing women. *Cochrane Database of Systematic Reviews*. 2013; 8: CD004667. doi: 10.1002/14651858.CD004667.pub3

42. Parliamentary Office of Science and Technology. *Caesarean sections – Postnote no. 184*. London: Parliamentary Office of Science and Technology, 2002.

43. National Health Service Litigation Authority. *Ten years of maternity claims: an analysis of NHS litigation authority data*. London: National Health Service Litigation Authority, 2012.

44. Weindling AM. The confidential enquiry into maternal and child health (CEMACH). Arch Dis Child. 2003; 88: 1034-37. doi: 10.1136/adc.88.12.1034 (CEMACH). *Arch Dis Child*. 2003; 88: 1034-37. doi: 10.1136/adc.88.12.103

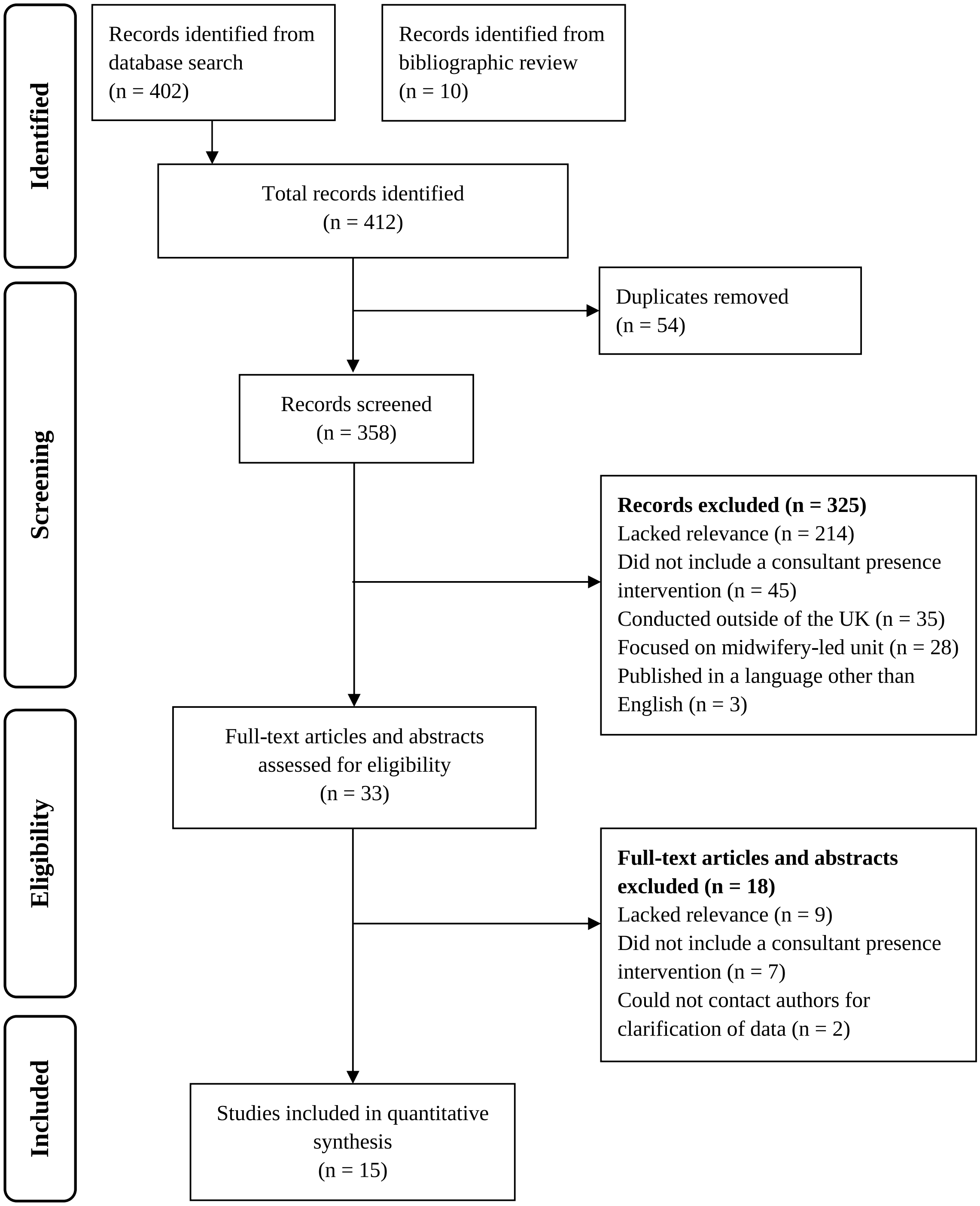

Figure 1. Flow chart of screening and selection of studies.

Table 1. Meta-analysis of all outcomes

	Overall meta-analysis					Type of increase in Consultant Presence			Type of unit	
Outcome	**No. of studies**	**No. of births**	**No. of women during increased consultant presence (%)**	**I^2 (%)**	**Overall OR (95% CI)**	**Group 1 OR (95% CI)**	**Group 2 OR (95% CI)**	**Group 3 OR (95% CI)**	**Secondary OR (95% CI)**	**Tertiary OR (95% CI)**
Emergency caesarean section	14	119 397	64 285 (53.8)	68.2	**0.98 (0.92–1.05)**	0.99 (0.94–1.05)	0.91 (0.86–0.96)	1.01 (0.87–1.17)	0.95 (0.88–1.05)	1.04 (0.91–1.18)
Non-instrumental vaginal delivery	14	117 686	64 773 (55.0)	71.7	**1.00 (0.95–1.06)**	0.99 (0.94–1.03)	1.07 (1.02–1.12)	0.97 (0.87–1.10)	1.03 (0.96–1.10)	0.95 (0.85–1.07)
Instrumental delivery	14	117 686	64 773 (55.0)	49.2	**1.04 (0.98–1.10)**	1.04 (0.98–1.10)	1.01 (0.90–1.14)	1.06 (0.95–1.19)	1.05 (0.97–1.14)	1.02 (0.91–1.13)
NICU admission	7	52 517	25 268 (48.1)	62.1	**1.03 (0.87–1.23)**	0.93 (0.80–1.09)	1.23 (1.06–1.43)	0.95 (0.69–1.31)		
Neonatal death	3	15 090	5 939 (39.4)	0.0	**1.27 (0.51–3.18)**					
Stillbirth	4	36 860	16 335 (44.3)	50.3	**1.17 (0.76–1.80)**					
PPH	4	24 564	12 243 (49.8)	83.8	**1.55 (0.72–3.33)**					
3rd and 4th degree tears	4	24 220	11 811(48.8)	0.0	**1.09 (0.90–1.32)**					

Group 1 = hours of rostered consultant presence per day during the weekend vs. hours of rostered consultant presence per day during the week, Group 2 = hours per week of rostered consultant presence pre-increase vs. hours per week of rostered consultant presence post increase, Group 3 = no rostered consultant presence vs. rostered consultant presence

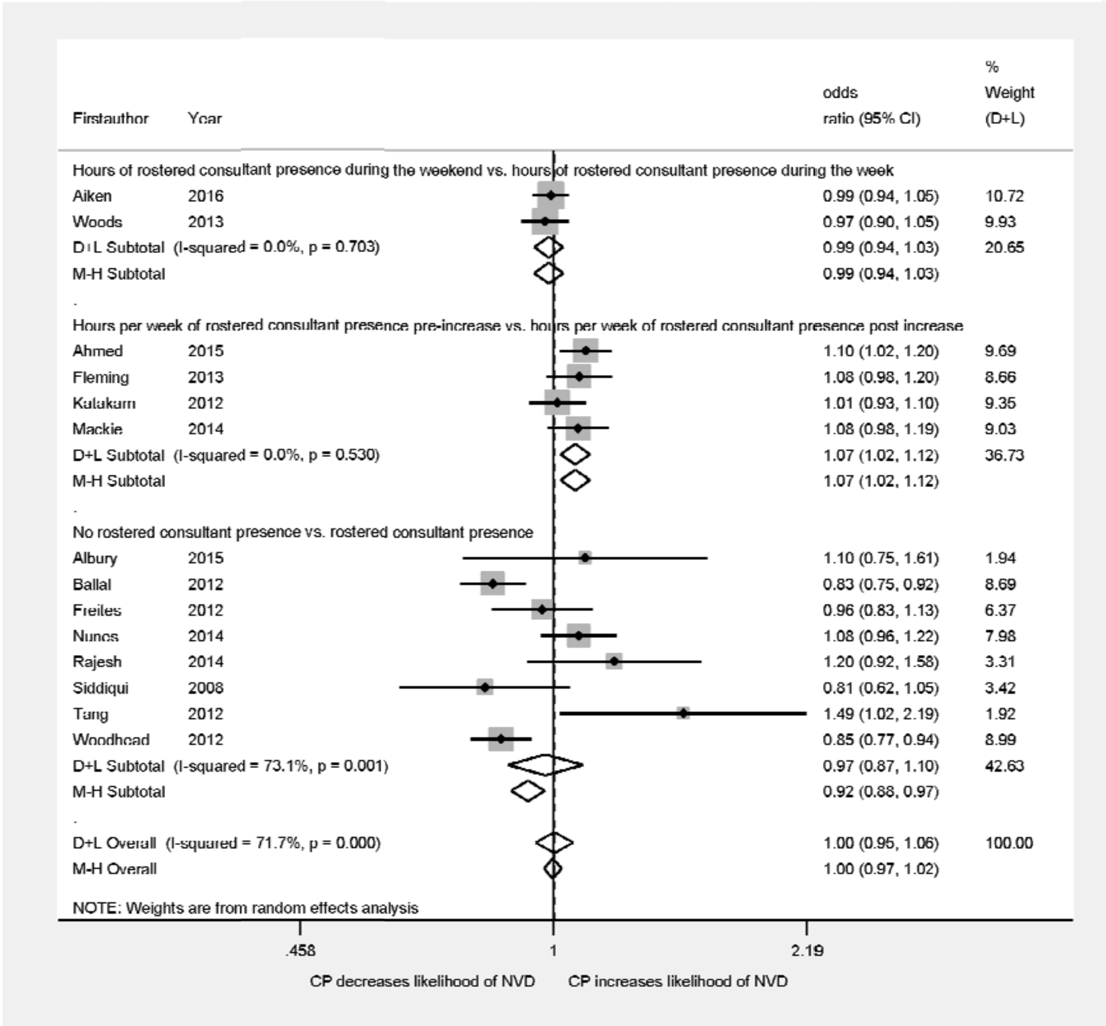

Figure 2. Forest plot of odds ratios of non-instrumental vaginal deliveries stratified by comparison group using random effects analysis

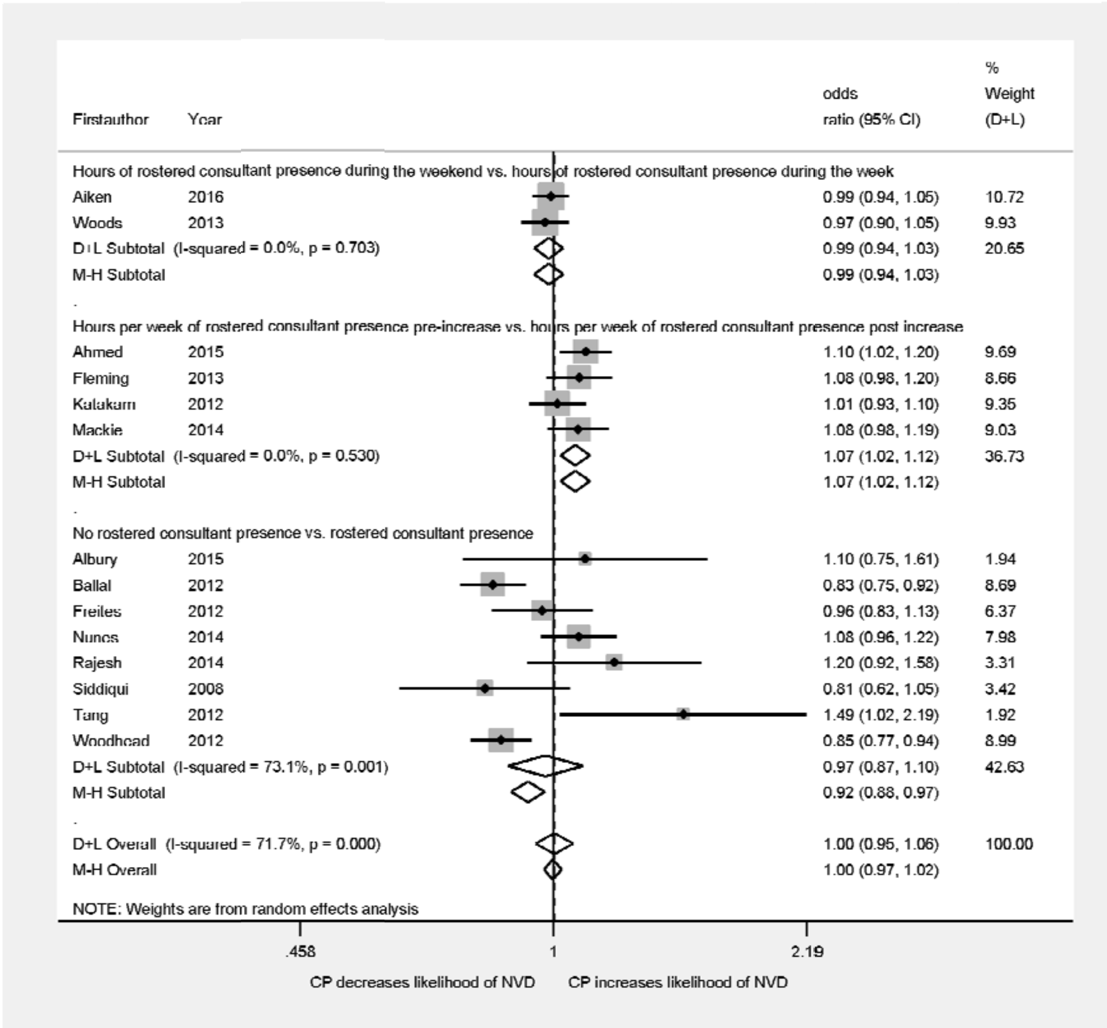

Figure 3. Forest plot of odds ratios of non-instrumental vaginal deliveries stratified by comparison group weighted from random effects analysis