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Safe midwifery staffing for maternity settings

The relationship between midwifery staffing at a local level and maternal and neonatal outcomes, and factors affecting these requirements

A report for the National Institute for Health and Care Excellence
Prepared by Bazian Ltd.
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Table of abbreviations

AMU	Alongside midwifery unit
AR	Absolute risk
CEFM	Continuous Electronic Fetal Monitoring
CI	Confidence interval
C-Section	Caesarean section
DwBI	Delivery with bodily integrity
FMU	Free standing midwifery unit
FTE	Full time equivalent
HIE	Hypoxic ischaemic encephalopathy
IVD	instrumental vaginal delivery
MW:LW	Midwives: Labouring women
LBW	Low birthweight
MVA	Multivariate analysis
NA	Not applicable
NHS	National Health Service
NICE	National Institute for Heath and Clinical Excellence
NICE CG	NICE Clinical Guideline
NICE QS	NICE Quality Standard
NICU	Neonatal Intensive Care Unit
NNU	Neonatal unit
NR	Not reported
NSCCRT	North Staffordshire Changing Childbirth Research Team
OECD	Organisation for Economic Cooperation and Development
O&G	Obstetrics and gynaecology
OR	Odds ratio
OU	Obstetric unit
PPH	Postpartum Haemorrhage
RCOG	Royal College of Obstetrics and Gynaecology
RCT	Randomised controlled trial
RR	Relative risk
SCBU	Special Care Baby Unit
SD	Standard deviation
SE	Standard error
SHA	Strategic Health Authority
SSBR	Birth weight standardised stillbirth rate
SVD	Spontaneous vaginal delivery
UVA	Univariate analysis
VLBW	Very low birthweight

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1. Executive summary

Introduction

The National Institute for Health and Care Excellence (NICE) has been asked by the Department of Health and NHS England to develop an evidence-based guideline on safe staffing in maternity settings.

This review is one of one of a series of reviews to inform the maternity safe staffing guideline. It aims to explore evidence to inform guidance related to the following six questions, set out in the scope:

- **Question 1:** What maternal and neonatal activities and outcomes are associated with midwifery staffing at a local level?
- **Question 2:** What maternal and neonatal factors affect midwifery staffing requirements, at any point in time, at a local level?
- **Question 3:** What environmental factors affect safe midwifery staffing requirements?
- **Question 4:** What staffing factors affect safe midwifery staffing requirements at a local level?
- **Question 5:** What unit level management factors affect midwifery staffing requirements?
- **Question 6:** What organisational factors influence safe midwifery staffing at a unit level?

Question 7 in the final scope about approaches for identifying midwifery staffing requirements and skill mix at a local level, and the economic aspects of safe maternity staffing are being reviewed separately in related reports.

Methods

Systematic searches were performed in June 2014 (see Appendix for details). The review considered English language primary studies from 1998 and onwards. Studies had to be performed in Organisation for Economic Cooperation and Development (OECD) countries for inclusion. Primary research assessing the relationship between midwife staffing levels and the outcomes specified in the scope (Question 1), and modifiers of this relationship (Question 2-6) were included.

Studies were critically appraised using an adapted version of the NICE quality appraisal checklists for quantitative studies reporting correlations and for intervention studies. Evidence was synthesised narratively.

Results

Of the 6,672 studies (including duplicates) identified, 8 primary studies were included, all of which were carried out in the UK. These included 1 RCT, 2 cohort studies, and 5 correlational studies. One study was of low quality [-], six of moderate quality [+], and one of good quality [++]. Only the RCT and cohort studies allowed assessment of midwife staffing before, or at the point of, the outcomes occurring. Therefore only these studies allow assessment of whether midwife staffing levels might be directly contributing to the outcomes seen.

Overall few significant associations between midwife staffing levels and outcomes were identified. The evidence suggests that increased midwife staffing may be associated with an increased likelihood of delivery with bodily integrity (no uterine damage, 2nd/3rd/4th degree tear, stitches, episiotomy, or C-section), reduced maternal readmissions within 28 days, and reduced decision-to-delivery times for emergency C-sections. However, it may not be associated with overall C-section rates, composite

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'healthy mother' or 'health baby' outcomes, rates of 'normal' or 'straightforward' births, or stillbirth or neonatal mortality.

No studies were identified which assessed the links between midwife staffing and on maternal mortality or never events (such as maternal death due to post-partum haemorrhage after elective caesarean section, wrongly prepared high-risk injectable medication, intravenous administration of epidural medication, or retained foreign objects post-procedure) or serious fetal/neonatal events such as Erb's palsy secondary to shoulder dystocia, meconium aspiration syndrome, hypoxic ischaemic encephalopathy (HIE).

These studies provided limited evidence on potential modifiers of the effect of midwife staffing levels on outcomes. Maternal clinical risk and parity were the only factors which were formally tested for an interaction. Both appear to be modifiers of the effect of midwife staffing levels on outcomes, and also themselves appear to have a large impact on outcomes.

Discussion and conclusions

Overall there is limited evidence, with relatively few relevant studies (8 studies included), and most of these using correlational designs, which limits their ability to determine causality. All of the included studies were carried out in the UK, so it is likely to be applicable to the NHS in England. While the number of studies is small, some of these have analysed recent data (2008-2011), and have analysed data for over 600,000 births across the majority of trusts within England. Most of the outcomes assessed are intrapartum outcomes, and none of the studies looked at the relationship between midwife staffing and outcomes specifically within alongside or freestanding midwifery units, or for births at home. This limits applicability to these settings and to outcomes outside of the intrapartum period.

Only one study formally assessed the interaction between modifying factors and midwife staffing levels. This study found that maternal clinical risk and parity showed significant interaction with midwife staffing for various maternal and neonatal outcomes. Limited conclusions can be drawn regarding the effects of other modifying factors on safe midwife staffing requirements.

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2. Introduction

Context

The National Institute for Health and Care Excellence (NICE) has been asked by the Department of Health and NHS England to develop an evidence-based guideline on safe staffing of maternity settings. NICE was identified in the high profile Francis report on Mid Staffordshire (2010) and the Berwick report on improving the safety of patients in England (2013) as a lead organisation in developing advice on NHS staffing.

A number of recent reports have also highlighted the need for safe staffing guidelines, including:

- House of Commons Public Accounts Committee (2014) Maternity services in England
- National Audit Office (2013) Maternity services in England
- National Quality Board (2013) How to ensure the right people, with the right skills, are in the right place at the right time – a guide to nursing, midwifery and care staffing capacity and capability
- Department of Health (2013) Hard truths: the journey to putting patients first
- King's Fund (2011) Staffing in maternity units. Getting the right people in the right place at the right time
- King's Fund (2008) Safe births: everybody's business. An independent inquiry into the safety of maternity services in England
- RCOG, RCM, RCA, RCPCH (2007) Safer childbirth. Minimum standards for the organisation and delivery of care in labour.
- The WI and NCT (2013) Support overdue: women's experiences of maternity services

The need for staffing in maternity settings to be reviewed is influenced by a number of factors, including the increasing numbers of births in the UK annually, and population trends such as the increasing prevalence of obesity, older age at first pregnancy, increasing use of fertility treatments, and other socio-demographic factors leading to greater medical and social complexity of pregnancies and births. In addition, there are greater expectations for personalised care (Department of Health 2007 and 2010), and changing service delivery models which include movement towards women choosing their birth location.

Midwifery roles are also changing, including changes to antenatal roles such as antenatal scanning and health improvement messages, to care in labour such as provision of critical care, and to postnatal roles, such as newborn checks and safeguarding, and the resulting administrative demands of these changes. The potential for litigation also means that maternity services carry higher insurance costs than other services.

Aims and objectives of the review

This evidence review aims to covers six questions set out in the final scope for the 'Safe midwifery staffing for maternity settings' guideline:

- **Question 1:** What maternal and neonatal activities and outcomes are associated with midwifery staffing at a local level?
    - Is there evidence that demonstrates a minimum staffing threshold of safe midwifery care at a local level?

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- **Question 2:** What maternal and neonatal factors affect midwifery staffing requirements, at any point in time, at a local level? These include:
    - Number of women pregnant or in labour
    - Maternal risk factors including medical and social complexity and safeguarding
    - Neonatal needs
    - Stage of the maternity care pathway (e.g. antenatal, intra-partum, postnatal)

- **Question 3:** What environmental factors affect safe midwifery staffing requirements? These include:
    - Local geography and demographic
    - Birth settings and unit size and physical layout

- **Question 4:** What staffing factors affect safe midwifery staffing requirements at a local level? These include:
    - Midwifery skill mix
    - Availability of and care provided by other healthcare staff (e.g. maternity support workers, obstetricians, anaesthetists, paediatricians and specialist midwives)
    - Requirements to provide additional services (e.g. high dependency care, public health roles, vaccinations)

- **Question 5:** What unit level management factors affect midwifery staffing requirements? These include:
    - Maternity team management and administration approaches
    - Models of midwifery care (e.g. caseloading/named midwife/social enterprises)
    - Staff and student supervision and the supernumerary arrangements

- **Question 6:** What organisational factors influence safe midwifery staffing at a unit level? These include:
    - Management structures and approaches
    - Organisational culture
    - Organisational policies and procedures, including staff training

Question 7 in the final scope (relating to approaches for identifying midwifery staffing requirements and skill mix at a local level such as toolkits) and the economic aspects of safe maternity staffing have been reviewed separately.

Identification of possible equality and equity issues

The review covers all maternity service provision by midwives, and aims to identify factors which modify safe midwifery staffing. The factors being assessed may include factors relating to inequalities, such as maternal risk factors including age as well as social complexity and safeguarding, and local demographic factors such as deprivation and ethnicity. Where these factors are identified as affecting safe midwifery staffing this will be described.

In addition, outcomes of interest include NICE standards for delivery of midwifery care, some of which relate to groups who may experience equalities in care, such as that women with complex social factors accessing appropriate services (NICE clinical guideline [CG] 10), and completion of screening questions for previous or current mental health problems at first antenatal and postnatal contact (CG45; NICE quality standard 37).

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Review team

Searches for the review were carried out by NICE, and all subsequent stages of the review carried out by Bazian Ltd.

3. Methods

This systematic review was conducted in accordance with the draft Developing NICE guidelines manual. The protocol for the methods of the review are presented in Appendix B.

Search methods

The search was carried out by a NICE information specialist and detailed methods for the search are provided in Appendix C.

Briefly, searches were performed in literature databases (Medline and Medline-in process, Embase, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, Health Management Information Consortium, Cochrane Central Register of Controlled Trials, Health Technology Assessment Database, Cumulative Index to Nursing and Allied Health, British Nursing Index) and on key websites in June 2014. Systematic reviews were used for citation searching and as sources of potentially relevant primary studies. The search included English language primary studies from 1998 and onwards. This is because midwifery practices have advanced over the years, making older studies of limited relevance to midwifery practice today. This cut-off date was chosen following advice from a topic expert. Studies also had to be performed in Organisation for Economic Cooperation and Development (OECD) countries for inclusion, to increase relevance of included evidence to the UK setting.

Sifting of studies and full text appraisal

The searches retrieved 5,526 unique citations, these were read at title level to remove any clearly non-relevant material (first pass appraisal, see protocol in Appendix B for details). This led to the selection of 748 studies to be appraised at title and abstract level (second pass appraisal, see Appendix B). An additional 55 studies (46 after duplicates removed) were identified as potentially relevant during appraisal of the searches for the related reviews or through citation in relevant studies, or through submission to NICE. These studies were also appraised at title and abstract level. Of these 794 studies, 149 citations were selected for retrieval and full text appraisal using the same criteria as the second pass appraisal. Five of the selected studies were not able to be obtained in full text (see Appendix A for references); assessment of their titles and abstracts suggested that they were not of high relevance to the current review (likely to be news items, be in isolated populations potentially of low relevance to the NHS, or assess methods of calculating required for midwife staffing). Of the full texts appraised, 8 studies were selected for inclusion (see Figure 1 for PRISMA flowchart). Details of studies excluded at full text appraisal and reasons for their exclusion are provided in Appendix A. A 10% double appraisal was conducted at the three sifting levels, and good inter-rater agreement was achieved (first pass: 96.6%; second pass: 87.3%; full text: 100%).

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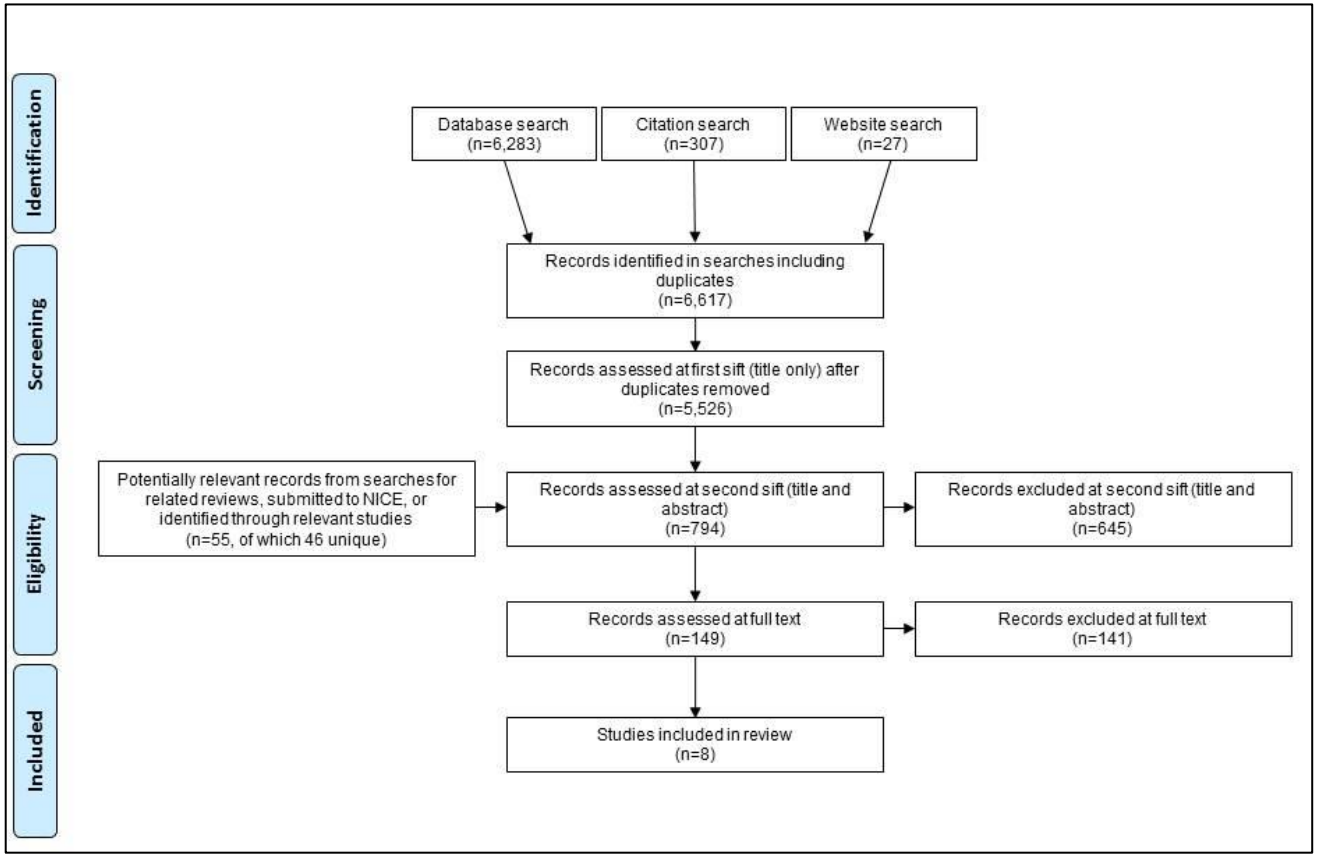
Figure 1: PRISMA flowchart



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Quality assessment and applicability appraisal

Quality was assessed using modified versions of the checklists in the draft NICE unified methods manual for 'quantitative studies reporting correlations and associations' for the correlation and cohort studies, and for 'quantitative intervention studies' for the RCT (see protocol in Appendix B for details). Modifications were made to remove less relevant items from the checklists (e.g. given the type of intervention being studies blinding was not feasible, therefore the item on blinding was removed), or to make more relevant to the current review by making the considerations under the individual items more specific (e.g. under item 4.2 in the correlation study checklist on analytical methods, querying whether there was adjustment for clustering of data in units/wards/hospitals, and adjustment/control for ward/unit/hospital characteristics where relevant).

Quality ratings include:

- [++] All or most of the checklist criteria have been fulfilled, and where they have not been fulfilled the conclusions are very unlikely to alter.
- [+] Some of the checklist criteria have been fulfilled, and where they have not been fulfilled, or are not adequately described, the conclusions are unlikely to alter.
- [-] Few or no checklist criteria have been fulfilled and the conclusions are likely or very likely to alter.

Methods of data extraction, synthesis and presentation

Study data was extracted into evidence tables based on the draft NICE unified manual (see Appendix). Evidence table templates were agreed with NICE prior to data extraction. All quantitative outcomes were verified by a second analyst.

The evidence was synthesised by outcome for each question, presented both narratively and summarised in table form.

In press information

The included study by Sandall et al. was in press at the time of drafting of this report. The version of Sandall et al. that was considered in this evidence review and by the Safe Staffing Advisory Committee was a draft version of the manuscript dated May 2014. That version underwent a full peer and editorial review process in line with the NIHR Journals Library policy. A later, corrected pre-publication version (not the final proof) was also seen and the evidence review updated in light of minor changes.

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4. Findings

Question 1: What maternal and neonatal activities and outcomes are associated with midwifery staffing at a local level?

Overview of studies

Eight studies were identified which assessed the relationship between outcomes and midwife staffing. The characteristics of these studies are summarised in Tables 1 and 2, with further details provided in the accompanying Evidence tables in Appendix D.

Seven of the 8 studies were observational. The eighth study was a cluster RCT with randomisation at the level of the geographical area. Broadly, the analyses provided by the 8 included studies were as follows:

- **Sandall et al. in press** (quality score ++) looked at the correlation between trust level midwife staffing and outcomes
- **Rowe et al. 2014** (quality score +) looked at the correlation between unit level midwife under staffing and outcomes
- **Cerbinskaite et al. 2011** (quality score -) looked at the association between delivery suite midwife staffing at the time of time of emergency C-section and outcomes
- **Gerova et al. 2010** (quality score +) looked at the correlation between trust level midwife staffing and outcomes
- **Tucker et al. 2003** (quality score +) looked at the association between unit staffing at the time of admission and outcomes
- **Joyce et al. 2002** (quality score +) and **Joyce et al. 2004** (quality score +) looked at the correlation between hospital level midwife staffing and outcomes using the same data set
- **North Staffordshire Changing Childbirth research team (NSCCRT) 2000** (quality score +) was a cluster RCT comparing the effects of midwifery caseload care versus traditional shared care on outcomes, and reported caseloads in both groups.

Five correlational studies assessed staffing levels averaged across the study time period and outcomes in that period (Sandall et al. in press [++], Rowe et al. 2014 [+], Gerova et al. 2010 [+], Joyce et al. 2002 [+], Joyce et al. 2004 [+]). Two cohort studies assessed the relationship between staffing levels at the time of each woman's admission/delivery (Tucker et al. 2003 [+]) or delivery (Cerbinskaite et al. 2011 [-]) and outcomes. The latter (Cerbinskaite et al. 2011 [-]) assessed staffing levels and each woman's outcome simultaneously (i.e. cross-sectionally).

The studies included between 1 unit or hospital and 64 units (where stated), with 2 studies assessing all births within 143 or 144 NHS trusts. The smallest study assessed 333 grade 1 and 2 emergency C-section births, while the largest assessed all 656,969 births across 143 NHS trusts.

The average midwife staffing levels in the observational studies were between 31.5 to 33.8 births per midwife full time equivalent (FTE) per annum where stated. The only study that reported consultant midwife staffing levels reported 1,642.5 births per consultant midwife FTE per annum across the 144 NHS trusts assessed (Gerova et al. 2010 [+]).

Seven studies covered maternal outcomes and 4 studies covered fetal/neonatal outcomes (some studies covered both types of outcomes).

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Methodological and applicability considerations

The 2 cohort studies and 1 RCT provide a more direct assessment of the potential for a causal association between staffing levels and outcomes, as the staffing levels are known to be in effect before (or at the same time as) the outcomes occur. In the correlational studies staffing levels and outcomes are both assessed as an average over the study period. Therefore they would not be able to detect changes in staffing levels and outcomes over time. This could reduce ability to detect relationship between midwife staffing and outcomes.

As outcomes are assessed at the same time as staffing levels in these correlational studies they may also be affected by reverse causation. For example, a unit may staff differently as a result of the case mix of women they see, potentially having higher staffing levels if they anticipate more complex case mixes. This could impact the relationships seen between staffing levels and outcomes if the case mix is not adequately adjusted for.

The 2 studies carrying out analyses at the trust level (Sandall et al. in press [++] and Gerova et al. 2010 [+]) would not be able to identify variation in outcomes associated with differences in staffing at the local (individual unit) level. This may also reduce ability to detect effect of staffing at the local level. However, due to the limited amount of data available assessing the impact of midwife staffing, these trust-level studies have been included.

The RCT reported caseloads for the two groups (35-40 women per midwife in the caseload group, a "caseload" of 100-150 women in the shared care group), but it was unclear how this related to overall staffing at the level of midwives per woman as the number of midwives was not clearly stated for the shared care group. Therefore, although the pattern of how the women were cared for was clear, it was not clear that overall the groups differed in the average number of women per midwife. In addition, the RCT aimed to compare models of care (specifically care division or distribution) rather than the effect of different staffing levels, and although staffing levels may have differed, the outcomes are likely to reflect the overall effect of the different models of care, rather than staffing levels specifically.

Only one study described any aspect of skill mix (Gerova et al. 2010 [+]), and it described the number of consultant midwives and midwives separately (unclear if the consultant midwives were included in the midwife total). None of the other studies explicitly described the skill mix, type or duties of the midwives. Four studies (Joyce et al. 2002 [+], Joyce et al. 2004 [+], Tucker et al. 2003 [+], Rowe et al. 2010 [+]) assessed midwife staffing at the hospital/obstetric unit level, these staffing figures presumably cover staff providing all midwifery care at that hospital/unit, which could include antenatal and postnatal care as well as intrapartum care. One study (Cerbinskaite et al. 2011 [-]) specifically looked at midwife staffing of the delivery suite at the time of delivery and therefore was focused specifically on intrapartum staffing. The RCT (NSCCRT 2000 [+]) looked at staffing within study areas, with duties for caseload midwives at least likely to cover all stages of care. The 2 studies assessed staffing at the trust level, which is also likely to include midwives involved in all stages of midwife care (Sandall et al. in press [++], Gerova et al. 2010 [+]).

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Table 1: Included study characteristics – study designs and participants

Study Quality score	Years studied	Country	Study design	# women/births /deliveries	Outcomes assessed	Key participant inclusions /exclusions
Sandall et al. in press Quality score: ++	2010-2011	UK (England)	Correlational	656,969 births	**Maternal:** Healthy mother (also composite healthy mother and baby), DwBI, SVD, intact perineum, normal birth, elective C-section, emergency C-section, all C-section **Fetal/neonatal:** Healthy baby (also composite healthy mother and baby)	None
Rowe et al. 2014 Quality score: +	2009-2010	UK (England)	Correlational	32,257 births	**Maternal:** Straightforward birth, normal birth, intrapartum C-section, IVD, epidural, augmentation **Fetal/neonatal:** None	Only low risk women with full term births planned to be in the obstetric unit included (C-sections before labour, multiple pregnancies, or stillbirths before labour were excluded)
Cerbinskaite et al. 2011 Quality score: -	2006	UK (England)	Cohort (cross sectional analysis)	333 grade 1 & 2 C-sections (5,167 births)	**Maternal:** Decision-to-delivery interval, transfer time to theatre, time between arrival in theatre to operation start **Fetal/neonatal:** None	Only grade 1 and 2 emergency C-section births included in midwife staffing analyses. Time of day analyses excluded elective C-section births
Gerova et al. 2010 Quality score: +	2008-2009	UK (England)	Correlational	615,042 women	**Maternal:** Maternal readmission within 28 days **Fetal/neonatal:** None	None
Joyce et al. 2004 Quality score: +	1994-1996	UK (England)	Correlational	540,834 births	**Maternal:** None **Fetal/neonatal:** Still birth, neonatal mortality	None

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Study Quality score	Years studied	Country	Study design	# women/births /deliveries	Outcomes assessed	Key participant inclusions /exclusions
Tucker et al. 2003 Quality score: +	2000	UK (Scotland)	Cohort	3,083 births	**Maternal:** None **Fetal/neonatal:** CEFM use, inappropriate or appropriate CEFM, lag time for senior doctor response to serious fetal heart trace abnormality, neonatal resuscitation	Only non-multiple, non-elective C-section live births included in analysis of fetal outcomes
Joyce et al. 2002 Quality score: +	1994-1996	UK (England)	Correlational	540,834 births	**Maternal:** C-section, epidural use in labour, IVD **Fetal/neonatal:** None	None
NSCCRT 2000 Quality score: +	NR	UK (England)	Cluster RCT	1,505 women	**Maternal:** Duration of labour, method of delivery (normal, IVD, emergency or elective C-section, multiple and breech delivery), gestation length, attended by known midwife, induction, augmentation, episiotomy, intact perineum, perineal laceration or tear **Fetal/neonatal:** Stillbirth and neonatal death, advanced neonatal resuscitation, admission to NNU, low birthweight	None

C-section caesarean section, CEFM continuous electronic fetal monitoring, DwBI delivery with bodily integrity, IVD instrumental vaginal delivery, NNU neonatal unit, NR not reported, NSCCRT North Staffordshire Changing Childbirth Research Team, RCT randomised controlled trial

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Table 2: Included study characteristics – units and staffing

Study (overall quality score)	# units/ hospitals/ trusts	Type(s) of delivery unit(s)	Level at which staffing assessed	Average midwife staffing level
Sandall et al. in press Quality score: ++	143 NHS trusts	Mixed. Consultant led with or without midwife led (alongside or freestanding)	Staffing at trust level (i.e. across all stages of care) across the study period	3.08 FTE midwives per 100 maternities (32.5 maternities per FTE midwife)
Rowe et al. 2014 Quality score: +	36 obstetric units	NR (likely consultant-led)	Staffing at the obstetric unit level across the study period	NR (median 29.6% of shifts per trust where number of women>number of midwives)
Cerbinskaite et al. 2011 Quality score: -	1 obstetric unit	NR (tertiary referral hospital)	Delivery suite staffing at the time of C-section	NR
Gerova et al. 2010 Quality score: +	144 NHS trusts	NR (likely to have been mixed)	Staffing at trust level (i.e. across all stages of care) across the study period	31.5 births per midwife FTE pa 1,642.5 births per consultant midwife FTE pa
Joyce et al. 2004 Quality score: +	64 obstetric units	Consultant-led	Staffing at hospital level across the study period	29.6 midwives per 1,000 deliveries pa (33.8 deliveries per midwife pa; unclear if FTE)
Tucker et al. 2003 Quality score: +	23 obstetric units	Consultant-led	Staffing on the unit at the time of admission (assessed 4 times a day)	NR (15% of observations where number of women>number of midwives)
Joyce et al. 2002 Quality score: +	64 obstetric units	Consultant-led	Staffing at hospital level across the study period	29.6 midwives per 1,000 deliveries pa (33.8 deliveries per midwife pa; unclear if FTE)
NSCCRT 2000 Quality score: +	1 hospital (32 GP practices in 6 areas)	NR (district general hospital)	Included community and hospital midwives, who provided all stages of care across the study period	NR (Caseload care group had a caseload of 35-40 women per midwife, standard care group had a caseload of 100-150 women)

FTE full time equivalent, GP general practitioner, NHS National Health Service, NR not reported

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The majority of the outcomes assessed by the studies related to intrapartum care, with some outcomes addressing postnatal care (mainly neonatal outcomes likely to occur while the neonate was still in hospital and one maternal readmission outcome). None of the studies assessed outcomes specifically relating to the antenatal period, such as access to antenatal care before 10 weeks, access to appropriate antenatal services for women with complex social factors, or women being offered a minimum set of antenatal test results.

None of the studies looked specifically at the relationship between midwife staffing in alongside or freestanding midwifery units or of midwives providing home births and outcomes.

The studies by Joyce et al. analysed data from 1994 to 1996, and the RCT was carried out prior to 2000, and their results may not be representative of current UK practice.

Summary of evidence/results

The evidence has been split by outcome into maternal and neonatal outcomes. A top level summary of findings of the association between midwife staffing levels and maternal and neonatal outcomes is presented in Table 3.

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Table 3: Overview of study results for Question 1

Outcome	Number of women/births n= (range)	Direction of effect of increased midwife staffing on outcome: (number of studies and quality score)		
		Increase	No association	Reduction
Maternal outcomes				
Delivery with bodily integrity	656,969	1 ++		
Attended by known midwife in labour	1,505	1 +		
Duration of labour	1,505	1 +		
Straightforward birth	32,257			1 +
Emergency C-section process timings	333			1 -
Maternal readmissions within 28 days	615,042			1 +
Any caesarean section	540,834 to 656,969		1 ++, 1 +	
Elective caesarean section	1,505 to 656,969		1 ++, 1 +	
Healthy mother	656,969		1 ++	
Normal birth	1,505 to 656,969		1 ++, 2+	
Non-intact perineum	1,505		1 +	
Multiple and breech delivery	1,505		1 +	
Instrumental vaginal delivery	1,505 to 540,834		3 +	
Spontaneous vaginal delivery	656,969		1 ++	
Induction	1,505		1 +	
Intact perineum	1,505 to 656,969	1 ++	1 +	
Emergency caesarean section	1,505 to 656,969	1 +	1 ++, 1 +	
Augmentation	1,505 to 32,257	1 +		1 +
Epidural use	1,505 to 540,834		2 +	1 +
Maternal mortality or never events	No evidence			
Other delivery of care outcomes	No evidence			
Fetal/neonatal outcomes				
Healthy baby	656,969		1 ++	
Stillbirth and neonatal mortality	1,505 to 540,834		2 +	
Neonatal resuscitation	1,505 to 3,083		1 +	1 +
Neonatal unit admission	1,505 to 3,083		2 +	
Gestational length	1,505		1 +	
Low birth weight	1,505		1 +	
Apgar score of <7 at 5 minutes	3,083		1 +	
Continuous electronic fetal monitoring	3,083		1 +	
Other fetal/neonatal outcomes	No evidence			

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Maternal outcomes

Seven studies assessed maternal outcomes (Sandall et al. in press [++]; Rowe et al. 2014 [+]; Cerbinskaite et al. 2011 [-]; Gerova et al. 2010 [+]; Tucker et al. 2003 [+]; Joyce et al. 2002 [+]; NSCCRT 2000 [+]) and their results are summarised in Tables 4 to 6. Similar outcomes have been grouped together, with sections for overall and perineal outcomes, mode of birth outcomes, and delivery of care outcomes. However, many of the outcomes are related (e.g. some outcomes are composites of other outcomes which have also been assessed).

Overall and perineal outcomes

One large correlational study (Sandall et al. in press [++]) across 143 NHS trusts in England (656,969 births) reported on the composite outcome of **"healthy mother"** (delivery with bodily integrity, return home in 2 days or less, and no instrumental delivery, maternal sepsis, anaesthetic complication, or readmission within 28 days). It found no significant association between the ratio of FTE midwives to maternities at trust level and the healthy mother outcome, although the direction of effect was towards a small benefit (OR 1.088, 95% CI 0.963 to 1.230, p=0.1759).

When it looked at **delivery with bodily integrity** alone (no uterine damage, 2nd/3rd/4th degree tear, stitches, episiotomy, or C-section) higher midwife staffing was associated with a small but significant increase in odds of delivery with bodily integrity (OR 1.110, 95% CI 1.005 to 1.227, p=0.0399).

The study carried out sensitivity analyses in the 50 trusts with only a single obstetric unit (i.e. reducing the analyses to effectively a unit level analysis plus home births within the trust). These analyses found that the size of the effect of midwife staffing on delivery with bodily integrity (β increased from 0.105 to 0.113) and intact perineum (main analyses for the latter reported below, β increased from 0.124 to 0.147, ORs not reported) increased relative to the trust level analyses, but the relationship became non-significant. This suggests that the effect of midwife staffing may remain when analysed at the unit level, but that these analyses lack power to detect this effect.

This large correlational study (Sandall et al. in press [++]) and one RCT (NSCCRT 2000 [+]) looked at the outcome of **intact perineum**. Sandall et al. in press [++] found that higher midwife staffing was associated with increased odds of intact perineum (OR 1.132, 95% CI 1.010 to 1.268, p=0.0324). The RCT compared caseload midwifery (35-40 women per midwife) versus shared care (caseload reported as 100-150 women, but midwives would share care of these women). It found no significant difference in likelihood of having an intact perineum between the groups (absolute risk 48% with caseload care vs. 49% with shared care, p=0.72). The RCT also found no significant difference between caseload care and shared care in **perineal laceration**, **tears**, or **episiotomy**. The differences between groups in the RCT for these outcomes were very small, but tended to favour shared care.

The RCT found that the **duration of labour** was significantly longer in the caseload group than the shared care group (duration <8 hours: 58.5% with caseload care vs. 68.4% with shared care; p≤0.001 for trend across durations). The authors suggested that this could be due to earlier identification of labour in the caseload group, with midwives seeing women at home.

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Table 4: Summary of association between midwife staffing and maternal outcomes (overall and perineal outcomes; plus one mode of birth outcome)

Study	Staffing variable	Healthy mother*	Delivery with bodily integrity*	Duration of labour	Intact perineum	Perineal laceration	Perineal tear	Episiotomy	Multiple and breech delivery
Sandall et al. in press	FTE midwives/100 maternities	(↑) OR 1.088 (95% CI 0.963 to 1.230, p=0.1759)	↑ OR 1.110 (95% CI 1.005 to 1.227, p=0.0399)		↑ OR 1.132 (95% CI 1.010 to 1.268, p=0.0324)				
NSCCRT 2000 (AR figures)‡	Caseload vs. standard care			↓ <8 hours: 58.5% vs. 68.4% (p <0.001 trend across all durations)	(↓) 48% vs. 49% (p=0.72)	(↓) 24.6% vs. 24.5% (p=0.67)	(↓) 32.2% vs. 30% (p=0.40)	(↑) (23.5% vs. 24%) (p=0.94)	(=) 2% vs. 2% (p=0.15 trend across all modes of delivery)

↑ Significantly better outcome with increased staffing; ↓ significantly worse outcome with increased staffing; ( ) bracketed arrows indicate non-significant effects; (=) equivalent outcomes; (≈) no reported or no clear direction of non-significant effect. Effects shown for the most adjusted analyses. ‡Unadjusted results

*Composite outcomes, definitions: *Healthy mother:* delivery with bodily integrity (DwBI), return home in ≤2 days, and no instrumental delivery, maternal sepsis, anaesthetic complication, or readmission within 28 days; *DwBI:* no uterine damage, 2nd/3rd/4th degree tear, stitches, episiotomy, or C-section.

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Mode of birth outcomes

Table 5 summarises the 4 studies reporting on mode of birth outcomes (Sandall et al. in press [++]; Rowe et al. 2014 [+]; Joyce et al 2002 [++]; NSCCRT 2000 [+]). These were the most commonly reported types of outcomes across studies. Overall few outcomes showed statistical significance.

Three studies found no significant effect of midwife staffing levels on **"normal birth"**, although the direction of effect tended to be towards small benefit with higher staffing (Sandall et al. in press [++]; Rowe et al. 2014 [+]; NSCCRT 2000 [+]). The two observational studies (Sandall et al. in press [++]; Rowe et al. 2014 [+]) used the same definition of normal birth (no induction, instrumental delivery, C-section, episiotomy or general or regional anaesthetic), while the RCT (NSCCRT 2000 [+]) did not provide an explicit definition of normal birth, but it appeared to exclude instrumental delivery, C-section, or multiple and breech delivery.

One large correlational study (Sandall et al. in press [++]) (656,969 births) found that midwife staffing at trust level was not associated with the likelihood of normal birth (OR 1.062, 95% CI 0.968 to 1.166, p=0.2048).

One RCT (NSCCRT 2000 [+])(1,505 women) found no significant difference between caseload and shared care in normal births (not defined, appeared to exclude instrumental delivery, C-section, or multiple and breech delivery; 70% with caseload care vs. 69% with shared care, p=0.15 for overall comparison of modes of delivery).

One correlational study (Rowe et al. 2014 [+]) (32,257 births) found no significant association between midwife staffing at the unit level and normal birth among low risk women with a term birth which was planned to be in the obstetric unit (nulliparous women: R^2 0.1%, ß=0.01, p=0.89; multiparous: R^2 1.7%, ß=-0.05, p=0.48; direction of betas reported in the text here have been inverted from those reported in the original paper to reflect the effect of higher staffing rather than lower staffing, as analyses in the paper were based on % "understaffed" shifts, where women outnumbered midwives on the delivery suite/labour ward).

Three studies assessed the effect of midwife staffing levels on **epidural use** (Rowe et al. 2014 [+], Joyce et al. 2002 [+], NSCCRT 2000 [+]) and found some suggestion that increased staffing may be associated with a reduction in this outcome.

One correlational study (Rowe et al. 2014 [+]) (32,257 births) found no significant association between midwife staffing and epidural use, although the direction of effect was towards a small reduction in nulliparous women (nulliparous: R^2 0.9%, ß=-0.05, p=0.59; multiparous: R^2 0%, ß=0.00, p=0.94). A second correlational study (Joyce et al. 2002 [+]) (540,834 births) found that increased midwife staffing at the hospital level was associated with reduced epidural use in labour (i.e. not in C-sections) in univariate analyses (R^2 0.081, ß=-0.532, p=0.049). However, the effect was no longer significant in multivariate analyses, with the final model including only father being in manual or 'other' social class, and woman being 40 years old or older, suggesting that differences seen in the univariate analysis may be related to these differences. One RCT (NSCCRT 2000)(1,505 women) found that caseload care (where midwives had lower caseloads) reduced epidural use (not specified if all epidural use or use in labour) compared with shared care (10.4% with caseload care vs. 15% with shared care, p=0.01).

Three studies found no significant effect of midwife staffing levels on the outcome of **instrumental vaginal delivery** (Rowe et al. 2014 [+]; Joyce et al. 2002 [+]; NSCCRT 2000 [+]). In general the

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direction of the non-significant effects were towards a small benefit with increased midwife staffing, except for in multiparous low risk women with term births (Rowe et al. 2014 [+]).

One correlational study (Rowe et al. 2014 [+]) (32,257 births) found no significant associations between midwife staffing at the unit level and instrumental delivery among low risk women with a term birth which was planned to be in the obstetric unit (nulliparous: R^2 0.2%, ß=-0.02, p=0.80; multiparous: R^2 5.6%, ß=0.04, p=0.07; direction of betas reported here inverted from those reported in the original paper to reflect the effect of higher staffing for consistency with other studies). A second correlational study (Joyce et al. 2002 [+]) (540,834 births) found no significant association between midwife staffing at the unit level and instrumental delivery in univariate analysis (R^2 0.055, ß=-0.087, p=0.105). The RCT (NSCCRT 2000 [+])(1,505 women) found no significant difference between caseload care and shared care in instrumental vaginal delivery (10% with caseload care vs. 11.5% with shared care; p=0.15 for comparison across all modes of delivery).

Two studies assessed the effect of midwife staffing on **caesarean sections** (C-sections) as a whole (Sandall et al. in press [++]; Joyce et al. 2002 [+]).

One large correlational study (Sandall et al. in press [++]) found no significant association between midwife staffing at the trust level and C-sections overall (OR 1.000, 95% CI 0.919 to 1.087, p=0.9962). Another large correlational study (Joyce et al. 2002 [+]) found no significant association between midwife staffing at the hospital level and C-sections overall in univariate analyses, although the direction of effect was towards a reduction (R^2 0.038, ß=-0.117, p=0.181).

Two studies (Sandall et al. in press [++]; NSCCRT 2000) assessed the effect of midwife staffing on both **elective C-sections** and **emergency C-sections** separately. In both cases there were no significant effects, but in both studies the trend was for small increases in elective C-sections with increased midwife staffing and reduced emergency C-sections with increased midwife staffing. The large correlational study (Sandall et al. in press [++]) (656,969 births) assessed midwife staffing at the trust level and found an OR of 1.032 (95% CI 0.936 to 1.137, p=0.5303) for elective C-sections and an OR of 0.978 (95% CI 0.897 to 1.066, p=0.6085) for emergency C sections. The smaller RCT found similar trends for the caseload care group (which had lower caseloads) compared to the standard care group (elective C-section: 10% with caseload care vs. 7% with shared care; emergency C-section: 8% with caseload care vs. 10.5% with shared care; p=0.15 for overall comparison of modes of delivery).

However, the direction of effect for emergency C-sections differed in the correlational study by Rowe et al. 2014 [+] (32,257 births to low risk women planned as vaginal births in the obstetric unit). It assessed intrapartum C-sections only (i.e. excluding those performed before labour). This is likely to exclude elective C-sections, also only births planned to be vaginal were included, this means that the intrapartum C-sections are likely to be emergency (i.e. unplanned) C-sections. It stratified analyses by parity, and found that increased midwife staffing (less under-staffing) at the unit level was associated with a significant increase in intrapartum C-section rates in nulliparous women, but not multiparous women, although the direction of effect was the same (nulliparous: R^2 17.6%, ß=0.10, p=0.03; multiparous: R^2 12.6%, ß=0.05, p=0.11; direction of betas reported here inverted from those reported in the original paper to reflect the effect of higher staffing for consistency with other studies). The fact that it only includes low risk women who planned to give birth vaginally (rather than all women) and that its approach to analysis used percentage of shifts with understaffing rather than actual staffing levels could contribute to the differences seen to the other studies.

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Two studies assessed use of labour **augmentation**, and found conflicting results. One correlational study (Rowe et al. 2014 [+]) (32,257 births) found that this was significantly increased with increased midwife staffing in multiparous women, the direction and magnitude of the increase were similar in nulliparous women but did not reach significance (multiparous: R^2 11.1%, ß=0.09, p=0.05; nulliparous: R^2 5.6%, ß=0.10, p=0.16). The reason for the difference in significance was not clear, but may relate to the power of the individual analyses (numbers of nulliparous and multiparous women not reported separately). The RCT found that augmentation with oxytocin was significantly less common with caseload care (where midwife caseload was lower) than with shared care (46% with caseload care vs. 53% with shared care, p=0.01).

Individual studies assessed the outcomes of spontaneous vaginal delivery, straightforward birth, and induction.

The correlational study (Rowe et al. 2014 [+]) (32,257 births) assessed the effect of midwife staffing and **straightforward birth** (defined as birth without forceps or ventouse, intrapartum caesarean section, third or fourth degree perineal trauma or blood transfusion). It stratified analyses by parity and did not report results pooled across parities. It found that increased midwife staffing in the delivery suite was associated with a reduced likelihood of straightforward birth in multiparous women (R^2 15.1%, ß=-0.08, p=0.01), the direction of effect was the same for nulliparous women but this relationship did not reach significance (R^2 3.5%, ß=-0.06, p=0.31; direction of betas inverted from those reported in the original paper to reflect the effect of higher staffing). Overall, the study authors noted that chance could not be ruled out for the midwife staffing findings as results were not consistently significant across multiple outcomes.

One large correlational study (Sandall et al. in press [++]) (656,969 births) found that midwife staffing at trust level was not associated with **spontaneous vaginal delivery** (OR 1.025, 95% CI 0.948 to 1.109, p=0.5362).

One RCT (NSCCRT 2000 [+]) found no effect of caseload care (lower midwife caseload) on **induction** (17.4% with caseload care vs. 18% with shared care, p=0.78) or on **multiple and breech delivery** (2% in both groups, p=0.15 for comparison across all modes of delivery, reported in Table 4).

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Table 5: Summary of association between midwife staffing and maternal outcomes (mode of birth)

Study	Staffing variable	Normal birth*	Straight-forward birth	Spontaneous vaginal delivery	Instrumental vaginal delivery*	Elective C-section	Emergency C-section	Any C-section	Epidural	Induction	Augment-ation
Sandall et al. in press [++]	FTE midwives/100 maternities	(↑) OR 1.062 (95% CI 0.968 to 1.166, p=0.2048)		(↑) OR 1.025 (95% CI 0.948 to 1.109, p=0.5362)		(↓) OR 1.032 (95% CI 0.936 to 1.137, p=0.5303)	(↑) OR 0.978 (95% CI 0.897 to 1.066, p=0.6085)	(=) OR 1.000 (95% CI 0.919 to 1.087, p=0.9962)			
Rowe et al. 2014 [+]	Less midwife under staffing (<1 midwife per woman)‡	Nullip (↑) B 0.01 (p=0.89) Multip (↓) B -0.05 (p=0.48)	Nullip (↓) B -0.06 (p=0.31) Multip ↓ B -0.08 (p=0.01)		Nullip (↑) B -0.02 (p=0.80) Multip (↓) B 0.04 (p=0.07)		Nullip¶ ↓ B 0.10 (p=0.03) Multip¶ (↓) B 0.05 (p=0.11)		Nullip (↑) B -0.05 (p=0.59) Multip (=) B 0.00 (p=0.94)		Nullip (↓) B 0.10 (p=0.16) Multip (↓) B 0.09 (p=0.05)
Joyce et al 2002 [+]†	Midwives/1000 deliveries/year				Univariate (↑) B -0.087 (p=0.105)			Univariate (↑) B -0.117 (p=0.181)	Univariate ↑ B -0.532 (p=0.049) Multivariate NS		

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Study	Staffing variable	Normal birth*	Straight-forward birth	Spontaneous vaginal delivery	Instrumental vaginal delivery*	Elective C-section	Emergency C-section	Any C-section	Epidural	Induction	Augment-ation
NSCCRT 2000 [+] (AR figures)†	Caseload vs. standard care	(↑) 70% vs. 69% (p=0.15 for trend across all modes of delivery)			(↑) 10% vs. 11.5% (p=0.15 for trend across all modes)	(↓) 10% vs. 7% (p=0.15 for trend across all modes)	(↑) 8% vs. 10.5% (p=0.15 for trend across all modes)		↑ 10.4% vs. 15% (p=0.01)	(↑) 17.4% vs. 18% (p=0.78)	↑ 46% vs. 53% (p=0.01)

↑ Significantly better outcome with increased staffing; ↓ significantly worse outcome with increased staffing; = equivalent outcome; ( ) brackets around arrows indicate non-significant directions of effect with increased staffing. Effects are shown for the most adjusted analyses presented in the study. †Unadjusted results. ‡Results are reported in a way that shows association with higher staffing (i.e. less under staffing). ¶ Intrapartum C-section (i.e. not those performed before labour. NS not significant. *Composite outcome definitions: *Normal birth:* Sandall and Rowe studies - no induction, instrumental delivery, C-section, episiotomy or general or regional (epidural or spinal) anaesthetic; NSCCRT study – not explicitly defined, based on reporting in results table appeared to exclude instrumental delivery, C-section, or multiple and breech delivery. *Straightforward birth:* no instrumental delivery, intrapartum C-section, 3rd or 4th degree perineal trauma or blood transfusion. *Instrumental vaginal delivery:* delivery using forceps or ventouse. Nullip nulliparous, multip multiparous

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Delivery of care

Table 6 summarises the 3 studies that assessed delivery of care outcomes (Cerbinskaite et al. 2011 [-]; Gerova et al. 2010 [+];NSCCRT 2000 [+]). This outcome group showed the most significant associations with midwife staffing. However, these outcomes were each only assessed in a single study, which reduces confidence in their validity.

One cross sectional analysis of a cohort study (Cerbinskaite et al. 2011 [-]) (333 grade 1 and 2 emergency C-sections) looked at the relationship between midwife staffing at the time of emergency C-section and whether the **decision-to-delivery interval** was within 30 minutes (reported to be based on NICE recommended optimal decision-to-delivery interval for C-sections in cased of confirmed or suspected acute fetal compromise). It found that the decision-to-delivery interval was significantly more likely to be less than 30 minutes if there was 1 midwife per labouring woman (MW:LW) on the delivery suite or more (grade 1 C-section: 93.9% with MW:LW ≥1 vs. 55.0% with MW:LW <1, p<0.001; grade 2 C-section: 53.6% with MW:LW ≥1 vs. 11.6% with MW:LW <1, p<0.001).

The study also looked at **transfer time to the operating theatre**. Again it found that transfer time was significantly more likely to be less than 15 minutes if there was 1 midwife per labouring woman (MW:LW) or more on the delivery suite (grade 1 C-section: 98.8% with MW:LW ≥1 vs. 85.0% with MW:LW <1, p<0.001; grade 2 C-section: 92.3% with MW:LW ≥1 vs. 67.4% with MW:LW <1, p<0.001).

The study found no effect of midwife staffing on **interval between arrival in theatre and start of the operation** (figures and p value not reported). As staffing was assessed at the time of the C-section this study offers a more temporally linked assessment of staffing and outcome than most other studies. However, the analyses were still essentially cross sectional, and as such cannot establish cause and effect.

One correlational study (Gerova et al. 2010 [+]) (615,042 women) looked at the relationship between midwife staffing at the trust level and **maternal readmissions within 28 days**. It found that higher midwife staffing was associated with significantly reduced risk of maternal readmission (β=-4.810, 95% CI -4.873 to -4.743, p<0.001).

One RCT (NSCCRT 2000 [+]) found that women receiving caseload care were significantly more likely to be attended by a known midwife or midwifery partner in labour than those receiving shared care (94.7% with caseload care vs. 6.7% with standard care, p<0.001).

No studies addressed maternal death as an outcome, or never events such as maternal death due to post- partum haemorrhage after elective caesarean section, wrongly prepared high-risk injectable medication, intravenous administration of epidural medication, or retained foreign objects post-procedure.

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Table 6: Summary of association between midwife staffing and maternal outcomes (delivery of care)

Study	Staffing variable	Emergency C-section decision-to-delivery interval <30 minutes	Transfer time to theatre <15 min	Pre-operative time in theatre	Attended by known midwife or midwifery partner in labour	Maternal readmission to hospital
Cerbinskaite et al. 2011 [-]	Midwife: labouring woman ratio Interval <30 min 1:1 or better vs. worse than 1:1†	Grade 1CS ↑ 93.9% vs. 55.0% (p<0.001) Grade 2CS ↑ 53.6% vs. 11.6% (p<0.001)	Grade 1CS ↑ 98.8% vs. 85.0% (p<0.001) Grade 2CS ↑ 92.3% vs. 67.4% (p<0.001)	Grade 1CS (≈) Grade 2CS (≈) (figures not reported)		
Gerova et al. 2010 [+]	Midwife FTE per birth (midwife ratio)					↑ B -4.810 (95% CI -4.873 to -4.746)
NSCCRT 2000 [+]†	Caseload vs. standard care				↑ 94.7% vs. 6.7% p=0.001	

↑ Significantly better outcome with increased staffing; ↓ significantly worse outcome with increased staffing

( ) Brackets indicate non-significantly directions of effect with increased staffing; (=) equivalent effect; (≈) no reported or no clear direction of non-significant effect.

Effects shown for the most adjusted analyses. † Unadjusted analyses.

*Composite outcomes, definitions below:

Inappropriate CEFM – Either given CEFM when there was no recorded indication for its use, or not given CEFM if there was a recorded indication for its use.

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Fetal/neonatal outcomes

Table 7 summarises the findings of the 4 studies (Sandall et al. in press [++], Joyce et al. 2004 [+], NSCCRT 2000 [+], Tucker et al. 2003 [+]) assessing the link between midwife staffing levels and fetal/neonatal outcomes.

One large correlational study (Sandall et al. in press [++]) across 143 NHS trusts in England (656,969 births) reported on the composite outcome of **"healthy baby"** (baby's weight 2.5 to 4.5 kg, gestational age 37 to 42 weeks, and live baby). It found no significant effect of midwife staffing on the healthy baby outcome, although the direction of effect was towards a small benefit (OR 1.029, 95% CI 0.912 to 1.161, p=0.6456). In sensitivity analyses that excluded preterm births and stillbirths, midwife staffing levels were associated with a greater effect on healthy baby outcome although this did not reach significance (OR 1.172, 95% CI 0.991 to 1.387, p=0.063).

One large correlational study (Joyce et al. 2004 [+]) and one RCT (NSCCRT 2000 [+]) assessed **stillbirth and neonatal mortality** rates. The correlational study (540,834 births) found no significant effect of midwife staffing on still birth or neonatal mortality in univariate analyses, with opposite directions of the non-significant effects for the two outcomes (still birth: ß=0.012, p=0.65; neonatal mortality: ß=-0.012, p=0.50; rates standardised for birthweight). The authors reported that no avoidable factors relating to midwifery care were seen for any of the deaths.

The RCT (NSCCRT 2000 [+])(1,505 women) pooled still birth and neonatal mortality rates, and found no significant difference in this outcome between caseload and standard care, although there rate was approximately halved in the caseload care group (0.7% with caseload care vs. 1.5% with standard care, difference -0.8%, 95% CI -1.8% to 0.2%, p=0.28). The RCT lacked power to assess an effect on this outcome (it would have needed 4,000 women in each arm to have 85% power to detect this level of difference as statistically significant at the p≤0.05 level).

One cohort study (Tucker et al. 2003 [+]) (3,083 live births) looked at the relationship between midwife staffing at the time of admission and **use of continuous electronic fetal monitoring** (CEFM). It found no significant difference between the ratio of available to required midwives (based on Birthrate Plus) and use of CEFM (OR 1.00, 95% CI 0.77 to 1.29), inappropriate use of CEFM (includes use of CEFM when not indicated and lack of use when indicated; OR 1.44, 95% CI 0.85 to 2.45), appropriate use of CEFM for high risk cases (OR 0.90, 95% CI 0.63 to 1.30), or appropriate use of CEFM for low risk cases (OR 1.12, 95% CI 0.85 to 1.47). There was also no significant effect of workload at the time of detection of a serious fetal heart trace abnormality and time to senior medical response, although the direction of the effect was towards benefit (ß=-7.8 minutes, 95% CI -52.4 to 36.8 minutes).

The RCT (NSCCRT 2000 [+]) and cohort study described above (Tucker et al. 2003 [+]) assessed the effect of midwife staffing on **neonatal resuscitation**. The RCT (1,505 women) found no significant difference between caseload and standard care in use of advanced resuscitation (intubation and ventilation: 1.2% with caseload care vs. 0.8% with standard care; difference 0.4%, 95% CI -0.6% to 1.4%; p=0.51). The cohort study (3,083 live births) assessed the impact of the ratio of available to required midwives immediately at or before the time of birth, with the required numbers of midwives calculated using Birthrate Plus. It found that higher midwife staffing was associated with a small but statistically significant reduction in the use of neonatal resuscitation not including resuscitation with bag and mask only (OR 0.97, 95% CI 0.94 to 0.99). The direction of effect for all neonatal

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resuscitation including resuscitation with bag and mask only was also towards benefit with a higher staffing ratio, but this did not quite reach significance (OR 0.98, 95% CI 0.96 to 1.00).

The RCT and cohort study also assessed the effect of midwife staffing on **admission to the neonatal unit** (NNU). The RCT (NSCCRT 2000 [+]) found no significant difference between caseload and standard care in admission to the NNU, with the direction of effect favouring the higher caseload shared care group (5.8% with caseload care vs. 4.6% with shared care; difference 1.2%, 95% CI -0.8% to 3.2%; p=0.34). The cohort study (Tucker et al. 2003 [+]) also found no difference between midwife staffing level and admission to the NNU for over 48 hours, although the direction of effect was towards small benefit with higher staffing (OR 0.97, 95% CI 0.95 to 1.00).

The RCT (NSCCRT 2000 [+]) found no significant difference between caseload and shared care in **gestation length** (p=0.16 for trend) or **low birth weight** (<2.5 kg: 6.7% with caseload care vs. 6.9% with standard care; difference -0.2%, 95% CI -2.2% to 1.7%; p=0.96). The cohort study by Tucker et al. 2003 [+] found no significant effect of the ratio of available to required midwives at or before the time of birth on **Apgar score of <7 at 5 minutes** (OR 0.98, 95% CI 0.94 to 1.04).

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Table 7: Summary of association between midwife staffing and fetal/neonatal outcomes

Study	Staffing variable	Healthy baby*	Still birth and neonatal mortality	Gestation length	Low birth weight (<2.5kg)	Apgar <7 at 5 minutes	Neonatal re-suscitation*	Overall CEFM use and appropriate CEFM	In-appropriate CEFM	Time to response to fetal heart trace abnormality	Admission to the NNU
Sandall et al. in press [++]	FTE midwives/100 maternities	(↑) OR 1.029 (95% CI 0.912 to 1.161, p=0.6456)									
Joyce et al. 2004 [+]	Midwives/1000 deliveries		**Still birth:** (↓) ß 0.012† (p=0.65) **Neonatal mortality:** (↑) ß -0.012† (p=0.50)								
NSCCRT 2000 [+] (AR figures)†	Caseload vs. standard care		(↑) 0.7% vs. 1.5% (p=0.28)	(≈) (p=0.16 for trend)	(↑) 6.7% vs. 6.9% (p=0.96)		**Advanced:** (↓) 1.2% vs. 0.8% (p=0.51)				(↓) 5.8% vs. 4.6% (p=0.34)

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Study	Staffing variable	Healthy baby*	Still birth and neonatal mortality	Gestation length	Low birth weight (<2.5kg)	Apgar <7 at 5 minutes	Neonatal re-suscitation*	Overall CEFM use and appropriate CEFM	In-appropriate CEFM	Time to response to fetal heart trace abnormality	Admission to the NNU
Tucker et al. 2003 [+]	Ratio of available to required midwives‡					(↑) OR 0.98 (95% CI 0.94 to 1.04)	**Any:** (↑) OR 0.98 (95% CI 0.96 to 1.00) **Excluding bag/mask only:** ↑ OR 0.97 (95% CI 0.94 to 0.99)	**Overall:** (=) OR 1.00 (95% CI 0.77 to 1.29) **Appropriate CEFM in high risk women:** (↓) OR 0.90 (95% CI 0.63 to 1.30) **Appropriate CEFM in low risk women:** (↑) OR 1.12 (95% CI 0.85 to 1.47)	(↓) OR 1.44 (95% CI 0.85 to 2.45)	(↑) B -7.8 minutes 95% CI -52.4 to 36.8)	(↑) OR 0.97 (95% CI 0.95 to 1.00)¶

↑ Significantly better outcome with increased staffing; ↓ significantly worse outcome with increased staffing. ( ) Brackets indicate non-significant directions of effect with increased staffing Effects shown for the most adjusted analyses reported in the study. † Unadjusted analyses. ‡ Based on Birthrate Plus. ¶ Admission to NNU >48 hours. *Composite outcome definitions: *Healthy baby:* baby's weight 2.5 to 4.5 kg, gestational age 37 to 42 weeks, and live baby. *Any neonatal resuscitation:* bag and mask with or without drugs, intubation for intermittent positive pressure ventilation with or without drugs, or drugs only (does not include facial oxygen). *Neonatal resuscitation excluding bag/mask only:* any resuscitation excluding resuscitations with bag and mask and no drugs. *Advanced neonatal resuscitation:* intubation and ventilation

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Evidence statement 1: Midwife staffing levels and maternal and fetal/neonatal outcomes

Evidence from 1 UK RCT[1] ([+] 1,505 women), 1 UK cohort study[2] ([+] 3,083 live births), 1 cross sectional analysis of a UK cohort study[3] ([-] 333 caesarean sections) and 5 UK correlational studies[4-8] ([++] 656,969 births[4]; [+] 540,834 births[5,6]; [+] 615,042 women[7]; [+] 32,257 births[8]) suggests that:

Maternal outcomes

- Higher midwife staffing may be associated with increased likelihood of 'delivery with bodily integrity'[4], longer labour[1], and attendance by a known midwife in labour[1]
- Higher midwife staffing levels may be associated with reduced decision-to-delivery time and theatre transfer time for emergency C-sections[3], and reduced likelihood of maternal readmission within 28 days[7]
- There is no association between midwife staffing and 'healthy mother'[4], 'normal birth'[2,4,8], instrumental vaginal delivery[5,8], overall caesarean sections[4,5], elective caesarean sections[1,4], spontaneous vaginal delivery[4], use of induction[1], multiple and breech deliveries[1] or preoperative time in theatre for emergency C-sections[3]
- There was conflicting evidence (a mixture of significant and non-significant associations) on the association with perineal outcomes[1,2], epidural use[1,4,8], emergency caesarean sections[1,4,8], augmentation[1,8], and 'straightforward birth'[8]
- No evidence was identified regarding maternal mortality or other never events, or other delivery of midwifery care outcomes

Fetal/neonatal outcomes

- There is no association between midwife staffing levels and the fetal/neonatal outcomes 'healthy baby'[4], stillbirth[1,6], neonatal mortality[1,6], neonatal unit admission[1], gestation length[1], low birth weight[1] and Apgar score[2] and use of continuous electronic fetal monitoring[2]
- Mixed evidence was identified regarding the association with different levels of neonatal resuscitation (significant and non-significant effects)[1,2]
- No evidence was identified regarding other serious neonatal events, including Erb's palsy secondary to shoulder dystocia, meconium aspiration syndrome, hypoxic ischaemic encephalopathy (HIE).

[1] NSCCRT 2000 [+]
[2] Tucker et al. 2003 [+]
[3] Cerbinskaite et al. 2011 [-]
[4] Sandall et al. in press [++]
[5] Joyce et al. 2002 [+]
[6] Joyce et al. 2004 [+]
[7] Gerova et al. 2010 [+]
[8] Rowe et al. 2014 [+]

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Questions 2-6: What factors affect safe midwifery staffing at a local level?

Questions 2 to 6 aim to identify potential modifiers of the relationship between midwife staffing levels and outcomes. Modifiers would affect the midwife staffing levels required to achieve an specified outcome. For example, the presence of a given modifier (e.g. a large proportion of women with low clinical risk, or more consultant obstetricians on the ward) might make it possible to achieve the same level of safety with lower midwife staffing levels than if the modifier wasn't present (e.g. if there were few or no women with low clinical risk, or there were fewer consultant obstetricians on the ward), or vice versa.

The potential modifying factors addressed in this review are:

- Maternal and neonatal factors
- Environmental factors
- Staffing factors
- Management factors
- Organisational factors

Ideally, studies looking for factors that influence the relationship between midwifery staffing and maternal and neonatal outcomes would do this in a direct way. For example, this could be by splitting the population into those with and without a particular modifier (stratifying) and looking at the effect of midwife staffing levels in the two different groups. If the effect in the two groups is significantly different, this would suggest that the factor is modifying the effect of midwife staffing (an interaction effect).

Few studies were identified which took this approach to looking at modifier variables, and the only variables assessed in this way were maternal factors. Only the study by Sandall et al. (in press) carried out formal interaction analyses for some maternal variables (clinical risk and parity), while a few studies stratified at least some of their analyses by individual maternal factors (Rowe et al. 2014 [+]; Cerbinskaite et al. 2011 [-], Tucker et al. 2003 [+]), but did not formally look for interaction between these and the effects of midwife staffing. Without statistical tests for interaction firm conclusions about their effect on safe midwife staffing requirements cannot be drawn.

To address this the previous evidence reviews for the first NICE safe staffing guideline (on safe nurse staffing in adult acute care wards) the review assumed that the presence of a significant relationship between a factor of interest and an outcome after adjustment for staffing levels identified a factor which might modify the effect of nurse staffing or require different levels of nurse staffing to achieve similar outcomes when it was not present. This approach was taken for the patient-related, staffing, and geographical factors. For management approaches and organisational factors, the review first identified the outcomes which were potentially influenced by nurse staffing levels, and then focused on these outcomes in the questions which these potential modifiers.

The current review has assessed only the most directly relevant evidence to answer these questions, i.e. studies which attempt to explicitly link the factors of interest with midwifery staffing levels and outcomes (direct evidence), or that have assessed the impact of factors of interest as well as midwife staffing on outcomes, noting whether the analyses adjusted for midwife staffing. The latter studies only offer indirect evidence of a potential effect of the factors on safe nurse staffing. It is also worth noting that other studies which assess the effect of these factors on outcomes may exist, these would not have been picked up by the search unless they included some mention of midwife staffing.

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The same 8 studies described under Question 1 above form the evidence base for Questions 2 to 6. Table 8 summarises the results of the studies included for each question:

- 7 of the studies were included for Question 2 (maternal and neonatal factors)
- 6 of the studies were included for Question 3 (environmental factors)
- 5 of the studies were included for Question 4 (staffing factors)
- 2 of the studies were included for Question 5 (management factors)
- no studies were included for Question 6 (organisational factors).

The results are discussed in greater detail for each question in the sections below. Where there is direct evidence of a potential relationship between a factor and safe midwife staffing, this is described first in each section, followed by any less direct evidence of the potential to modify an effect.

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Table 8: Overview of study results for Questions 2 to 6

Outcome	Number of women/births n= (range)	Association of factors with outcomes: (number of studies and quality score)		
		Association found for all outcomes assessed	Mixed findings (association for some measures/ outcomes)	No association
Question 2: Maternal and neonatal factors				
Number of women in labour	333 to 3,083	1 -		1 +
Maternal clinical risk	333 to 656,969	[1 ++], 1 +, 1 +, 1 -	1 +	
Parity	32,257 to 656,969	[1 ++], 1 +	2 +	
Maternal age	540,834 to 656,969	1 ++	1 +, 1+	1 +
Interventions used	333 to 540,834		1 +, 1+, 1 -	
Birthweight	540,834	1 +	1 +	
Stage of maternity care pathway, other maternal and neonatal factors	No evidence			
Question 3: Environmental factors				
Local geography	656,969		1 ++	
Local demography	540,834 to 656,969	1 ++, 2+	1 +	
Birth settings	32,257 to 656,969		1 ++, 1 +	
Unit size	32,257 to 656,969	1+	1 ++, 3 +	
Dedicated maternity theatre	540,834			2 +
Other physical layout factors	No evidence			
Question 4: Staffing factors				
Midwifery skill mix	615,042	1 +		
Availability of other staff	540,834 to 656,969	1 +	1 ++, 1 +, 1 +	
Time of day	333		1 -	
Additional services provided by midwives, division of tasks with support workers	No evidence			
Question 5: Management factors				
Models of care	1,505		1 +	
Service provision and risk management	540,834			1 +
Team management and administration approaches; supervision and supernumerary arrangements	No evidence			
Question 6: Organisational factors				
Any organisational factors	No evidence			

Underline indicates analysis of the factor's effect on outcomes adjusted for midwife staffing or possible interaction suggested by different effect of midwife staffing on outcomes if stratified by the factor. [ ] Square brackets indicate significant interaction between that factor and midwife staffing in formal interaction analysis.

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Question 2: What maternal and neonatal factors affect midwifery staffing requirements, at any point in time, at a local level?

Maternal and neonatal factors were assessed in 7 studies: Cerbinskaite et al. 2011 [-], Tucker et al. 2003 [+], Sandall et al. in press [++], Rowe et al. 2014 [+], Gerova et al. 2010 [+], Joyce et al. 2002 [+], and Joyce et al. 2004 [+].

The potential maternal and neonatal modifying factors addressed by these studies included:

- Number of women in labour
- Maternal/fetal clinical risk factors
- Interventions used
- Neonatal characteristics (birth weight)

Number of labouring women

No studies directly assessed the impact of number of labouring women on safe midwife staffing. Two studies assessing midwife staffing also looked at the relationship between number of labouring women or bed occupancy in the unit on outcomes (Cerbinskaite et al. 2011 [-], Tucker et al. 2003 [+]). Their results are summarised in Table 9.

Cerbinskaite et al. 2011 [-] (333 emergency grade 1 and 2 C-sections) reported that decision-to-delivery interval was longer for both grade 1 and 2 C-sections when there were more labouring women on the delivery suite (results displayed graphically). The authors reported that for grade 1 C-sections the decision-to-delivery interval for grade 1 C-sections was “rarely” over 30 minutes if there were fewer than 8 women on the suite, but “frequently” exceeded 30 minutes if there were more women (absolute figures not reported). Results were not adjusted for staffing levels or other potential confounders. The effect of number of women on outcomes was not statistically tested on its own, rather the ratio of labouring women to midwives available was assessed. Therefore it is not possible to assess the impact of number of labouring women specifically, independently to the ratio of midwives to labouring women.

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Table 9: Association between number of labouring women and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Cerbinskaite et al. 2011 [-] (labouring women on the delivery suite)	**Delivery of care outcomes:** Decision-to-delivery interval (grade 1 & 2 emergency C-sections)*	None	No	Decision-to-delivery interval (grade 1 & 2 emergency C-sections)	No (although number of labouring women was part of the midwife staffing ratio i.e. midwives:labouring women)
Tucker et al. 2003 [+] (labour ward bed occupancy)	None	CEFM-use and response related outcomes, neonatal outcomes (Apgar score <7 at 5 minutes, any neonatal resuscitation, neonatal resuscitation excluding bag and mask only, admission to the NNU for >48 hours)	Unclear	Neonatal resuscitation excluding bag and mask only	Unclear

**Figures showed graphically, significance not reported; C-section caesarean section, CEFM continuous electronic fetal monitoring*

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One cohort study by Tucker et al. 2003 [+] (3,083 live births) analysed the effect of unit occupancy (% beds occupied) on outcomes. It was unclear whether these results were adjusted for midwife staffing (and vice versa). Similarly to midwife staffing levels, occupancy appeared to have been assessed 4 times daily, with analyses assessing the effect of occupancy at the time of admission for continuous electronic fetal monitoring [CEFM] outcomes, immediately before or at the time of birth for neonatal outcomes, and at the time of first serious heart trace abnormality for response time outcome.

It found that occupancy was not significantly associated with any of the delivery of care or neonatal outcomes assessed (effect of each 10% increase in occupancy on: having CEFM OR 1.01, 95% CI 0.93 to 1.10); having inappropriate CEFM OR 1.06, 95% CI 0.90 to 1.24; having appropriate CEFM in high risk women: OR 0.96, 95% CI 0.86 to 1.08; having appropriate CEFM in low risk women: OR 0.99, 95% CI 0.91 to 1.07; lag time until senior medical attendance for a serious fetal heart trace abnormality: -6.7 minutes, 95% CI -21.8 to 8.4 minutes; Apgar score <7 at 5 minutes: 0.97, 95% CI 0.83 to 1.15; any neonatal resuscitation: OR 1.04, 95% CI 0.97 to 1.11; neonatal resuscitation excluding bag and mask only: OR 1.07, 95% CI 0.95 to 1.21; admission to the NNU for >48 hours: OR 1.04, 95% CI 0.95 to 1.13). No tests for interaction between occupancy levels and midwife staffing were carried out, therefore any relationship between these is unclear.

Maternal/fetal risk factors

One study (Sandall et al. in press [++]) specifically tested for interactions between maternal risk factors (clinical risk and parity) and midwife staffing, while 3 studies stratified at least some of their results by maternal clinical risk (Tucker et al. 2003 [+]), grade of emergency C-section (Cerbinskaite et al. 2011 [-]) or parity (Rowe et al. 2014 [+]), but did not carry out formal interaction tests. As well as these studies, 3 additional studies which looked at the association between midwife staffing and outcomes also looked at the association between maternal risk factors and outcomes (Gerova et al. 2010 [+], Joyce et al. 2002 [+], Joyce et al. 2004 [+]). These are described at the end of this section, as they offer less direct evidence about a possible effect of maternal risk factors on midwife safe staffing levels. Table 10 summarises the findings of the studies.

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Table 10: Association between maternal/fetal risk factors and safe midwifery staffing and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Sandall et al. in press [++] Interaction analyses (maternal clinical risk, parity, age; interaction assessed for maternal clinical risk and parity only)	**Factors interacting with midwife staffing:** Maternal clinical risk for healthy mother and baby outcomes (p≤0.009 for all) Parity for intact perineum outcome (p=0.007)	Delivery with bodily integrity, spontaneous vaginal delivery	NA (interaction analyses)	Delivery with bodily integrity, intact perineum	Yes
	Outcomes associated with factors: All healthy mother and baby outcomes, mode of delivery outcomes, and C-section outcomes	None	Yes		
Cerbinskaite et al. 2011 [-] (grade of C-section)	**Possible interaction suggested in stratified analyses:** Decision-to-delivery interval, transfer time to theatre (interaction not formally tested)	Pre-operative time in theatre	NA (stratified midwife staffing analyses)	Decision-to-delivery interval, transfer time to theatre (grade 1 & 2 C-sections)(UVA)	NA (stratified by C-section grade)

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Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Tucker et al. 2003 [+] (maternal/fetal risk)	**Possible interaction suggested in stratified analyses:** Appropriate CEFM monitoring (maternal risk category) (interaction not formally tested)	None	NA (stratified midwife staffing analyses)	Neonatal resuscitation excluding bag and mask	No (not for risk category, although analyses were adjusted for various maternal/fetal risk variables)
	Outcomes associated with factors: Use of continuous electronic fetal monitoring (various maternal/fetal clinical risk variables)	Not clear	No	Neonatal resuscitation excluding bag and mask	Yes
Rowe et al. 2014 [+] (parity)	**Possible interaction suggested in stratified analyses:** straightforward birth, augmentation, intrapartum C-section, normal birth and instrumental vaginal delivery, epidural rates (interaction not formally tested)	None	NA (stratified midwife staffing analyses)	Straightforward birth, intrapartum C-section	NA (stratified by parity)

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Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Gerova et al. 2010 [+] (various maternal clinical risk factors, age)	Various maternal risk factors: Maternal readmission within 28 days Age: None	None	No	Maternal readmission within 28	Yes
Joyce et al. 2002 [+] (maternal age [% teenage mothers, % mothers ≥40 years old], parity [% nulliparous], % multiple births at hospital level)	All: C-section rates (UVA not MVA) Age: Instrumental vaginal delivery (UVA not MVA), epidural use in labour (MVA)	Age: None Parity and multiple births: IVD, epidural use in labour	Mixed (epidural in labour analysis yes, others no)	Epidural use in labour (UVA not MVA)	Yes
Joyce et al. 2004 [+] (factors as for Joyce et al. 2002 above)	All: Still birth (UVA not MVA)	Neonatal mortality	No	None	NA

C-section caesarean section, CEFM continuous electronic fetal monitoring, IVD instrumental vaginal delivery, MVA multivariate analysis, NA not applicable, UVA univariate analysis

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The correlational study by Sandall et al. in press [++] (656,969 deliveries) found that there was an interaction between midwife staffing and the woman's clinical risk (based on presence or absence of medical conditions or situations listed in NICE intrapartum care guidelines as increasing risk for the woman or baby) for all healthy mother and baby outcomes, with greater benefit of increased staffing in lower risk women (OR for outcome in lower risk vs. higher risk, p for interaction: healthy mother OR 1.12 vs. 1.06, p<0.001; healthy baby OR 1.09 vs. OR 1.02, p=0.009; healthy mother and baby OR 1.12 vs. 1.06, p=0.007). There was no interaction between midwife staffing and clinical risk for the other outcomes assessed (delivery with bodily integrity, p=0.15; spontaneous vaginal delivery, p=0.98; intact perineum, p=0.77).

There was also an interaction between midwife staffing and parity for the outcome of intact perineum, with greater benefit of increased staffing seen in women who had 4 or more children (OR 1.25 vs. OR 1.11 to 1.18 for lower parities; p for interaction = 0.007). There was no interaction between midwife staffing and parity for the other outcomes assessed (delivery with bodily integrity, p=0.33; spontaneous vaginal delivery, p=0.98).

Overall, the study found that woman's clinical risk, parity, and age were the largest determinants of outcomes, with about 98-99% of variability in outcomes across trusts estimated to be due to maternal differences, and 1-2% of the variation due to differences between the trusts.

As well as looking at the impact of maternal clinical risk and parity on safe midwife staffing levels, the study also looked at the effect of these variables and maternal age, and ethnicity on outcomes in their own right (results for ethnicity reported under demography in question 2). Based on relative chi squared values, maternal clinical risk and parity were the variables with the largest impact on outcomes:

- Maternal clinical risk showed a dominant (relative chi squared value ≥10,000) significant effect for all outcomes except intact perineum (range from 945 for intact perineum to 54,882 for all C-sections). Increasing clinical risk was associated with reduced chances of positive outcomes (healthy mother and baby outcomes and mode of birth outcomes) and increased chances of C-section outcomes.
- Parity showed a strong (relative chi squared values 1,000 to <10,000) or dominant significant effect for all outcomes except healthy baby (range from 615 for healthy baby to 14,185 for delivery with bodily integrity, 3 effects dominant: healthy mother, intact perineum, and delivery with bodily integrity). Increasing parity was associated with increased chances of positive outcomes (mode of birth outcomes, healthy mother, and healthy mother and baby) and reduced chances of emergency and all C-section, while the relationship was not linear (monotonic) across all parities for healthy baby (least likely for nulliparous women and most likely for women with 1 previous baby) and elective C-section (least likely for nulliparous women and most likely for women with 2 children).
- Maternal age group showed moderate (relative chi squared values 100 to <1000) or strong significant effects for all outcomes except healthy baby (range 14 for healthy baby to 1,746 for spontaneous vaginal delivery, 4 strong effects: healthy mother, delivery with bodily integrity, spontaneous vaginal delivery, and all C-sections). Increasing age was associated with reduced chances of most positive outcomes (healthy mother and baby and mode of delivery outcomes) and elective C-sections, and increased likelihood of emergency C-sections and all C-sections. The relationship was not linear (monotonic) across all ages for healthy baby (increasing likelihood up to age 40 to 44, but lowest for women aged 45 and over) and intact perineum (most likely for age 19 and under and reducing likelihood to age 39, then increasing slightly from age 40).

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The only other factors showing relative chi squared values over 10 were maternal ethnicity (range 6 for healthy baby to 158 for intact perineum) and deprivation of the area of residence (range 2 for all C-section to 337 for intact perineum). All other factors (rural-urban classification, Strategic Health Authority, trust size, university trust status, type of birth settings/units in the trust, FTE staff available including FTE midwives, and staff ratios) had smaller effects on all outcomes. These results were all from multilevel modelling, which included midwife staffing levels as well as other variables.

These results show the difficulties in using anything other than formal interaction analyses to assess interactions with safe maternity staffing. For example, maternal clinical risk is itself significantly associated with all outcomes assessed, even after adjustment for midwife staffing levels. This could be interpreted as suggesting that maternal clinical risk could affect safe midwifery staffing levels for all of these outcomes. However, maternal clinical risk only interacts with midwife staffing levels for healthy mother and baby outcomes, and not the other outcomes assessed (delivery with bodily integrity, intact perineum, and spontaneous vaginal delivery). This is despite midwife staffing also being significantly associated with delivery with bodily integrity and intact perineum.

A cross sectional analysis of the cohort study by Cerbinskaite et al. 2011 [-] (333 emergency C-sections) stratified results by grade of emergency C-section: grade 1 bring those where there was immediate threat to the life of the woman or fetus, and grade 2 being evidence of maternal or fetal compromise which is not immediately life threatening. It found that decision-to-delivery interval and transfer time to the operating theatre were significantly shorter with higher midwife staffing for both grades of C-section. For both outcomes the relative improvement with increased midwife staffing was greater for grade 2 C-sections (1:1 midwives:labouring women or more vs. fewer midwives than labouring women, decision-to-delivery interval ≤30 minutes: RR 1.71 for grade 1 vs. 4.62 for grade 2; transfer time ≤15 minutes: RR 1.16 for grade 1 vs. 1.37 for grade 2; RRs reviewer calculated). Midwife staffing was reported not to impact the time taken between arrival in the theatre to start of the operation (figures not reported), and this time span did not differ between grade 1 and 2 C-sections (mean: 19.1 minutes [SD 9.6] for grade 1 vs. 20.4 minutes [SD 8.6] for grade 2, p=0.201). The analyses of grade 1 C sections may not be as robust and have less power than those for grade 2 C-sections, as there were fewer grade 1 C-sections.

Without a formal test for interaction it is not possible to say whether the differences were statistically significant. However, they appear to suggest that higher midwife staffing may have a greater effect on timings of the less urgent grade 2 C-sections than the most urgent grade 1 C-sections. This may reflect the urgency of grade 1 C-sections resulting in their prioritisation over other tasks even at lower midwife staffing levels, while the speed of the less urgent grade 2 sections may be more susceptible to midwife staffing levels at the time. However, due to the urgency of grade 1 C-sections even if delays are shorter or less common than for grade 2 C-sections, this could still have a greater impact on outcomes.

The cohort study by Tucker et al. 2003 [+] (3,083 live births) stratified one of its outcomes (appropriate use of continuous electronic fetal monitoring) by maternal risk (not further defined). It found that increasing staffing was associated with a non-significant reduction in risk of appropriate CEFM monitoring in high risk women (OR 0.90), but a non-significant increase in risk of CEFM monitoring in low risk women (OR 1.12). Without formal interaction analysis it is not possible to say with certainty that clinical risk showed significant interaction with midwife staffing for this outcome. However, the different directions of effect suggest potential interaction.

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This study also reported that various maternal/fetal variables were associated with the use of continuous electronic fetal monitoring (CEFM): pre-eclampsia, suspected abruption, previous C-section, preterm labour, no liquor, meconium stained liquor, use of oxytocin to accelerate labour, epidural, fetal heart rate anomaly at admission or in labour (figures not reported). Most of these would be indications for use of CEFM (e.g. fetal heart rate anomaly), which could explain the association seen. These factors were adjusted for in the analyses of impact of midwife staffing on CEFM monitoring. Results of univariate analysis were not reported, but after adjustment for these factors midwife staffing levels were not associated with any of the CEFM-related outcomes. The same variables (except for fetal heart rate anomaly variables) were adjusted for in the analyses of neonatal outcomes (Apgar score, neonatal resuscitation, or admission to the NNU) but it was not clearly reported whether this was because these factors were associated with these outcomes. Again no results of univariate analyses were reported, and midwife staffing showed no significant association with outcomes, except for a reduction in neonatal resuscitation excluding bag and mask resuscitation only (see Question 1 for details). Also, these analyses were not adjusted for midwife staffing levels.

The correlational study by Rowe et al. 2014 [+] (32,257 births to low risk women) did not formally assess interactions between parity and midwife staffing, but did stratify analyses by parity. The findings were not consistent across outcomes (see Tables in Question 1 for summary). For some outcomes the direction of effect differed: increased staffing was associated with a non-significant increase in normal birth and instrumental vaginal delivery in nulliparous women but non-significant reductions in multiparous women. Midwife staffing levels showed no association with epidural rates in multiparous women, but were associated with a non-significant reduction in epidurals in nulliparous women. For other outcomes the direction of effect was the same but significance differed: increased midwife staffing was associated with a reduction in straightforward birth and augmentation which was significant for multiparous but not nulliparous women (sizes of effect similar), and with an increase in intrapartum C-section which was significant for nulliparous but not multiparous women. For the latter groups power may explain differences in significance rather than interaction. Without formal interaction analysis it is not possible to say with certainty whether parity significantly interacted with midwife staffing for any outcomes in this study.

Additional indirect evidence from 3 studies supported that maternal and fetal characteristics are significantly associated with various process outcomes (e.g. epidural use in labour, C-section, instrumental vaginal delivery). They may therefore interact with or influence safe midwife staffing levels, but without formal tests of interaction it is not possible to say this with certainty.

One large correlational study (Gerova et al. 2010 [+]) found that the following maternal variables were associated with an significantly increased risk of maternal readmission within 28 days of discharge in multivariate regression analysis (presence of ≥1 maternal comorbidities (β 0.168 [SE 0.068], p=0.014), ≥1 maternal admission in the past 12 months (0.499 [0.044], 0.741 [0.083], 0.995 [0.108] for 1,2, or 3 admissions respectively, p<0.001 for all), longer pre-birth length of stay (0.114 [0.03], 0.452 [0.100], 0.746 [0.223] for 1-4, 5-16 and 17+ days' stay respectively, p≤0.001 for all), longer post-birth length of stay (0.231 [0.047], 0.437 [0.067] for 1-4 and 5-16 days' stay respectively, p<0.001 for both), having a more complicated delivery (normal delivery with complications: 0.360 [0.041], assisted delivery with complications: 0.444 [0.094], C-section: 0.472 [0.050], C-section with complications: 0.518 [0.041], p<0.001 for all). Maternal age was not significantly associated with readmission risk overall. These analyses did not include midwife or other staffing variables. The regression model was used to derive an expected readmission rate for each woman, and summed each trust, and this was used in the staffing regression model to adjust for between-trust differences in these variations. Midwife staffing levels were significantly associated with 28 day readmissions after

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this risk adjustment. As unadjusted figures for the effects of midwife staffing ratios were not reported, and without formal interaction analyses it is difficult to determine whether these factors might directly affect safe midwife staffing.

One correlational study (Joyce et al. 2002 [+]) (540,834 births) assessed the impact of maternal/fetal characteristics at the unit level as well as midwife and other staffing on outcomes (C-section, instrumental vaginal delivery, epidural use). The maternal/fetal characteristics assessed were: % teenage mothers, % mothers >40 years old, % nulliparous, and % multiple births.

In univariate analyses, increased maternal age (% mothers ≥40 years old: ß=2.08 [SE 0.627], p=0.002) and more multiple births (ß=1.55 [SE 0.430], p=0.001) were associated with increased C-section rates, and fewer nulliparous women with reduced C-section rates (ß=-0.32 [SE 0.148], p=0.033). Increased maternal age was also associated with increased instrumental vaginal delivery (IVD) and use of epidural in labour (% mothers >40 years old, for IVD: ß=1.895 [SE 0.408], p<0.001; epidural rate: ß=12.87 [SE 1.737], p<0.001), with the opposite for lower maternal age (% teenage mothers: ß=-0.968 [SE 0.158], p<0.001; epidural rate: ß=-4.66 [SE 0.828], p<0.001). Parity and multiple births were not associated with epidural rates in labour or IVD in univariate analyses.

The only maternal characteristic which remained in the final multivariate models was % mothers aged 40 or over, which was associated with a significant increase in rate of epidural use in labour (ß=6.30 [SE 1.310], overall model R^2 0.637, p<0.001, model also included only % fathers in manual/other social class). The associations seen may represent preferences for or confidence to request epidurals by older women and those in higher social classes. Higher midwife staffing was associated with a significant reduction in epidural use in labour (but not other outcomes) in univariate analyses, but did not remain in the final multiple regression model.

A later publication by Joyce et al. 2004 [+], appeared to use the same data set, and looked at the effect of the same variables on the outcomes of stillbirth and neonatal mortality. Several of the unit level maternal characteristics were significantly associated with birth weight standardised stillbirth rates in univariate analyses, with an increase in stillbirth rates seem with fewer nulliparous women (ß=-0.079, p=0.037), more births to teenage women (ß=0.183, p=0.038), and fewer babies from multiple births (ß=-0.485, p=0.001, SE figures not reported). Parental and other groups of related variables showed high levels of inter-correlation, so they were combined using principal component analysis before carrying out multiple regression. The parental combined variable included the significant maternal variables plus % births to fathers of manual or “other” social class, and was not retained in the final multiple regression model for standardised stillbirth rate. None of the maternal variables were associated with birth weight standardised neonatal mortality rates. Midwife staffing was not significantly associated with either outcome in univariate analysis.

Interventions used

None of the studies identified looked specifically at the effect of the interventions used on safe midwifery staffing levels. Three studies looking at the association between midwife staffing and outcomes also assessed the effect of intervention type or use and outcomes (Cerbinskaite et al. 2011 [-], Joyce et al. 2002 [+], Joyce et al. 2004 [+]). See Table 11 for a summary of their findings.

One cross sectional analysis of a cohort study (Cerbinskaite et al. 2011 [-]) (333 emergency grade 1 and 2 C-sections) found that **type of anaesthesia** in grade 1 C sections was significantly associated with decision-to-delivery interval (p=0.007). Mean decision-to-delivery interval was significantly

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shorter with general anaesthesia (19.7 minutes [SD 8.5]) than with spinal blockade (27.0 minutes [SD 8.2], p<0.001). The mean decision-to-delivery interval with epidural top up (26.0 minutes [SD 18.7]) was similar to that for spinal blockade (no pairwise statistical comparisons reported).

For grade 2 C-sections, the type of anaesthesia was not significantly associated with decision-to-delivery interval (mean [SD]: 29.2 [15.4] with epidural top up vs. 30.1 [19.4] with general anaesthetic vs. 34.7 [12.0] with spinal blockade; p=0.681). Higher midwife staffing levels were associated with a reduced decision-to-delivery interval for both grade 1 and 2 C-sections.

The effect of type of anaesthesia on decision-to-delivery interval was in at least in part due to differences in time from arrival in theatre to start of the operation for grade 1 C-sections, where type of anaesthesia had a significant effect (p<0.001), which was not seen for grade 2 C-sections (p=0.335). For grade 1 C-sections this interval was significantly shorter with general anaesthesia (mean 14.4 minutes [SD 6.0]) than with spinal blockade (24.6 [SD 9.6], p<0.001), or with epidural top up (20.0 [SD 11.4], p=0.032). Midwife staffing had no impact on this outcome for grade 1 or 2 C-sections.

Midwife staffing influences decision-to-delivery interval for grade 1 and 2 C-sections, as does type of anaesthetic for grade 1 C-sections. This suggests that type of anaesthetic and midwife staffing may potentially interact to influence decision-to-delivery interval. However, without any statistical assessment of the interaction it is not possible to draw firm conclusions about their relationship. None of the figures from this study were adjusted for staffing levels or other potential confounders.

One correlational study (Joyce et al. 2002 [+]) (540,834 births) assessed the impact of intervention rates as well as midwife and other staffing on outcomes (C-section, instrumental vaginal delivery, epidural use). The demographic variables assessed were: overall epidural rate/100 deliveries, rate of epidural use in labour (i.e. not for C-sections)/100 labour deliveries, induction rate/100 deliveries, instrumental vaginal delivery rate/100 births, and C-section rate/100 deliveries.

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Table 11: Association between intervention use and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Cerbinskaite et al. 2011 [-] (Type of anaesthesia)	Decision-to-delivery interval (grade 1 C-sections) Time from arrival in theatre to operation start (grade 1 C-sections)(UVA)	Decision-to-delivery interval (grade 2 C-sections) Time from arrival in theatre to operation start (grade 2 C-sections)	No	Decision-to-delivery interval (grade 1 & 2 C-sections)(UVA)	No
Joyce et al. 2002 [+] (*Overall epidural rate, epidural in labour rate,* induction rate, *IVD rate, C-section rate*)	Induction: None All other interventions: C-section rates (UVA not MVA, except for epidural for labour rate - UVA and MVA), IVD rate and epidural in labour rates (UVA not MVA)	Induction: C-section, epidural in labour, IVD rates All other interventions: None	Mixed (C-section or IVD outcomes no, epidural for labour outcome MVA model tested midwifery staffing as a significant UVA variable but not retained)	Epidural in labour rates (UVA not MVA)	Yes (MVA of epidural for labour outcome)
Joyce et al. 2004 [+] (As for Joyce et al. 2002 plus *SVD rate,* vaginal breech birth rate, emergency and elective C-sections for breech rates, *forceps birth rate,* vacuum delivery rate, *general anaesthetic for C-section rate*)	Birth weight standardised still birth rate (various in UVA, intervention score in MVA which incorporated italicised variables)	Neonatal mortality	No	None	NA

C-section caesarean section, IVD Instrumental vaginal delivery, MVA multivariate analysis, NA not applicable, UVA univariate analysis, SVD spontaneous vaginal delivery

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In general, higher rates of the individual interventions (except induction rates) were associated with significant increases in the other interventions in univariate analyses. Higher overall epidural rate (ß=0.142 [SE 0.033], p<0.001), epidural in labour rate (ß=0.147 [SE 0.045], p=0.002), and instrumental vaginal delivery rate (ß=0.407 [SE 0.180], p=0.028), were associated with increased C-section rates. Higher overall epidural rate (ß=0.155 [SE 0.016], p<0.001), epidural in labour rate (ß=0.195 [SE 0.022], p<0.001), and C-section rate (ß=0.199 [SE 0.088], p=0.028), were associated with increased instrumental vaginal delivery rates. Higher instrumental vaginal delivery rates (ß=3.942 [SE 0.418], p<0.001), and C-section rate (ß=1.762 [SE 0.404], p<0.001), were associated with increased overall epidural rate. Higher midwife staffing levels were associated with reduced epidural rate in univariate analyses, but not the other outcomes.

In the final multiple regression models epidural rates for labour remained a significant predictor of C-section rates (ß=0.126 [SE 0.039], overall model R^2 0.435, p<0.001, model also included delivery bed rate and junior obstetrician/gynaecologist staffing levels) and instrumental vaginal delivery rates (ß=0.123 [SE 0.028], overall model R^2 0.644, p<0.001, model also included father's social class only). The other intervention rates were not retained in the final models. As midwife staffing levels were associated with epidural rates in univariate analysis (but not multivariate analysis), and epidural rates are a significant predictor of other interventions (C-section and instrumental vaginal delivery), these factors may interact, but without formal tests for this it is not possible to say this with certainty.

A later publication by Joyce et al. 2004 [+], used the same data set, and looked at the effect of the same variables plus a few additional intervention/non-intervention variables (spontaneous vaginal delivery/100 births, vaginal births/100 breeches, emergency C-sections/100 breeches, elective C-sections/100 breeches, forceps/100 births, vacuum delivery/100 births, general anaesthetics/100 C-sections) on the outcomes of stillbirth and neonatal mortality. None of the intervention variables (or midwife staffing) were significantly associated with neonatal mortality in univariate analyses.

In univariate analyses a number of the intervention variables showed a significant association with birth weight standardised stillbirth rates (SSBR), with the following associated with increased SSBR: more spontaneous vaginal deliveries (ß=0.088, p=0.002), fewer C-sections (ß=-0.091, p=0.026), fewer forceps deliveries (ß=-0.176, p=0.035), fewer instrumental deliveries (ß=-0.153, p=0.008), fewer epidurals overall (ß=-0.036, p=0.001), fewer epidurals for labour (ß=-0.042, p=0.005), more general anaesthetics for C-sections (ß=0.032, p=0.002; SEs not reported). Due to a high level of inter-correlation between intervention and other related variables, the study combined these using principal components analysis to give two principal components. One of these remained significant in the final multiple regression model, with more interventions associated with significantly lower birth weight standardised stillbirth rates (ß=-0.21 [SE 0.07], p=0.003, R^2 for overall model 0.27, model also included number of consultant obstetricians per 1000 births). For an increase in one interquartile range in the intervention score (2.47 units), there was a reduction of 0.52 in the SSBR (larger than the 0.26 reduction seen with an interquartile increase in obstetrician variable).

Whether there is an interaction between an interventionist approach and safe midwife staffing levels is not possible to say with certainty. Midwife staffing was not associated with the outcomes which were associated with the intervention variables in multiple regression models. It was associated with a reduction in epidural rates in univariate analysis, so if epidural (and intervention) rates are associated with outcomes then there could be interaction. Without formal interaction analyses it is not possible to say with certainty.

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Neonatal risk factors or needs

No studies directly assessed whether neonatal risk factors or needs affected safe midwife staffing levels. Two publications (Joyce et al. 2002 [+], Joyce et al. 2004 [+]) based on analysis of the same observational data assessed the association between birth weight and outcomes. See Table 12 for a summary of their findings.

One correlational study (Joyce et al. 2002 [+]) (540,834 births) assessed the impact of neonatal characteristics as well as midwife and other staffing on outcomes (C-section, instrumental vaginal delivery, epidural use). The neonatal characteristics assessed were: mean birth weight and % very low birth weight (<1.5kg).

Higher mean birth weight was associated with a reduced C-section rate (ß=-0.014 [SE 0.006], p=0.040) while the opposite was true of increased proportion of very low birth weight babies (ß=1.31 [SE 0.429], p=0.004). These relationships may relate to multiple births and premature births, where lower birth weight and C-sections may be more likely (multiple births were also significantly associated with C-sections in univariate analysis, while gestational age was not a variable tested). Neither neonatal characteristic remained significantly associated with C-section in the multiple regression model. They were not associated with the other outcomes in univariate analysis (instrumental vaginal delivery or epidural use in labour). Midwife staffing was associated with epidural rate in univariate analyses but was not retained in the final multiple regression model; it was not associated with the other outcomes.

A later publication by Joyce et al. 2004 [+], appeared to use the same data set, and looked at the effect of the same variables on the outcomes of stillbirth and neonatal mortality. Birth weight accounted for over 70% of the variability in overall death rates (stillbirth and neonatal) (mean birth weight: R^2 0.708, p<0.001; % births <1.5kg: R^2 0.752, p<0.001; % births <2.5kg: R^2 0.719, p<0.001; betas not reported). Therefore stillbirth and neonatal mortality rates were standardised for birth weight, and rather than including birth weight variables in subsequent analyses. Midwife staffing was not significantly associated with either outcome in univariate analysis.

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Table 12: Association between birth weight and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Joyce et al. 2002 [+] (mean birth weight; very low birth weight [VLBW])	C-section (UVA not MVA)	Epidural use in labour, instrumental vaginal delivery	No	Epidural use in labour (univariate not multivariate)	No
Joyce et al. 2004 [+] (mean birth weight; LBW; VLBW)	Pooled stillbirth & neonatal mortality (UVA, not included in MVA)	None	No	None	Yes (mortality rates standardised by birth weight)

C-section caesarean section, LBW low birth weight (<2.5 kg), MVA multivariate analysis, UVA univariate analysis, VLBW very low birth weight (<1.5 kg)

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Stage of maternity care pathway

None of the studies identified looked specifically at the effect of stage of the maternity care pathway on safe midwifery staffing levels.

Five of the observational studies dealt specifically with midwife staffing on obstetric units (Rowe et al. 2014 [+], Cerbinskaite et al. 2011 [-], Joyce et al. 2002 [+], Joyce et al. 2004 [+], Tucker et al. 2003 [+]). The other two observational studies looked at midwife staffing at the trust level (Sandall et al. in press [++], Gerova et al. 2010 [+]) and therefore would cover all care provided at all stages of the maternity care pathway. The RCT (NSCCRT 2000 [+]) also covered all stages of the maternity care pathway.

Evidence statement 2: Effect of maternal and neonatal factors on midwifery staffing requirements

Evidence from 1 UK cohort study[1] ([+] 3,083 live births), 1 cross sectional analysis of a UK cohort study[2] ([-] 333 caesarean sections) and 5 UK correlational studies[3-7] ([++] 656,969 births[3]; [+] 540,834 births[4,5]; [+] 615,042 women[6]; [+] 32,257 births[7]) suggests that:

- **Maternal clinical risk** and **parity** may modify the association between midwife staffing and a range of outcomes[1,2,3,7], they are also associated with some maternal and neonatal outcomes[1,3,4,6] although not all associations were formally tested for significance, adjusted for midwife staffing, or remained significant after adjustment for confounders
- **Maternal age**[3,4,5,6] and **use of intrapartum interventions**[2,4,5] may be associated with some maternal and neonatal outcomes, although not all analyses were adjusted for midwife staffing or remained significant after adjustment for confounders
- Mixed results were found for the association between **number of women in labour on the ward**[1,2] and **birthweight**[4,5] and maternal and neonatal outcomes in analyses not adjusted for midwife staffing
- No evidence was identified on the effect of **stage of the maternity care pathway** on midwife staffing requirements.

[1] Tucker et al. 2003 [+]
[2] Cerbinskaite et al. 2011 [-]
[3] Sandall et al. in press [++]
[4] Joyce et al. 2002 [+]
[5] Joyce et al. 2004 [+]
[6] Gerova et al. 2010 [+]
[7] Rowe et al. 2014 [+]

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Question 3: What environmental factors affect safe midwifery staffing requirements?

Environmental studies were assessed in 6 studies: Sandall et al. in press [++], Joyce et al. 2002 [+], Joyce et al. 2004 [+], Gerova et al. 2010 [+], Rowe et al. 2014 [+], and Tucker et al. 2003 [+].

The potential maternal and neonatal modifying factors addressed by these studies included:

- Local geography (urban-rural classification, region)
- Local demography (deprivation, ethnicity, social class)
- Birth settings (types of unit available within the trust, presence of an alongside midwifery unit, proportion of planned out of hospital and out of obstetric unit births within the trust)
- Unit size (number of births, delivery beds, or neonatal unit beds)
- Physical layout (presence of dedicated maternity theatre)

Local geography

No studies directly assessed the potential impact of local geography on safe midwife staffing. One correlational study (Sandall et al. in press [++]) assessed the association between the geographical location (urban-rural classification, which included the type of area and population density), and the region (Strategic Health Authority, SHA) of the women's residence on trust-level outcomes. See Table 13 for a summary of their findings.

In multilevel models including a midwife staffing variable, there was some variability in outcome across the SHAs, with the East Midlands performing best on a number of outcomes, and London the worst. For example, for the healthy mother and baby outcome ORs ranged from 1.253 (East Midlands, p=0.0480) to 0.907 (London, p=0.3329). Only some of the differences were statistically significant, for example, variations in C-section outcomes, spontaneous vaginal delivery, and intact perineum were not significant (see Evidence table for details, comparison/reference group was South West SHA).

In sensitivity analyses which only included the 50 trusts which only had a single obstetric unit (i.e. where exposures and outcomes would effectively refer to a single unit only), the performance of trusts in London improved for some outcomes (e.g. moving from worst to 5th best for the healthy mother outcome). This suggests that within individual regions there is variability in outcomes between units within trusts which is influencing results.

There was also variability across the urban-rural classifications, with living in an area falling into the "Village – less sparse" classification tending to be associated with better outcomes, and "Urban ≥10k - sparse" or "Hamlet and isolated dwelling – sparse" associated with poorer outcomes. For example, for the healthy baby outcome ORs ranged from 1.104 (Village – less sparse, p=0.0146) to 0.797 (Urban ≥10k - sparse, p=0.0478). Only some of the differences were significant for example, variations in C-section outcomes were not significant (see Evidence Table for details, "Hamlet and isolated dwelling-less sparse" was the reference/comparator group).

The presence of significant associations between both local geography measures and healthy mother and baby outcomes, delivery with bodily integrity, and normal birth, and between urban-rural classification and the outcomes of spontaneous vaginal delivery and intact perineum after adjustment for midwife staffing suggests that these factors could influence safe midwife staffing levels. This may particularly be the case for the outcome of delivery with bodily integrity, which also shows a significant association with midwife staffing levels.

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Table 13: Association between local geography and demography and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Geography					
Sandall et al. 2011 [++] (urban-rural classification, region based on Strategic Health Authority)	Urban-rural classification and region: Healthy mother and baby outcomes, delivery with bodily integrity (DwBI), and normal birth Urban-rural classification: spontaneous vaginal delivery (SVD), intact perineum	C-section outcomes	Yes	Delivery with bodily integrity, intact perineum	Yes
Demography					
Sandall et al. in press [++] (Deprivation, maternal ethnicity)	Healthy mother and baby outcomes, DwBI, normal birth, SVD, intact perineum, C-section outcomes	None	Yes	Delivery with bodily integrity, intact perineum	Yes
Joyce et al. 2002 [+] (Deprivation, social class)	Deprivation: None Social class: epidural in labour (MVA), instrumental vaginal delivery (MVA)	C-section	Mixed (epidural in labour analysis yes, other analyses no)	Epidural in labour (UVA, not MVA)	Yes
Joyce et al. 2004 [+] (Deprivation, social class)	Deprivation: Neonatal mortality (UVA) 1. Social class: Still births (UVA not MVA)	None	No	None	NA
Gerova et al. 2010 [+] (Deprivation, ethnicity)	Maternal readmission within 28 days of discharge	None	No	Maternal readmission within 28 days of discharge	Yes

C-section caesarean section, DwBI Delivery with bodily integrity, MVA multivariate analysis, SVD spontaneous vaginal delivery, UVA univariate analysis

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Local demography

No studies directly assessed the impact of local demography on safe midwife staffing levels. Four studies which assessed midwife staffing also assessed the effect of local demographic variables on the same outcomes (Sandall et al. in press [++], Joyce et al. 2002 [+], Joyce et al. 2004 [+], Gerova et al. 2010 [+]). See Table 13 for a summary of their findings.

One correlational study (Sandall et al. in press [++]) (656,969 births) assessed the association between ethnicity and index of multiple deprivation (based on postcode of residence) on trust-level outcomes.

In multilevel models which adjusted for midwife staffing, women who were Caribbean (Black or Black British) or mixed Black and White Caribbean had a number of better outcomes compared with other ethnicities (highest rates of healthy mother, healthy mother and baby, delivery with bodily integrity, normal birth, spontaneous vaginal delivery, and intact perineum). Indian women had a number of poorer outcomes (lowest rates of healthy mother, healthy mother and baby, delivery with bodily integrity, and spontaneous vaginal delivery). Relationships between ethnicity and outcomes were minor to moderate in strength, and there was significant variation in outcome by ethnicity among all of the outcomes assessed (see Evidence table for details; comparison/reference group “any other ethnic group”).

In these models increasing deprivation was linearly associated with increased likelihood of healthy mother outcome (most deprived vs. least deprived quintile OR 1.382), healthy mother and baby outcome (OR 1.323), delivery with bodily integrity (OR 1.457), normal births (OR 1.125), spontaneous vaginal delivery (OR 1.100) and intact perineum (OR 1.546) but decreased likelihood of healthy baby outcome (OR 0.854, $p<0.0001$ for all comparisons). Relationships for C-sections were significant, but mixed in terms of direction of the effect, with increasing deprivation associated with an increased risk of emergency C-section (OR 1.113, $p<0.0001$), but reduced risk of elective C-section (OR 0.816, $p<0.0001$), and overall C-section (OR 0.971, $p=0.019$). These relationships were minor to moderate in strength.

One correlational study (Joyce et al. 2002 [+]) (540,834 births) assessed the impact of demographic characteristics at the unit level as well as midwife and other staffing on outcomes (C-section, instrumental vaginal delivery, epidural use). The demographic variables assessed were: % fathers in the manual or “other” social class and mean Townsend deprivation score of the district of birth.

In univariate analyses, deprivation was not significantly associated with any of the outcomes (increase in Townsend score indicates greater deprivation so betas show effect of increasing deprivation; C-section: ß=0.337, $p=0.116$; instrumental vaginal delivery: ß=-0.167, $p=0.269$; epidural in labour: ß=0.395, $p=0.607$). This may differ from the findings of Sandall et al. due to the use of a different measure of deprivation (Townsend score versus Index of Multiple Deprivation), different time periods assessed (1994-1996 for Joyce et al. and 2010-2011 for Sandall et al.), the lack of adjustment for midwife staffing and other factors in the analysis by Joyce et al., or differences in the level of analysis (unit level for Joyce et al. and trust level for Sandall et al.).

In univariate analyses, an increase in the percentage of fathers in the manual or “other” social class was significantly associated with reduced instrumental vaginal delivery rate (ß=-0.193 [SE 0.024], $p<0.001$) and reduced epidural rate (ß=-0.96 [SE 0.120], $p<0.001$), but was not significantly associated with C-section rates (ß=-0.08 [SE 0.048], $p=0.088$).

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In the final multiple regression models, father's manual or "other" social class, remained significantly associated with reduced instrumental vaginal delivery rate (ß=-0.105 [SE 0.029], overall R^2 0.644 and p<0.001 for model, which included epidural rate as the only other variable), and also with epidural rate (ß=-0.49 [SE 0.094], overall R^2 0.637 and p<0.001 for model, which included % mothers aged ≥40 as the only other variable). Midwife staffing level had only been associated with epidural rate in univariate analysis (ß=-0.532 [SE 0.264], p=0.049), but did not remain significant in the final multiple regression model.

There is some evidence that higher levels of midwife staffing are also associated with reduced epidural use (see Question 1), if father's social class also influences this outcome they may interact. However, without a stratified analysis by father's social class or interaction analysis it is difficult to assess the impact of father's social class on safe midwife staffing levels.

A later publication by Joyce et al. 2004 [+], used the same data set, and looked at the effect of the same variables on the outcomes of stillbirth and neonatal mortality. In univariate analysis increased deprivation was the only variable associated with an increase in birth weight standardised neonatal mortality (ß=0.106, p=0.106), and as such multiple regression was not carried out. An increasing proportion of babies with paternal manual or "other" social class was associated with an increase in birth weight standardised still birth (ß=0.039, p=0.008), but this variable was not retained in the final multiple regression model. Midwife staffing was not associated with either of these outcomes in univariate analysis.

The correlational study by Gerova et al. 2010 [+] assessed a number of individual level variables on maternal readmission within 28 days of discharge. It found that living in the most deprived areas was associated with significantly higher risk of readmission (Carstairs deprivation index score 5 vs. 1 [least deprived]: ß=0.133 [SE 0.048], p=0.006), as was Black or Black British vs. White ethnicity (0.238 [0.056], p<0.001). These analyses did not include staffing variables.

Birth settings

No studies directly assessed the impact of birth settings on safe midwife staffing levels. Two studies which assessed midwife staffing also assessed the effect of birth setting variables (type of birth units available in the trust, whether the trust was a university hospital trust, presence of a midwifery unit alongside the obstetric unit [AMU], % of births planned to be outside of the obstetric unit and % of births planned to be outside of the hospital) on the same outcomes (Sandall et al. in press [++], Rowe et al. 2014 [+]). See Table 14 for a summary of their findings.

One correlational study (Sandall et al. in press [++]) (656,969 births) assessed the association between type of birth units available within the trust (obstetric units alone, or with alongside midwifery units [AMU] and/or freestanding midwifery units [FMU]) and whether the trust included a university hospital on trust-level outcomes.

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Table 14: Association between birth settings and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Sandall et al. in press [++] (university trust, type of birth units in the trust)	**University trust:** healthy baby, SVD **Type of birth units in the trust:** normal birth (single significant association identified, no consistent pattern of outcomes across unit types)	Healthy mother, healthy mother and baby, delivery with bodily integrity, intact perineum, C-section outcomes	Yes	Delivery with bodily integrity, intact perineum	Yes
Rowe et al. 2014 [+] (presence of AMU in the hospital, % planned non-OU births and % planned non-hospital births at the trust level)	**Presence of AMU:** straightforward birth, normal birth, intrapartum C-section **% planned non-OU births at trust level*:** straightforward birth, normal birth, intrapartum C-section **% planned non-hospital births at trust level:** augmentation	Instrumental delivery, epidural use	No	Straightforward birth, intrapartum C-section	No

*AMU alongside midwifery unit MVA multivariate analysis NA not applicable UVA univariate analysis SVD spontaneous vaginal delivery OU obstetric unit *outcomes were for planned OU births only*

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Unadjusted rates of outcomes showed that university hospital trusts performed less well than non-university trusts on all outcomes (statistical comparisons not provided). In multilevel models adjusted for midwife staffing and other variables, compared to women from a university hospital trust, women from non-university trusts were more likely to give birth to a healthy baby (OR 1.134, 95% CI 1.016 to 1.265, p=0.0253) and to have a spontaneous vaginal delivery (OR 1.090, 95% CI 1.012 to1.175, p=0.024), but the effect was small (based on relative chi squared values).

University trust status did not have a significant association with other outcomes, although the direction of effect was consistently towards better outcomes at non-university hospital trusts (healthy mother, healthy mother and baby, normal birth, delivery with bodily integrity, intact perineum, elective C-section, emergency C-section, or all C-section). While the results did take into account women's clinical risk, this may still reflect that university hospitals may deal with more complicated pregnancies.

In sensitivity analyses including only the 50 trusts with a single obstetric unit (i.e. reducing it to an approximation of unit level analysis, with the exception of home births) the direction of effects changed, and attending a university trust no longer appeared disadvantageous. Non-university trusts were no longer better for the healthy baby indicator or for spontaneous vaginal delivery, and performed worse than university trusts for the normal birth outcome (ß=-0.207 [SE 0.106], p=0.050). The reason for this reversal of effect is not clear, as it could reflect a variety of causes, for example poorer university hospital outcomes in university trusts with more than one obstetric unit, or poorer non-university hospital outcomes in university trusts with more than one obstetric unit reducing overall outcomes at that trust. The results suggest that a unit level analysis is needed to determine associations between university hospital status and outcomes.

There was not a clear pattern of unadjusted outcomes by type birth units available within the trust. In multilevel models the only significant association identified was for the outcome of normal birth, where trusts with obstetric units alone had a significantly lower rate of normal births than those with obstetric units (OUs) and FMUs (OR 0.885, 95% CI 0.789 to 0.992, p=0.0362). There was not a consistent pattern of non-significant outcomes across the different type of birth units available (see Evidence Table for details, comparator/reference group trusts with OU and FMU).

The correlational study by Rowe et al. 2014 [+] (32,257 births to low risk women planned to take place vaginally and in an obstetric unit) assessed the association between presence of an AMU, % of planned non-obstetric unit births (i.e. at home, an AMU or [FMU]) and of planned out of hospital births (i.e. at home or in an FMU) in the NHS trust which included the obstetric unit, and mode of birth outcomes for that obstetric unit (straightforward birth, normal birth, intrapartum C-section, and instrumental delivery, and use of epidural or augmentation).

Although the study assessed the impact of the presence of alternative types of birth units the outcomes were solely assessed in births which were planned to take place within an obstetric unit. In the analyses outcome rates were adjusted for maternal/fetal characteristics but not adjusted for midwife staffing or other variables. The study considered $p<0.05$ to be statistically significant (i.e. p=0.05 was not significant). Results in this study were for low risk women only, and therefore may not apply to higher risk women.

Presence of an AMU was associated with a significant reduction in straightforward birth or normal birth in multiparous women, the direction of effect was the same in nulliparous women but this did not reach significance (straightforward birth: nulliparous R^2 1.4%, ß=-1.40, p=0.55; multiparous R^2

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14.8%, ß=-3.14, p=0.04; normal birth: nulliparous R^2 10.1%, ß=-5.16, p=0.08; multiparous R^2 21.1%, ß=-6.35, p=0.02). It was also associated with a significant increase in intrapartum C-section for nulliparous women, the direction of effect was the same in multiparous women but this did not reach significance (nulliparous R^2 22.8%, ß=4.99, p=0.03; multiparous R^2 23.1%, ß=3.23, p=0.06). The association between presence of an AMU and increased use of augmentation just missed significance in nulliparous women (nulliparous R^2 14.0%, ß=5.59, p=0.05; multiparous R^2 9.6%, ß=2.73, p=0.07). All other associations were not significant. Study authors noted that chance could not be ruled out as results were not consistently significant across multiple outcomes.

A higher percentage of planned non-obstetric unit births in the NHS trust was significantly associated with a reduced rate of straightforward births and normal births in multiparous women in the obstetric unit, with the same direction of effect in nulliparous women but not reaching significance (straightforward birth: nulliparous R^2 8.2% ß=-0.17, p=0.06; multiparous R^2 26.3% ß=-0.22, p=0.01; normal birth: nulliparous R^2 6.1% ß=-0.20, p=0.08; multiparous R^2 17.4% ß=-0.25, p=0.01). A higher percentage of planned non-obstetric unit births was also associated with an increased rate of intrapartum C-sections in both parity groups (nulliparous: R^2 31.8% ß=0.31, p=0.02; multiparous: R^2 43.4% ß=0.23, p=0.01). Associations with other outcomes were non-significant.

A higher percentage of planned out of hospital births (i.e. at home of in an FMU) was associated with a significantly reduced rate of augmentation in nulliparous women, with the same direction of effect in multiparous women but not reaching significance (nulliparous: R^2 13.7% ß=-0.73, p=0.02; multiparous: R^2 1.3% ß=-0.13, p=0.43). All other associations were not significant.

Outcome rates in this study only included planned obstetric unit births, so transfers from home, or AMUs/FMUs would not contribute to these rates. If the lowest risk women in a population selectively choose to give birth in non-obstetric unit or non-hospital setting, this could be reflected by poorer outcomes in the women who choose to give birth in the obstetric unit. However, as outcome rates were adjusted for maternal/fetal demographic and clinical characteristics, they should not be influencing the results. The study carried out additional exploratory analyses to try and understand the association seen with % of non-obstetric unit and non-hospital births. No association was found between the proportion of planned non-obstetric unit births in a trust and the proportion of planned obstetric unit births which were to higher risk women (data not shown). The relationships between the proportion of planned obstetric units births which were to higher risk women and outcomes in the low risk women were reported to be not consistent (data not shown). There was significant positive correlation between most intervention rates in low risk and higher risk women planning to give birth in the same obstetric unit; there was less correlation for intrapartum C-section rates. This led the authors to suggest that intervention rates may be affected by some common factors across settings, or by an institutional level factor such as an “interventionist culture”.

The authors also suggested that results could be affected by reverse causality, that is, if lower risk women know that units have higher intervention rates (as rates are available online), they may plan to have their birth outside of hospital to avoid this. They also suggest the possibility of selection bias, in that women planning to give birth in obstetric units despite potentially knowing about high intervention rates, could be less averse to intervention.

One important distinction between the results from Rowe et al. 2014 [+] and those of Sandall et al. is that the latter included outcomes of women who gave birth in all settings and gives only overall trust level results, and does not separate outcomes by setting (except for trusts with only obstetric units). While the study by Rowe et al. 2014 looked at associations with the % of births within the trust which

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were planned outside of the obstetric unit, it only included outcomes of women who planned to give birth in an obstetric unit.

Unit size

No studies directly assessed the impact of unit size on safe midwife staffing levels. Five studies which looked at the relationship between midwife staffing and outcomes, also looked at the link between unit size (number of births per year or beds) and outcomes (Sandall et al. in press [++], Joyce et al. 2002 [+], Joyce et al. 2004 [+], Tucker et al. 2003 [+], Rowe et al. 2014 [+]). Table 15 summarises their findings.

One correlational study (Sandall et al. in press [++]) assessed the association between trust size (number of maternities – not explicitly stated, but presumably per year) and trust-level outcomes. In multilevel models, size of trust did not significantly affect the healthy mother and baby outcomes, although there was a non-significant trend for larger trusts to have poorer outcomes, and this just missed significance for the healthy mother outcome (OR 0.972, 95% CI 0.944 to 1.001, p=0.060). Although results were adjusted for maternal clinical risk, the authors suggested that this could reflect less healthy women and babies being referred to the larger units.

Giving birth in larger trusts was associated with reduced likelihood of delivery with bodily integrity (OR 0.975, 95% CI 0.952 to 0.999, p=0.0411) and an intact perineum (OR 0.971, 95% CI 0.945 to 0.998, p=0.0335), but the effects were small (based on relative chi squared values). Trust size was not significantly associated with C-section outcomes.

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Table 15: Association between unit size and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Sandall et al. in press [++] (maternities in the trust)	Delivery with bodily integrity, intact perineum	Healthy mother and baby outcomes, C-section outcomes, normal birth, SVD	Yes	Delivery with bodily integrity, intact perineum	Yes
Joyce et al. 2002 (births in the unit per year, delivery bed rate, NICU bed rate, SCBU + NICU bed rate)	Births per year: None Delivery beds: C-section rates (MVA) NICU, SCBU+NICU beds: C-section rates (UVA not MVA)	Instrumental vaginal delivery, epidural in labour rates	No	Epidural in labour (UVA not MVA)	No
Joyce et al. 2004 [+] (as for Joyce et al. 2002)	NICU, SCBU+NICU beds: Still birth rates (UVA not MVA) Other variables: None	Neonatal mortality	No	None	NA
Tucker et al. 2003 [+] (births in the unit per year)	% of labour ward observations with <1:1 midwives:women ratio, % of labour ward observations with available: required midwives (adjusted for dependency) <1:1	None	No	Neonatal resuscitation excluding bag and mask only	No
Rowe et al. 2014 [+] (births in the unit per year, delivery bed rate)	Births per year: Intrapartum C-section Delivery beds: None	Straightforward birth, normal birth, instrumental delivery, epidurals, augmentation	No	Straightforward birth, intrapartum C-section	No

MVA multivariate analysis NICU neonatal intensive care unit NA not applicable SCBU special care baby unit SVD spontaneous vaginal delivery UVA univariate analysis

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Sensitivity analysis including only the 50 trusts with a single obstetric unit (i.e. reducing the analysis to almost a unit level analysis, with the exception of home births) strengthened the effect of trust size on a number of outcomes, including the healthy mother outcome and combined healthy mother and baby outcome. This suggested that relationships with unit size are to some extent obscured by trusts where there are multiple units contributing to the trust size.

One correlational study (Joyce et al. 2002 [+]) (540,834 births) assessed the impact of unit size as well as midwife and other staffing on outcomes (C-section, instrumental vaginal delivery, epidural use in labour i.e. not for C-sections). The unit size variables assessed were: number of births in the hospital per annum (pa), number of delivery beds/1000 deliveries pa, number of neonatal intensive care unit (NICU) beds/1000 deliveries pa, number of special care baby unit (SCBU) and NICU beds/1000 deliveries pa.

In univariate analyses, larger units, as indicated by higher delivery bed rate (ß=1.379 [SE 0.606], p=0.026), NICU rate (ß=1.073 [SE 0.424], p=0.014), and SCBU and NICU rate (ß=0.542 [SE 0.229], p=0.022) were associated with significantly higher C-section rates, but none of the outcomes were associated with unit size in terms of births/year. In the final multiple regression model, higher delivery bed rate remained associated with significantly increased C-section rate (ß=1.356 [SE 0.504], overall R^2 for model 0.435, p<0.001, model also included epidural rate for labour and junior obstetrician and gynaecologist staffing level).

Unit size variables were not significantly associated with instrumental vaginal delivery rates or epidural in labour rates in univariate analyses. Midwife staffing level was only significantly associated with epidural in labour rates in univariate analyses, but was not one of the variables retained in the final multiple regression model.

A later publication using the same data set (Joyce et al. 2004 [+]), looked at the effect of the same variables on the outcomes of stillbirth and neonatal mortality. In univariate analysis an increased number of NICU beds and of SCBU and NICU beds were associated with reduced birth weight standardised still birth rates (NICU beds/1000 deliveries: ß=-0.378, p=0.006; SCBU+NICU beds/1000 deliveries: ß=-0.153, p=0.04). NICU and SCBU bed rates were combined into a single variable using principal component analysis, but this variable was not retained in the final multiple regression model. None of the unit size variables were associated with birth weight standardised neonatal mortality rates, and midwife staffing was not associated with either of the outcomes in univariate analysis.

The cohort study by Tucker et al. 2003 [+] found that there was a significant difference in percentage of daily observations falling short of the an unadjusted 1:1 ratio of midwives to women on the labour ward depending on the number of births per year at the unit (p<0.001). In general the smaller units seemed to have more shortfall using this measure, although the largest units had similar shortfall to the smallest (units with <1000 births per annum [pa]: 21%, 1000-1999 births pa: 10%, 2000-2999 births pa: 13%, 3000-6999 births pa: 18%). If the staffing ratio took into account casemix/dependency (using Birthrate Plus), then percentage of observations falling short of this adjusted “required” ratio was significantly higher for larger units (units with <1000 births pa: 21%, 1000-1999 births pa: 32%, 2000-2999 births pa: 33%, 3000-6999 births pa: 46%, p<0.001). This may reflect that larger throughput units deal with more complex cases. These figures did not appear to have been adjusted for other potential confounders. The study did not look at the association between unit size and the process or neonatal outcomes it assessed. Higher midwife staffing (based on available : required midwife ratio) was found to be associated with reduced odds of neonatal resuscitation excluding bag and mask only

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resuscitation (see Question 1). Therefore if unit size affects likelihood of reaching this ratio, it could also influence this outcome.

The correlational study by Rowe et al. 2014 [+] (32,257 births to low risk women planned to take place vaginally, in an obstetric unit) assessed the association between two unit size variables (number of births in the obstetric unit over 1 year and number of delivery beds) and mode of birth outcomes for obstetric units (straightforward birth, normal birth, intrapartum C-section, and instrumental delivery, and use of epidural or augmentation).

Larger unit size in terms of number of births in the unit in a year was significantly associated with reduced rates of intrapartum C-section in multiparous women, but just missed significance in nulliparous women (the study considered $p<0.05$ to be significant; nulliparous: R^2 5.8% ß=-0.08, p=0.05; multiparous: R^2 10.6% ß=-0.07, p=0.01). The association between increased number of births and increased likelihood of straightforward birth in multiparous women just missed significance (nulliparous: R^2 0.1% ß=-0.01, p=0.88; multiparous: R^2 8.8% ß=0.08, p=0.05). Relationships between number of births in the unit and other outcomes were not significant, and number of delivery beds was not associated with any outcome. Outcome rates were adjusted for maternal/fetal characteristics but analyses were not adjusted midwife staffing or other variables. The effect on C-section rate (a reduction with increased unit size) was in the opposite direction of effect seen in Joyce et al. 2002 [+]. This may reflect the different populations in the studies (low risk women in Rowe et al. and all women in Joyce et al.), differences in outcome assessed (intrapartum C-section in Rowe et al. and any C-section in Joyce et al.) or differences in adjustment for maternal clinical risk (Rowe et al. adjusted for more variables).

Physical layout

No studies directly assessed the potential impact of physical layout and safe midwife staffing. Two correlational studies (Joyce et al. 2002 [+], Joyce et al. 2004 [+]) analysed the same data set (540,834 births), and assessed the impact of a dedicated maternity theatre as well as midwife and other staffing on outcomes (C-section, instrumental vaginal delivery, epidural use in labour i.e. not for C-sections, still birth and neonatal mortality). Table 16 summarises their findings.

Presence of a dedicated maternity theatre was not significantly associated with any of the outcomes (C-section p=0.177, instrumental vaginal delivery p=0.530, epidural use in labour p=0.180, birth weight standardised still birth rate p=0.51, birth weight standardised neonatal mortality rate p=0.88). Of these outcomes, midwife staffing was only associated with epidural use in labour in univariate (but not multivariate) analysis. The vast majority of units had a dedicated maternity theatre (92.5%), and this may reduce ability to detect an association with the outcomes.

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Evidence statement 3: Effect of environmental factors on midwifery staffing requirements
Evidence from 1 UK cohort study[1] ([+] 3,083 live births) and 5 UK correlational studies[2-6] ([++] 656,969 births[2]; [+] 540,834 births[3,4]; [+] 615,042 women[5]; [+] 32,257 births[6]) suggests that:

- **Local geography**[2] and **demography**[2,3,4,5] may be associated with some maternal and neonatal outcomes although not all associations were adjusted for midwife staffing, or remained significant after adjustment for confounders.
- Mixed results were found for the association between various **birth setting** related variables and maternal and neonatal outcomes[2,6]. The study[2] that adjusted for midwife staffing levels found that the association between university trusts and outcomes were not robust to sensitivity analysis, and that most other associations between birth settings available in the trust were not significant and did not show a consistent pattern.
- Mixed results were found for the association between various measures of **unit size** and maternal and neonatal outcomes[1,2,3,4,6]. Different studies looking at the same unit size measures (maternities/births per year or delivery beds) obtained differing results for the same outcome (C-section)[2,3,4,6] in terms of significance or direction of effect. The study[2] that adjusted for midwife staffing levels found an association between number of maternities at trust level and some outcomes. A second study found an association between births per year in the unit ad ability to reach either a 1:1 ratio of midwives or the case mix adjusted ratio.
- **Presence of a dedicated maternity theatre** is not associated with maternal and neonatal outcomes in analyses unadjusted for midwife staffing.
- No evidence was identified on the effect of **other physical layout factors** on midwife staffing requirements.

[1] Tucker et al. 2003 [+]
[2] Sandall et al. in press [++]
[3] Joyce et al. 2002 [+]
[4] Joyce et al. 2004 [+]
[5] Gerova et al. 2010 [+]
[6] Rowe et al. 2014 [+]

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Table 16: Association between physical layout and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Joyce et al. 2002 [+] (presence of a dedicated maternity theatre)	None	C-section, instrumental vaginal delivery, epidural use in labour i.e. not for C-sections	No	Epidural in labour (UVA, not MVA)	No
Joyce et al. 2004 [+] (as for Joyce et al 2002)	None	Still birth and neonatal mortality	No	None	NA

MVA multivariate analysis UVA univariate analysis

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Question 4: What staffing factors affect safe midwifery staffing requirements at a local level?

Staffing factors were assessed in 5 studies: Gerova et al. 2010 [+], Sandall et al. in press [++], Joyce et al. 2002 [+], Joyce et al. 2004 [+], and Cerbinskaite et al. 2011 [-].

The potential staffing modifying factors addressed by these studies included:

- Midwifery skill mix
- Availability of other healthcare staff
- Time of day

Midwifery skill mix

Only one study looked at the impact of **midwifery skill mix** at a trust level on outcomes (Gerova et al. 2010 [+]). Its findings are summarised in Table 17.

This correlational study (615,042 women) assessed the association between ratio of consultant midwives FTE per birth to midwives FTE per birth on maternal readmissions within 28 days of discharge from the postnatal ward (taking maternal characteristics into account). A higher ratio of consultant midwives to midwives was associated with a significantly reduced likelihood of maternal readmission (β=-4.348, 95% CI -4.408 to -4.289, $p<0.001$), as were midwife FTE per birth and consultant obstetrician and gynaecologist to midwife ratios assessed in the multivariate regression model (results reported under Questions 1 and 3). It was unclear whether the "midwife" group in this analysis included consultant midwives or not. The model was adjusted for maternal risk factors for readmission and also other staffing variables, including midwife staffing.

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Table 17: Association between availability of midwifery skill mix, other healthcare staff and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Midwifery skill mix					
Gerova et al. 2010 [+] (consultant midwife: midwife ratio)	Maternal readmission within 28 days of discharge	None	Yes	Maternal readmission within 28 days of discharge	Yes
Availability of other healthcare staff					
Gerova et al. 2010 [+] (consultant O&G: midwife ratio, registered nurse: midwife ratio)	Maternal readmission within 28 days of discharge	None	Yes	Maternal readmission within 28 days of discharge	Yes
Sandall et al. in press [++] (obstetric doctor: midwife ratio, support worker: midwife ratio, obstetric doctor and support worker staffing, all staffing level i.e. doctor, midwife, and support worker)	All staffing level: delivery with bodily integrity, intact perineum Other staffing variables: none	Healthy mother and baby outcomes, C-section outcomes, normal birth, spontaneous vaginal delivery	Mixed (analysis including all staffing levels and doctor: midwife and support worker: midwife ratios not adjusted for a separate midwife staffing variable)	Delivery with bodily integrity, intact perineum	Mixed (analysis did not adjust for all staffing levels and doctor: midwife and support worker: midwife ratios)

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Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Joyce et al. 2002 [+] (junior O&G staffing, consultant O&G staffing, consultant O&G ward sessions/week, consultant anaesthetist sessions/week)	Junior O&G staffing: C-section (MVA), epidural use in labour (UVA not MVA) Consultant O&G staffing: C-section (UVA not MVA) Consultant O&G ward sessions/week: None Consultant anaesthetist sessions/week: epidural use in labour (UVA not MVA)	Instrumental vaginal delivery	Mixed (only epidural use in labour analysis)	Epidural in labour (UVA not MVA)	No
Joyce et al. 2004 [+] (as for 2002 publication above plus consultant paediatrician staffing, junior paediatrician staffing)	Consultant O&G staffing: still birth (MVA) All other staffing variables: None	Neonatal mortality	No	None	NA
Time of day					
Cerbinskaite et al. 2011 [-] (time of day)	Decision to perform grade 2 emergency C-section, type of anaesthetic used	Decision to perform grade 1 emergency C-section, decision-to-delivery interval (grade 1&2)	No	Decision-to-delivery interval (grade 1 & 2 emergency C-sections)	No

O&G obstetricians and gynaecologists MVA multivariate analysis NA not applicable UVA univariate analysis

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Availability of other healthcare staff

Two studies looked specifically at the effect of availability of other healthcare staff on safe midwifery staffing levels, by looking at the relationship between ratios of other healthcare staff:midwives on outcomes (Gerova et al. 2010 [+], Sandall et al. in press [++]). As well as these studies, 2 studies which looked at the relationship of midwife staffing on outcomes also looked at the relationship of other healthcare staff to these outcomes (Joyce et al. 2002 [+], Joyce et al. 2004 [+]). Table 17 summarises their results.

One correlational study (Gerova et al. 2010 [+]) (615,042 women) assessed the association between ratios of **consultant obstetrician and gynaecologist FTE per birth : midwife FTE per birth** and **registered nurse per birth : midwife FTE per birth** to on maternal readmissions within 28 days of discharge from the postnatal ward (taking maternal characteristics into account). A higher ratio of consultants to midwives was associated with a significantly reduced likelihood of maternal readmission (ß=-3.563, 95% CI -3.605 to -3.522, p<0.001), as was midwife FTE per birth and consultant midwife:midwife ratio (results reported under Questions 1 and above). However, a higher ratio of registered nurses to midwives was associated with an increased risk of maternal readmission (ß=3.133, 95% CI 3.115 to 3.151, p<0.001). It was unclear whether the nurses in question were specifically part of maternity services, but this was assumed to be the case. The study did not include healthcare assistants (including maternity support workers) in the model as there was colinearity with other staff groups. These results came from a multivariate model adjusted for maternal risk factors for readmission, and including the staffing variables described above.

The large correlational study by Sandall et al. in press [++], carried out analyses of the effect of **obstetric doctor: midwife ratio** and **support worker: midwife ratio** at trust level on a range of outcomes (healthy mother and baby outcomes, mode of delivery outcomes, and C-section outcomes, see Table 18 for summary of results). None of the associations were found to be significant in multivariate analyses. In general, a higher doctor to midwife ratio was associated with a non-significant improvement in outcomes.

Higher support worker to midwife ratio was generally associated with a non-significant worsening of outcomes. (An increase in elective C-sections is not necessarily a worse outcome, if it reduces need for emergency C-sections, but in this case both elective and emergency C-sections were increased with increasing support staff:midwife ratios.)

The exception was normal birth (no induction, instrumental delivery, C-section, episiotomy or general or regional anaesthetic) where the direction of non-significant effect was for reduced likelihood with a greater doctor: midwife ratio (OR 0.849) and increased likelihood with a greater support worker: midwife ratio (OR 1.031). There is the possibility that this outcome reflects more about the potential to perform these activities (e.g. C-section) when the staff mix includes fewer doctors:midwives and more support workers:midwives, rather than differences in clinical need. It could also to some extent reflect reverse causality, with trusts staffing to match their population's clinical need.

This study also looked at the association between doctor and support staff levels per 100 maternities separately (i.e. not in relation to midwife staffing) on outcomes. Multilevel modelling showed that maternal factors had the greatest effect on outcomes, and staffing variables (including midwife staffing only had minor effects (relative chi squared values all <10).

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In these models none of the staffing level variables (including midwife staffing) were significantly related to healthy mother and baby outcomes or C-section outcomes. There was a non-significant trend for an increased level of support worker staffing to be associated with a reduction in the likelihood of healthy mother and combined healthy mother and baby outcomes (healthy mother: OR 0.892, 95% CI 0.776 to 1.026, p=0.11; healthy mother and baby: OR 0.897, 95% CI 0.781 to 1.031, p=0.13). Higher levels of doctor staffing were associated with a non-significant trend for reduced C-section rate (OR 0.857, 95% CI 0.709 to 1.036, p=0.11). Higher levels of overall staffing (i.e. of all staff combined) were associated with significantly increased likelihood of delivery with bodily integrity (OR 1.079, 95% CI 1.016 to 1.147, p=0.0135) and intact perineum (OR 1.092, 95% CI 1.019 to 1.170, p=0.0127).

The study also carried out interaction analyses to look at the effect of maternal clinical risk and parity on the associations between doctor and support worker staffing and outcomes. It found that there was significant interaction for some outcomes (see Evidence Table for details). In general, support worker staffing level had less of a negative effect in lower risk women and their babies for the healthy mother and baby outcomes and some mode of delivery and C-section outcomes, and greater benefit for women with higher parity (4 or more previous children) for the outcome of intact perineum.

The effect of higher doctor staffing levels by parity varied depending on the outcome, with effects greater in nulliparous women for some outcomes (healthy mother and baby outcomes and delivery with bodily integrity) but greater in women with higher parity for other outcomes (spontaneous vaginal delivery, normal birth, elective C-section). Similarly for clinical risk, lower risk women benefitted more from high doctor staffing levels for one outcome (healthy mother) but higher risk women benefited more for other outcomes (spontaneous vaginal delivery, normal birth, elective C-section, all C-section).

In sensitivity analyses including only the 50 trusts with a single obstetric unit (i.e. essentially reducing it to a unit level analysis, plus home births), the relationship between increased support workers and reduction in likelihood of a healthy baby became significant (ß=increased from -0.034 to -0.221, p=0.048).

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Table 18: Summary of association between ratios of doctors and support workers to midwives and maternal and neonatal outcomes

Study	Staffing variable	Healthy mother*	Delivery with bodily integrity*	Intact perineum	Normal birth*	Spontaneous vaginal delivery	Elective C-section	Emergency C-section	Any C-section	Healthy baby
Sandall et al. in press [++]	Doctor-midwife ratio	(↑) OR 1.316 (95% CI 0.608 to 2.846, p=0.4860)	(↑) OR 1.149 (95% CI 0.606 to 2.180, p=0.6702)	(↑) OR 1.001 (95% CI 0.482 to 2.078, p=0.9981)	(↓) OR 0.849 (95% CI 0.448 to 1.608, p=0.6150)	(↑) OR 1.018 (95% 0.615 to 1.685, p=0.9441)	(↑) OR 0.652 (95% CI 0.349 to 1.220, p=0.1809)	(↑) OR 0.760 (95% 0.437 to 1.322, p=0.3314)	(↑) OR 0.650 (95% CI 0.380 to 1.114, p=0.1172)	(↑) OR 1.363 95% CI 0.638 to 2.914, p=0.4239
	Support worker-midwife ratio	(↓) OR 0.716 (95% CI 0.452 to 1.135, p=0.1552)	(↓) OR 0.884 (95% CI 0.610 to 1.280, p=0.5137)	(↓) OR 0.911 (95% CI 0.597 to 1.389, p=0.6640)	(↑) OR 1.031 (95% CI 0.729 to 1.457, p=0.8649)	(↓) OR 0.876 (95% CI 0.655 to 1.171, p=0.3706)	(↓) OR 1.209 (95% CI 0.842 to 1.734, p=0.3035)	(↓) OR 1.082 (95% CI 0.786 to 1.489, p=0.6296)	(↓) OR 1.182 (95% CI 0.866 to 1.613, p=0.2914)	(↓) OR 0.758 (95% CI 0.482 to 1.191, p=0.2296)

↑ Significantly better outcome with increased staffing; ↓ significantly worse outcome with increased staffing; ( ) bracketed arrows indicate non-significant effects; (=) equivalent outcomes; (≈) no reported or no clear direction of non-significant effect. Effects shown for the most adjusted analyses. ‡Unadjusted results

*Composite outcomes, definitions: *Healthy mother:* delivery with bodily integrity (DwBI), return home in ≤2 days, and no instrumental delivery, maternal sepsis, anaesthetic complication, or readmission within 28 days; *DwBI:* no uterine damage, 2nd/3rd/4th degree tear, stitches, episiotomy, or C-section.

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One correlational study (Joyce et al. 2002 [+]) (540,834 births) assessed the impact of other healthcare staffing at the unit level as well as midwife staffing on outcomes (C-section, instrumental vaginal delivery, epidural use). The staffing variables assessed were: consultant obstetrician and gynaecologists (O&G)/1000 deliveries per annum (pa), junior O&G/1000 deliveries pa, number of consultant O&G sessions on labour ward/week, number of consultant anaesthetist sessions on labour ward/week.

In univariate analyses, higher consultant O&G doctor rates and higher junior O&G doctor rates were both associated with higher C-section rates (consultant O&G: ß=1.968 [SE 0.786], p=0.013; junior O&G: ß=0.862 [SE 0.188], p<0.001). Also, more consultant anaesthetist sessions on the ward and higher junior O&G doctor rates were both associated with higher epidural use in labour (anaesthetist sessions: ß=2.013 [SE 0.993], p=0.047; junior O&G: ß=1.539 [SE 0.264], p<0.001). Other associations were not significant.

In the final multiple regression models the only staffing variable that was retained was junior O&G rate, where increasing rates were associated with increasing C-section rates (ß=0.671 [SE 0.178], overall model R^2 0.435, p<0.001; other model variables epidural for labour rate and delivery bed rate).

A later analysis using the same data set (Joyce et al. 2004 [+]) looked at the same and some additional staffing variables on birth weight standardised still birth and neonatal mortality. The additional variables were number of consultant paediatricians per 1000 births and junior paediatricians per 1000 births. In univariate analyses the only significant association was between increasing consultant O&G rates and reduced birth weight standardised still birth rates (ß=-0.681, p=0.006, SE not reported). This variable was retained in the final multiple regression model (ß=-0.55 [SE 0.23], p=0.019, overall R^2 for model 0.27; only other variable in the model was intervention score, with more interventions also associated with reduced still birth rates). For one interquartile range increase in number of consultant obstetricians and gynaecologists/1000 deliveries, birth weight standardised still birth rate reduced by 0.26.

Time of day

No studies directly assessed the potential impact of time of day and safe midwife staffing. One study (Cerbinskaite et al. 2011 [-]) assessed impact of time of day as well as midwife staffing on outcomes. Medical staffing differed between the day and night, but results were not adjusted for this. Whether midwife staffing differed between the day and night shifts was not reported. Table 17 summarises its findings.

The study (5,167 births not by elective C-section, 333 emergency grade 1 and 2 C-sections) found that a decision to perform a grade 1 emergency C-section was equally likely during the day and night (59/2620 [2.3%] vs. 63/2547 [2.5%], p=0.104). However, grade 2 C-sections were more likely at night (97/2620 [3.7%] vs. 114/2547 [4.5%], p=0.015). This increase was mainly due to an increase in grade 2 C-sections resulting from cardiotocographic abnormality without fetal blood sampling (37 vs. 62, p<0.001) and failure to progress in the second stage of labour (11 vs. 20, p=0.01). Time of day was reported to not affect decision-to-delivery interval for either grade of C-section (results displayed graphically). Results were not adjusted for midwife or other staffing levels or other potential confounders.

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Type of anaesthesia used for grade 1 C-section varied by time of day, with general anaesthesia most common in the day (31/59 [52.5%] vs. 22/63 [34.9%], p=0.005) and spinal blockade most common at night (17/59 [28.8%] vs. 29/63 [46.0%], p=0.009). Type of anaesthesia used in grade 2 C-sections did not vary by time of day (p>0.07 for comparisons of day vs. night for each anaesthetic type).

Lower midwife staffing was associated with a longer decision-to-delivery interval, and the extent of this effect seemed to greatest for grade 2 C-sections, therefore if grade 2 C-sections are more common at night, time of day may influence safe midwife staffing levels. In addition, type of anaesthetic used was affected by time of day, and itself affected decision-to-delivery for grade 1 C-sections but not grade 2 C-sections (see section on interventions used in Question 2). Although time of day did not directly influence decision-to-delivery interval, these factors (time of day, type of anaesthetic and midwifery staffing) could interact. Without any statistical assessment of the interaction between time of day, midwife staffing, other factors, and outcome it is not possible to draw firm conclusions about their relationship. In addition, this study included a small number of C-sections, within a single obstetric unit and therefore may not be representative of obstetric units as a whole.

Care provided by other healthcare staff and division of tasks between midwives and maternity support workers

No studies assessed the effect of specific care provided by other healthcare staff, or division of tasks between midwives and maternity support workers and safe midwife staffing levels.

Requirements to provide additional services

No studies assessed the effect requirements to provide additional services (e.g. high dependency care, public health roles, vaccinations) and safe midwife staffing levels.

Evidence statement 4: Effect of staffing factors on midwifery staffing requirements

Evidence from 1 cross sectional analysis of a UK cohort study[1] ([-] 333 emergency C-sections) and 4 UK correlational studies[2-5] ([++] 656,969 births[2]; [+] 540,834 births[3,4]; [+] 615,042 women[5]) suggests that:

- A higher **consultant midwife: midwife ratio** is associated with reduced maternal readmission within 28 days of discharge[5].
- Higher ratios of **obstetric medical staff:midwives** at trust level, particularly consultants, may be associated with improved outcomes[2,5] while higher levels of **nurses:midwives**[5] or **support workers:midwives**[2] may be associated with worse outcomes. However, in one study these associations were not significant after adjustment for midwife staffing and other factors[2]. Levels of doctor staffing[2,3,4] (mainly obstetricians and gynaecologists where different specialties were assessed), support worker staffing[2], and all staffing combined[2] were found to be associated with some outcomes, but not all of the associations were adjusted for midwife staffing, or significant after adjustment for potential confounders.
- Mixed results were found for the association between **time of day** (staffing of differed in the day and night time) and likelihood of decisions to perform emergency C-section, with associations identified for grade 2 but not grade 1 C-sections[1].
- No evidence was identified on the effect of **specific care provided by other healthcare staff**, **division of tasks between midwives and maternity support workers**, or **requirement for midwives to provide other services** (e.g. high dependency care, public health roles, vaccinations) and safe midwife staffing levels.

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[1] Cerbinskaite et al. 2011 [-]
[2] Sandall et al. in press [++]
[3] Joyce et al. 2002 [+]
[4] Joyce et al. 2004 [+]
[5] Gerova et al. 2010 [+]

Question 5: What unit level management factors affect midwifery staffing requirements?

Unit level management factors were assessed by two studies: NSCCRT 2000 [+] and Joyce et al. 2004 [+]. The potential local level management modifying factors addressed by these studies included:

- Models of midwifery care (caseload versus shared care)
- Service provision and risk management processes

Models of care

No studies directly assessed the impact of models of care on safe staffing levels. One cluster RCT (NSCCRT 2000 [+]) (1,505 women) compared caseload care versus shared care. The caseload group midwives had a lower caseload (35-40 women) than the shared care group (100-150 women), but it was unclear whether staffing levels (overall ratio of midwives:women) in the two groups was different. Its findings are summarised in Table 19.

The RCT found that caseload care significantly increased the likelihood of being attended by a known midwife or midwifery partner in labour (94.7% vs. 6.7%, p<0.001) and duration of labour (<8 hours 58.5% vs. 68.4%, p for overall trend ≤0.001), and significantly reduced use of epidurals (10% vs. 15%, p=0.01) and oxytocin/syntocinon augmentation (46% vs. 53%, p=0.01). The increase in length of labour may have been due to earlier documentation of labour starting if midwives in the caseload group attended the women at home. There was no significant difference between the groups in mode of delivery, gestation length, stillbirth and neonatal death, advanced neonatal resuscitation, admission to the neonatal unit, low birthweight (<2.5 kg), induction, intact perineum, episiotomy, perineal laceration or perineal tear (results figures reported in under Question 1 above).

As caseload care does improve some outcomes, use of this model of care may affect safe midwife staffing levels if it does require more midwives to provide it.

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Table 19: Association between models of care, service provision, and risk management and outcomes

Study (factor assessed)	Associated outcomes	Outcomes not associated	Analyses of adjusted for midwife staffing?	Outcomes associated with midwife staffing	Midwife staffing analyses adjusted for modifying factor?
Models of care					
NSCCRT 2000 [+] (caseload care vs. shared care)	Attendance by known midwife or midwifery partner, duration of labour, epidural use, augmentation	Mode of delivery, gestation length, stillbirth and neonatal death, advanced neonatal resuscitation, admission to the NNU, low birthweight, induction, perineal outcomes	NA	(No separate analyses, as per overall caseload analyses)	NA
Service provision and risk management					
Joyce et al. 2004 [+] (presence of a 24 hour epidural service, whether the unit had a risk manager, the grade of person who was the risk manager (obstetrician, midwife manager, clinical midwife, other, or no risk manager), and the frequency of perinatal meetings)	None	Still birth, neonatal mortality	No	None	No

NA not applicable NNU neonatal unit

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This RCT was performed before 2000, and may not be representative of current practice. For example, at that time shared care was the usual model of care in the study areas. However, this model of care may no longer be seen as standard care within the UK.

No other studies assessing other models of care and meeting inclusion criteria were identified.

Service provision and risk management processes

No studies directly assessed the impact of service provision and risk management processes on safe staffing levels. One correlational study (Joyce et al. 2004 [+]) (540,834 births) assessed the impact of various service and risk management processes as well as midwife and other staffing levels on outcomes (birth weight standardised still birth and neonatal mortality rates). Its findings are summarised in Table 19.

The variables assessed were: presence of a 24 hour epidural service, whether the unit had a risk manager, the grade of person who was the risk manager (obstetrician, midwife manager, clinical midwife, other, or no risk manager), and the frequency of perinatal meetings. None of these variables were significantly associated with still birth or neonatal mortality rates in univariate analysis, nor was midwife staffing levels.

Other local level management factors

No studies were identified which met inclusion criteria and assessed the effect of maternity team management and administration (e.g. shift patterns), staff and student supervision, or supernumerary arrangements on safe midwifery staffing levels.

Evidence statement 5: Effect of unit level management factors on midwifery staffing requirements

Evidence from 1 UK RCT[1] ([+] 1,505 women) and 1 UK correlational study[2] ([+] 540,834 births) suggests that:

- **Model of care**[1] (caseload or shared care) may be associated with some maternal and neonatal outcomes.
- **Risk management practices** (presence and grade of a risk manager, frequency of perinatal meetings) and **presence of a 24 hour epidural service** are not associated with stillbirth and neonatal mortality rates.
- No evidence was identified about the effect of **maternity team management and administration** (e.g. shift patterns), **staff and student supervision**, or **supernumerary arrangements** on safe midwifery staffing levels.

[1] NSCCRT 2000 [+]
[2] Joyce et al. 2004 [+]

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Question 6: What organisational factors influence safe midwifery staffing at a unit level?

No studies were identified which met inclusion criteria and assessed the effect of organisational factors, such as management structures and approaches, organisational culture, organisational policies and procedures (including staff training) on safe midwifery staffing levels.

Evidence statement 6: Effect of organisational factors on safe midwifery staffing levels
No studies were identified which met inclusion criteria and assessed the effect of organisational factors, such as management structures and approaches, organisational culture, organisational policies and procedures (including staff training) on safe midwifery staffing levels.

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5. Discussion

Overall few significant associations between midwife staffing levels and outcomes were identified. The evidence suggests that increased midwife staffing may be associated with an increased likelihood of delivery with bodily integrity (no uterine damage, 2nd/3rd/4th degree tear, stitches, episiotomy, or C-section), reduced maternal readmissions within 28 days, and reduced decision-to-delivery times for emergency C-sections. However, it may not be associated with overall C-section rates, composite 'healthy mother' or 'health baby' outcomes, rates of 'normal' or 'straightforward' births, or stillbirth or neonatal mortality.

Interpretation is also complicated by the use of differing, but overlapping, outcomes in different studies. For example, although delivery with bodily integrity (DwBI) was increased with higher midwife staffing in one study, another study suggested a possible reduction in straightforward birth with increasing levels of midwife staffing. Straightforward birth includes some of the same outcomes as DwBI (straightforward birth defined as no intrapartum C-section or 3rd/4th degree perineal trauma both of which form part of DwBI, as well as no birth without forceps or ventouse or blood transfusion).

No studies were identified which assessed the links between midwife staffing and on maternal mortality or never events (such as maternal death due to post-partum haemorrhage after elective caesarean section, wrongly prepared high-risk injectable medication, intravenous administration of epidural medication, or retained foreign objects post-procedure) or serious fetal/neonatal events such as Erb's palsy secondary to shoulder dystocia, meconium aspiration syndrome, hypoxic ischaemic encephalopathy (HIE).

Limited evidence was identified on potential modifiers of the effect of midwife staffing levels on outcomes, therefore limited conclusions can be drawn about their effects. Only one study (Sandall et al. in press [++]) formally assessed potential interactions between modifying factors and midwife staffing levels. Its findings suggested that, maternal clinical risk and parity both appear to be modifiers, and to themselves have a large impact on outcomes.

Overall the amount of evidence is relatively limited, with relatively few relevant studies (8 studies included), and most of these using correlational designs, which limits their ability to detect potential causality. However, all of the relevant studies identified were carried out in the UK, so are likely to be applicable. Also, while the number of studies is small, some of these have analysed recent data (2008-2011), and some of these have analysed data for over 600,000 births across the majority of trusts within England. Most of the outcomes assessed are intrapartum outcomes, and none of the studies looked at the relationship between midwife staffing and outcome specifically within alongside or freestanding midwifery units, or for births at home. Therefore results may be less applicable to these settings.

The limited nature of the empirical evidence has also been noted by other reports, for example, Gerova et al. 2010 noted that "Most of the studies which have specifically focused on staffing issues are descriptive in nature, relying primarily on staff opinions, but confirm the perception that lower staffing levels are associated with adverse outcomes in terms of safety and experience. However these studies cannot provide estimates of the impact of changes to staffing or provide robust evidence to guide policy about staffing levels." A report from the King's Fund in 2011 (Sandall et al.

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2011) also noted that "few studies have examined the relationship between midwifery staffing levels and patient outcomes."

Limitations to the studies mean that inference of direct causal links between midwife staffing levels and outcome is not possible. For example, only 3 included studies attempted to temporally link individual women's exposure to midwife staffing levels and their outcomes (Tucker et al. 2003 [+], Cerbinskaite et al. 2002 [-], and NSCCRT 2000 [+]). The other studies were correlational, and therefore cannot establish a granular temporal sequence of midwife staffing levels and outcomes, or establish links for individual women. However, given that staffing levels are generally assessed on a population level (i.e. as an overall ratio of midwives: women cared for), analysis of exposures of individual women may not be appropriate or feasible on anything other than a relatively limited scale.

Seven of the included studies were observational, and despite attempts by some of these to adjust for confounders, residual confounding cannot be ruled out. The same applies to the RCT (NSCCRT 2000), despite its design. This is because it compared different models of care rather than specifically midwife staffing levels, which means that other differences between groups may confound any effect of differences in staffing levels. RCTs comparing different midwife staffing levels are likely to be unethical, therefore well-adjusted observational evidence is likely to be the best available evidence to answer this question.

Another consideration regarding the observational studies, particularly the correlational studies, is the potential for reverse causality. For example, a unit which deals with more (or less) complicated pregnancies or births may staff differently as a result, and if these units have worse outcome this may relate to the complexity of births rather than the staffing levels.

For outcomes which have been found not to be associated with midwife staffing levels, this may be due to various reasons, including:

- A true lack of association between midwife staffing and the given outcome
- Insufficient variation in the midwife staffing levels in the studies to be able to detect an effect (i.e. if the effect may occur below or above a certain staffing threshold which has not been reached in the studies)
- A lack of power to detect an association between midwife staffing and the given outcome, particularly for less common outcomes
- Confounding of results by other staffing levels or other variables and lack of or insufficient adjustment for these factors in the analyses

The latter two possibilities form part of the quality assessment and scores of the individual studies, and are noted in cases where they are particularly of concern.

For modifying factors, while there was suggestion of greater benefit of higher midwife staffing for women of lower clinical risk, this does not necessarily mean that midwife staffing has no impact on outcomes for women of higher clinical risk. Rather it may reflect that higher risk women may be prioritised for care even in lower staffing conditions, it may also reflect reverse causality, with higher risk women being cared for in settings with higher medical rather than midwife staffing.

The majority of directly relevant evidence about potential modifiers of safe midwife staffing levels related to maternal factors and staffing factors (skill mix of midwives and presence of other healthcare staff). The absence of evidence for other factors should not be interpreted as evidence of absence of an effect of these factors on midwife safe staffing.

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None of the included studies looked specifically at the relationship between midwife staffing in alongside or freestanding midwifery units or of midwives providing home births and outcomes, and results may not apply to these settings.

The current evidence review also has some limitations. Due to the limited timescale in which it was produced a number of pragmatic approaches were taken, based on discussed and agreement with NICE. For example, the review included only studies which assessed the effect of midwife staffing on at least one documented safety or process of care outcome. Studies which assessed satisfaction with care only, qualitative studies or other studies assessing only perceptions of the effect of midwife staffing were excluded. While satisfaction with care is an important outcome, safety is the key focus of the safe staffing guidelines. This decision allow the review to focus on a more in-depth assessment of studies providing objective assessments of safety-related outcomes in the time available, rather than providing a less in depth review of a wider range of outcomes.

A review of qualitative studies relating to midwife staffing was not feasible within the timescale. This type of study can provide information about perceptions about potential effects of midwife staffing levels on causes of events or outcomes, and also about women's views on care. For example, the qualitative study by Ashcroft et al. 2003 suggested that some adverse events and unreported 'near misses' were related to midwife shortages, and that this was influenced by clerical duties taking the midwives away from clinical work and also by poor organisation. However, these studies cannot provide a quantitative assessment of the links between midwife staffing and outcomes. Ideally the findings of qualitative research would be followed up with quantitative assessments of the hypotheses/approaches they generate.

As few studies have directly assessed the impact of midwife staffing on outcomes, another approach could be to identify all midwife activities shown to be associated with improved outcomes and calculate times required for a midwife to be able to perform these tasks. However, this reductionist approach has not been taken here, and it would be unlikely to provide a comprehensive list of tasks, as many may not have been tested in this way but may still be important.

An alternative approach to look at modifiers of midwife safe staffing levels would be to identify outcomes affected by midwife staffing, and then search for all studies assessing the impact of the potential modifiers on these outcomes, whether or not they assess staffing. This was also not feasible in the timescale, so the review has described links between the factors if interest and outcomes seen within the studies assessing midwife staffing. However, these findings may not reflect an impact on midwife safe staffing requirements, and should be interpreted with caution. For example, the results from Sandall et al. in press [++] show that even if a factor is significantly associated with midwife-staffing-adjusted outcomes (e.g. maternal clinical risk), this does not mean that an interaction between this factor and midwife staffing exists for all of these outcomes. In addition, other studies assessing the link between these factors and outcomes may exist which have not been identified or included by this review, as they have not assessed midwife staffing.

The current review did not aim to assess the effectiveness of caseload or other models of care per se, rather the impact of models of care on safe midwife staffing levels. As such, studies of models of care have only been included here if they provided explicit quantitative information about staffing levels in the two groups. The included RCT (NSCCRT 2000 [+]) came closest to this as it quantified midwife caseloads in both groups, however, it is not clear whether overall staffing levels differed between these groups. Other RCTs comparing caseload versus shared care are also likely to have similar

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caseload differences due to the way in which care is organised in these approaches, but as these were not explicitly quantified they were not included.

Evidence gaps / need for future research

This review has identified evidence gaps. The amount of research directly relevant to identifying the relationship between midwife staffing and outcomes is limited. There is even less research which specifically aims to identify what factors might modify this relationship, and in what way. The existing research almost all focuses on outcomes in the intrapartum and immediate post-partum period. The most recent, highest quality study addressed staffing at the trust level, and many studies could not establish temporal links between midwife staffing levels and outcomes.

Future research could include:

- Studies assessing the impact of differing midwife staffing levels on outcomes in the antenatal period
- Studies aiming to assess the temporal links between midwife staffing and outcomes
- Unit level analysis specifically assessing modifiers of safe midwife staffing levels, including the impact of organisational and local level management factors

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The version of Sandall et al. that was considered in this evidence review and by the Safe Staffing Advisory Committee was a draft version of the manuscript dated May 2014. That version underwent a full peer and editorial review process in line with the NIHR Journals Library policy.

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Wrong question (n=27)

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7. Appendix B: Study protocol/methods

Operational definitions

Definitions are based on those used in the first safe staffing review on nursing in acute adult wards and on the full guideline for NICE CG55 on Intrapartum care.

Midwife staffing: the size and skill mix of the midwife team, relative to the number of women or neonates cared for expressed as midwife hours per woman/neonate day, women/neonates per midwife or an equivalent measure.

Local level: The level of hospital, ward or unit.

Skill mix: The composition of the midwife team in terms of grade, qualification and experience.

Management approach: An explicit and defined management measure, intervention or practice as opposed to passive characteristics like leadership styles. This does not preclude active changes to leadership styles.

Caseload midwifery: Where one midwife (may be referred to as the named midwife') provides the majority of care and takes responsibility for a group of women from the antenatal, through intrapartum to the postnatal period. It aims for a more personal relationship with the woman than in team midwifery and involves a small group of midwives. When there is one midwife backing up a named midwife this system is also known as 'one-to-one' care. Caseload midwifery schemes tend to be community based.

Team midwifery: Team midwifery is a team of midwives looking after a group of women and caseload midwifery aims for a more personal relationship with the woman and involves a small group of midwives. Sizes of teams vary. The aim of most team midwifery schemes is to increase the chance that women will be cared for in labour by a midwife they have met antenatally, with the focus on intrapartum continuity often taking precedence over antenatal and postnatal continuity. Team midwifery schemes have usually been hospital based, or integrated across hospital and community settings.

Continuity of care: Refers to both continuity of carer and consistency of care. Often refers to continuity of carer and describes care provided by a midwife or a small group of midwives, from early pregnancy to the postnatal period. Team midwifery and caseload midwifery are the two main models of midwifery care that have evolved as a way of organising services so as to provide continuity of carer.

One to one care in labour and childbirth: One-to-one care is defined as continuous presence and support either by husband/partners, mid-wives or other birth supporters during labour and childbirth. Continuity of care in maternity services refers to both continuity of carer and consistency of care.

Process overview

- Identifying potentially relevant studies using three sifts based on agreed sifting criteria:
  - at title level for the initial sift by information specialists
  - at title and abstract level for the second sift by health research analysts
  - full text sift by health research analysts
- Assessing quality of the included studies

- Extracting data from included studies
- Assessing the quantity, quality and applicability of evidence available
- Summarising findings in line with process agreed
- Developing evidence statements

Further details of the methods for Review are outlined below.

Searching

Searching for this project will be carried out by NICE. The searches provided by NICE to Bazian will cover:

- Searches of literature databases
- Grey literature searches
- Primary study reference from relevant systematic reviews

Filtering evidence identified

First pass appraisal

Evidence identified in the search will be filtered at the title level by an information specialist to remove any clearly non-relevant material. Studies will be excluded on the basis of the following:

- Studies not addressing midwife staffing
- Systematic reviews and meta-analyses
- Non-English language studies
- Non-primary study publications e.g. editorials
- Studies not performed in OECD countries
- Studies about maternity workforce planning at a network, regional or national levels, or optimal service delivery models
- Studies not relevant to the questions/scope being addressed in the reviews

A random sample of 10% of citations identified in the searches will be double sifted by a second Information Specialist, and agreement will be reported. Reasons for exclusion of individual studies are not recorded at this stage. Any uncertainties regarding inclusion/exclusion will be resolved by discussion with a second information specialist. This stage of screening will act as a “coarse filter” and err on the side of inclusion, to avoid exclusion of studies that may be relevant.

Second pass appraisal

The filtered references will be tagged in Reference Manager and passed on to a Health Research Analyst, who will carry out a more detailed assessment of the studies based on title/abstract, to select relevant studies for full text appraisal. The reasons for exclusion will be:

- Studies not addressing midwife staffing
- Systematic reviews and meta-analyses
- Non-English language studies
- Non-primary study publications e.g. editorials
- Studies not performed in OECD countries
- Studies about maternity workforce planning at a network, regional or national levels, or optimal service delivery models
- Studies not relevant to the questions/scope being addressed in the reviews
- Studies without abstracts (unless title indicates a high level of relevance)

- Studies comparing care provided by midwives with care provided by another healthcare professional (e.g. a direct comparison of safety of care provided by a midwife versus that of an obstetrician)
- Purely qualitative studies (i.e. no quantitative data)
- Studies without any documented safety or delivery of care outcomes (the latter to include number of complaints), i.e. studies with only qualitative assessment of e.g. maternal/partner/staff experience and satisfaction alone or perception of workload or delivery of care would be excluded. If these are outcomes in studies assessing safety and care outcomes they will be reported.
- Non-comparative studies (this could be a within group comparison, e.g. RCT, cohort, cross-sectional, before/after should be included)
- Conference abstracts/theses
- Simulation studies (e.g. modelling studies)

In addition, comparisons across different types of units (e.g. freestanding and conventional labour wards) or management/organisational approaches that do not specifically mention midwife staffing level were initially excluded, but these studies were tagged for further reference. After agreement with NICE these papers were also reviewed in full text.

All uncertainties regarding inclusion or exclusion (that is, possible includes/excludes where the first reviewer is unsure) were resolved by discussion with a second analyst, or if uncertainty remains after discussion, by discussion with NICE.

A 10% sample of titles and abstracts will then be double screened at this stage for eligibility for inclusion. Agreement and inter-rater reliability will be reported. Any disagreements regarding inclusion/exclusion will be resolved by discussion, with recourse to a third analyst if needed. This stage of screening will act as a slightly finer filter than the first pass appraisal, but will again err on the side of inclusion if details are not included to allow decisions about the eligibility of the paper. Papers selected for full text appraisal will be tagged in Reference Manager.

Full text appraisal

The full text papers will be appraised by a Health Research Analyst, using the same exclusion criteria as for the second pass appraisal, in order to select studies that match the review scope as laid out in Section 2.5. In addition, studies assessing the impact of management and organisational factors on outcomes will be excluded unless the provide information about midwife staffing levels (i.e. midwives per woman/neonate in the ward/unit/hospital/other setting) for both groups being compared.

Information on reason for exclusion will be recorded in Reference Manager. The reason for exclusion will be recorded as:

- Wrong question (e.g. not assessing effect of midwife staffing on outcomes, directly comparing midwife versus doctor care)
- Wrong study type (e.g. systematic review, qualitative study)
- Wrong population (e.g. not pregnant women, neonates, or women trying to conceive)
- No comparator
- Wrong/no outcome data (e.g. includes studies not linking maternity staffing levels to outcome data, outcomes outside of scope, no documented safety/delivery of care outcomes)
- No midwife staffing level data (i.e. midwives per woman/neonate in the ward/unit/hospital/other setting data not provided for both groups being compared).

- Other (e.g. studies in non-OECD countries, non-primary study publications, simulation study, conference abstract/thesis)

All queries regarding inclusion or exclusion (that is, possible includes/excludes where the first reviewer is unsure) will be resolved by discussion with a second analyst. A 10% sample of full texts will be double screened at this stage for eligibility for inclusion. Agreement will be reported.

Scope

The review scope is outlined below, including what is covered and not covered by the review.

Parameters	Criteria	Additional comments
Level to be covered	Local level i.e. individual ward/hospital/midwife unit/local catchment area for community midwives	
Levels not to be covered	Maternity workforce planning at network, regional and national levels and optimal service delivery models for maternity services	
Study types/designs to be included	Other than the exclusions listed below, any study design included at early sifting stages. Once initial sifting stages are complete, we will agree with NICE any restrictions on study designs based on the hierarchy of evidence.	
Studies types/designs that will not be included	Non-OECD studies Non-English language studies Studies published before 1999 Systematic reviews (see note) Case reports/case studies Letters Editorials	Primary studies in systematic reviews identified in the search for Q1-5 were assessed for relevant primary studies by NICE. Primary studies included in Cochrane systematic reviews identified in the toolkit and economic searches as potentially relevant to Q1-5 were also assessed by Bazian for additional relevant primary studies.
Exposures/ interventions that will be covered	See individual question breakdowns in tables below. In general the exposure/intervention of interest is midwife staffing levels: At any of the following stages of care, i.e.	Will consider whether these groupings will be used to group studies in the review e.g. by stage of care, setting. Feasibility is likely to

Parameters	Criteria	Additional comments
	• Pre-conception • Antenatal • Care during labour • Postnatal care up to 6 weeks In any of the following settings: • Home • Community • Obstetric units • Alongside midwifery-led units (i.e. alongside obstetric units) • Free-standing midwifery-led units And factors that modify the relationship between midwife staffing and outcomes, including: • Maternal and neonatal factors • Environmental factors • Staffing factors • Local level management factors • Organisational factors	depend on the evidence identified.
Exposures/ interventions that will not be covered	• Staffing requirements for other members of the multidisciplinary team (except as a modifier of the effect of midwife staffing levels) • Optimal service delivery models for maternity services • Toolkit studies	Toolkit studies are being covered by NICE.
Populations (groups) that will be covered	Women attempting to get pregnant, pregnant women, women in labour, and neonates and mothers up to 6 weeks postnatally.	
Populations (groups) that will not be covered	Mothers and babies after 6 weeks postnatally.	
Outcomes that will be	**Serious preventable events** • Maternal death and unexpected	This would include the inverse of these

Parameters	Criteria	Additional comments
covered	stillbirths and neonatal death • 'Never events' (serious, largely preventable safety incidents), including: o Maternal death due to post-partum haemorrhage (PPH) after elective caesarean section, wrongly prepared high-risk injectable medication, IV administration of epidural medication, retained foreign objects post-procedure etc. • RCOG maternity dashboard maternal events: o Eclampsia o Major obstetric haemorrhage o Major blood transfusion o Admissions to ITU o Failed instrumental delivery o 3rd & 4th degree perineal tears • RCOG maternity dashboard infant events o Erb's palsy secondary to shoulder dystocia o Meconium aspiration syndrome o Hypoxic ischaemic encephalopathy o Unexpected admission to special care baby unit	outcomes i.e. if reported as "maternal survival", % without a never event etc.
	Delivery of midwifery care Measures of quality of midwifery activity including current NICE standards for delivery of midwifery care, e.g.: • Women accessing antenatal care before 10 weeks (NICE quality standard [QS] 22) • Women with complex social factors	

Parameters	Criteria	Additional comments
	accessing appropriate services (NICE clinical guideline [CG]110) • Women offered minimum set of antenatal test results (QS22) • Completion of screening questions for previous or current mental health problems at first antenatal and postnatal contact (CG45; QS37) • Women provided with a named midwife • Mode and location of delivery • Continuity of care during established labour (CG55) • Provision of 1:1 midwifery care during labour (CG55) • Completion of recommended care after caesarean section (CG132) • Completion of recommended neonatal screening • Completion of education on mode of infant feeding (CG37 and QS37) • Continuity of care during the postnatal period (QS37) Completion of observations and other clinical paperwork Drug omission and other midwife associated drug errors Duration of postnatal stay Hospital postnatal readmission for mother or neonate	
	Reported feedback • Maternal and/or partner/relative experience and satisfaction ratings related to maternity care, e.g. Maternity Patient Reported Outcome Measures (PROMS), Maternity Services Liaison Committee (MSLC) minutes and available surveys	Reported feedback outcomes are only reported for studies which also reported safety or delivery of care outcomes.

Parameters	Criteria	Additional comments
	• Complaints relating to maternity care • Staff experience and satisfaction ratings	
	Other outcomes • Completion and maintenance of relevant staff training • Staff retention and sickness rates • Staff clinical appraisal and statutory review rates • Midwife vacancy rates • Closure to admission due to staffing capacity	
Outcomes that will not be covered	• Costs	This aspect is being covered separately

Assessing study quality

This will be based on the appropriate NICE quality checklists in the draft unified manual and the modified quality checklists used in the first safe staffing review. The modified checklists are below.

Quantitative studies reporting correlations and associations

Guidance topic	Maternity safe staffing	Comments
Study assessed by		
Study identification Ref ID, Author name, year		
Study design Temporally ordered study designs ranked higher than cross-sectional in terms of internal validity		
1. Population		
1.1 Is the source population or source area well described? Was the country (e.g. developed or non-developed, type of health care system), setting (hospital, community, unit type etc.), location (urban, rural), population demographics etc. adequately described?	**++** **+** **-** **NR** **NA**	
1.2 Is the eligible population or area representative of the source population or area? Was the recruitment of individuals,	**++** **+** **-** **NR**	

clusters or areas well defined (e.g. advertisement, birth register)? Was the eligible population representative of the source? Were important groups underrepresented?	**NA**	
1.3 Do the selected participants or areas represent the eligible population or area? Was the method of selection of individuals/clusters/areas from the eligible population well described? What % of selected individuals or clusters agreed to participate (should be 60% or more)? Were there any sources of bias? Were the inclusion or exclusion criteria explicit and appropriate?	**++** **+** **-** **NR** **NA**	
2. Method of selection of exposure (or comparison) group		
2.4 How well were likely confounding factors identified and controlled? Were there likely to be other confounding factors not considered or appropriately adjusted for? E.g. patient outcome analyses adjusted for woman's age, comorbidity; also for unit/ward/hospital/trust characteristics, including other (non-midwife) staff Was this sufficient to cause important bias?	**++** **+** **-** **NR** **NA**	
2.5 Is the study applicable to the UK? UK ++ Other developed country + Other -	**++** **+** **-** **NR** **NA**	
3. Outcomes		
3.1 Were the outcome measures and procedures reliable? Were outcome measures subjective or objective? How reliable were outcome measures (e.g. inter- or intra-rater reliability scores)? Was there any indication that measures had been validated (e.g. validated against a gold standard measure or assessed for content	**++** **+** **-** **NR** **NA**	

validity)?		
3.2 Were the outcome measurements complete? Were all or most of the outcomes likely to have been identified? (e.g. was data on outcomes from hospital records complete)	**++** **+** **-** **NR** **NA**	
4. Analyses		
4.1 Was the study sufficiently powered to detect an intervention effect (if one exists)? Were there sufficient wards/hospitals/units/women/births to detect an effect? Large multi-hospital (20+) studies ++ Smaller/single hospital studies with large numbers of births (100,000 or more) + Other -	**++** **+** **-** **NR** **NA**	
4.2 Were the analytical methods appropriate? Was there adjustment for clustering of data in units/wards/hospitals? Was there adjustment/control for ward/unit/hospital characteristics where relevant?	**++** **+** **-** **NR** **NA**	
4.6 Was the precision of association given or calculable? Is association meaningful? Were confidence intervals or p values for effect estimates given? Were CIs wide or were they sufficiently precise to aid decision-making? If precision is lacking, is this because the study is underpowered?	**++** **+** **-** **NR** **NA**	
5. Summary		
5.1 Are the study results internally valid (i.e. unbiased)? How well did the study minimise sources of bias (i.e. adjusting for potential confounders)? Were there significant flaws in the study design? (Consider answers to: study design, 2.4, 3.1, 3.2, 2.1, 4.2, 4.6)	**++** **+** **-**	
5.2 Are the findings generalisable to the source population (i.e. externally valid)?	**++** **+** **-**	

Are there sufficient details given about the study to determine if the findings are generalisable to the source population? Consider: participants, interventions and comparisons, outcomes, resource and policy implications. (Consider answers to: 1.1, 1.2, 1.3, 2.5, 4.1)		

Quantitative intervention studies

Guidance topic	Maternity safe staffing	Comments
Study assessed by		
Study identification Ref ID, Author name, year		
Study design Randomised designs ranked higher than non-randomised designs		
1. Population		
1.1 Is the source population or source area well described? Was the country (e.g. developed or non-developed, type of health care system), setting (hospital, community, unit type etc.), location (urban, rural), population demographics etc. adequately described?	**++** **+** **-** **NR** **NA**	
1.2 Is the eligible population or area representative of the source population or area? Was the recruitment of individuals, clusters or areas well defined (e.g. advertisement, birth register)? Was the eligible population representative of the source? Were important groups underrepresented?	**++** **+** **-** **NR** **NA**	
1.3 Do the selected participants or areas represent the eligible population or area? Was the method of selection of individuals/clusters/areas from the eligible population well described? What % of selected individuals or clusters agreed to participate (should be 60% or more)? Were there any sources of bias?	**++** **+** **-** **NR** **NA**	

Were the inclusion or exclusion criteria explicit and appropriate?		
2. Method of allocation to intervention (or comparison)		
2.1 Allocation to intervention (or comparison). How was selection bias minimised? Was allocation to exposure and comparison randomised? Was it truly random ++ or pseudo-randomised + (e.g. consecutive admissions)? If not randomised, was significant confounding likely (−) or not (+)? If a cross-over, was order of intervention randomised?	**++** **+** **-** **NR** **NA**	
2.2 Were interventions (and comparisons) well described and appropriate? Were interventions and comparisons described in sufficient detail (i.e. enough for study to be replicated)? Was comparisons appropriate (e.g. usual practice rather than no intervention)? If unclear intervention or comparison score -	**++** **+** **-** **NR** **NA**	
2.3 Was the allocation concealed? Could the person determining allocation of participants or clusters to intervention or comparison groups have influenced the allocation? Adequate allocation concealment (++) would include centralised allocation or computerised allocation systems.	**++** **+** **-** **NR** **NA**	
2.5 Was the exposure to the intervention and comparison adequate? The extent to which the intervention/control were implemented were clear and complete or nearly complete (>95%) (++) High implementation of intervention control (80-95%), unlikely to introduce important bias (+) Unclear or low implementation (<80%) of intervention control, likely to introduce important bias (-)	**++** **+** **-** **NR** **NA**	
2.7 Were other interventions similar	**++**	

in both groups? Staffing levels of other (non-midwife) staff equal in both groups, if relevant? Other interventions similar and groups treated similarly by research personnel? If other staffing levels not measured/controlled or substantially different between groups score –	**+** **-** **NR** **NA**	
2.8 Were all participants accounted for at study conclusion? Were those lost-to-follow-up (i.e. dropped or lost pre-,during or post-intervention) acceptably low (<20%)? Did the proportion lost differ by group?	**++** **+** **-** **NR** **NA**	
2.9 Did the setting reflect usual UK practice? UK ++ Other developed country + Other –	**++** **+** **-** **NR** **NA**	
2.10 Did the intervention or control comparison reflect usual UK practice? Did the intervention or comparison differ significantly from usual practice in the UK? For example, did participants receive intervention (or comparison) delivered by a different type/level of staff than it would normally be in the UK? Were participants monitored more closely?	**++** **+** **-** **NR** **NA**	
3. Outcomes		
3.1 Were the outcome measures and procedures reliable? Were outcome measures subjective or objective? How reliable were outcome measures (e.g. inter- or intra-rater reliability scores)? Was there any indication that measures had been validated (e.g. validated against a gold standard measure or assessed for content validity)?	**++** **+** **-** **NR** **NA**	
3.2 Were the outcome measurements complete? Were all or most of the outcomes likely to have been identified? (e.g.	**++** **+** **-** **NR**	

was data on outcomes from hospital records complete)	**NA**	
3.4 Were outcomes relevant? Where surrogate outcome measures were used, did they measure what they set out to measure? (e.g. are these objective, valid and reliable?)	**++** **+** **-** **NR** **NA**	
4. Analyses		
4.1 Were exposure and comparison groups similar at baseline? If not, were these adjusted? Were there any differences between groups in important confounders at baseline? If so, were these adjusted for in the analyses (e.g. multivariate analyses or stratification). Were there likely to be any residual differences of relevance? No difference ++ Difference, but adjusted for + Difference, not adjusted for, or unclear -		
4.3 Was the study sufficiently powered to detect an intervention effect (if one exists)? At least 80% power to detect a clinically important difference ++ Some consideration of power but incomplete (e.g. not achieved, importance of outcome not reported) No power calculation -	**++** **+** **-** **NR** **NA**	
4.4 Were the estimates of effect size given or calculable? Were effect estimates (e.g. relative risks, absolute risks) given or possible to calculate?	**++** **+** **-** **NR** **NA**	
4.5 Were the analytical methods appropriate? Were important differences in follow-up time and likely confounders adjusted for? If a cluster design, were analyses of sample size (and power), and effect size performed on clusters (and not individuals)? Were subgroup analyses pre-specified?	**++** **+** **-** **NR** **NA**	
4.6 Was the precision of	**++**	

intervention effect given? Is it meaningful? Were confidence intervals or p values for effect estimates given? Were CIs wide or were they sufficiently precise to aid decision-making? If precision is lacking, is this because the study is underpowered?	**+** **-** **NR** **NA**	
5. Summary		
5.1 Are the study results internally valid (i.e. unbiased)? How well did the study minimise sources of bias (i.e. adjusting for potential confounders)? Were there significant flaws in the study design? (Consider answers to: study design, 2.1, 2.2, 2.3, 2.5, 2.7, 2.8, 3.1, 3.2, 4.1, 4.4, 4.5, 4.6)	**++** **+** **-**	
5.2 Are the findings generalisable to the source population (i.e. externally valid)? Are there sufficient details given about the study to determine if the findings are generalisable to the source population? Consider: participants, interventions and comparisons, outcomes, resource and policy implications. (Consider answers to: 1.1, 1.2, 1.3, 2.9, 2.10, 4.3)	**++** **+** **-**	

The quality checklist will be applied to all studies selected for inclusion at full text, with 10% double appraisal. Any disagreements will be resolved by discussion, with recourse to a third analyst if needed.

Data extraction templates

Data will be extracted and provided in evidence tables (which will be attached as appendices to the review). These tables will be based on the templates in the draft NICE unified manual (2014) and the tables in the first safe staffing reviews (on nurse staffing in adult acute units). The data extraction table templates were provided to NICE for agreement on the information to be extracted, and are pasted below. Quantitative outcome data extracted will be check by a second analyst.

Study details	Bibliographic reference [authors, title, year etc] **Study aim** **Study type**

	[describe method of allocation if applicable] **Source of funding** [describe role of funding organisation if applicable] **Time period/length of follow up** [Years covered by the study if given] **Country** **Quality score** **Internal validity** [e.g. ++, +, -] **External validity** [e.g. ++, +, -]
Population and setting	**Setting** **Stage of care** [Antenatal/intrapartum/ post-partum] **Number of hospitals/units** [source, eligible, selected if applicable] **Number of women/births** [source, eligible (including whether multiple births included), selected if applicable; describe age if stated] **Skill mix/type/duties of midwives** [e.g. specialist midwives, grades of midwives etc. and any key description of their duties that might affect interpretation **Key characteristics of hospitals/units assessed** [If presented, give variables that give an idea of the type and characteristics of the hospitals/units being compared. This is to allow comparison across studies and add nuance to results. These may be reported in e.g. a baseline characteristics table] e.g. average or range of: Births in hospital/year Midwives/1000 deliveries/year Consultant O&G sessions on labour ward/week Number of beds/ 1000 deliveries/year % with maternity theatres SBCU beds (including NICU)/1000 deliveries/year **Key characteristics of participants assessed** [[particularly for RCTs]

	Data sources [e.g. data from hospital records, national databases, surveys etc.]
Factors assessed/Intervention	**If observational study:** **Midwife staffing** [Give variable as expressed in the study eg midwives/1000 births. Please note if stated whether specialist midwives were counted in this number or not] **Other staffing factors** [Any other staff assessed e.g. doctors, nurses, maternity support workers etc.] **Maternal and neonatal factors** [group factors as reported in the scope i.e. in here might be: number of women pregnant or in labour, maternal risk factors, neonatal needs, stage of care pathway etc.) **Environmental factors** e.g. local geography and demography, birth settings, unit size, unit layout **Management factors** e.g. maternity team management and administration approaches (eg shift patterns), models of midwifery care (eg caseload/named midwife/social enterprises), staff and student supervision and supernumerary arrangements **Organisational factors** Management structures and approaches, organisational culture, organisational policies and procedures including staff training **Control variables/adjustment** Anything adjusted for but not considered by itself as an independent variable **If intervention study:** **Intervention** [if applicable, delete if not; content, delivered by, duration, method, mode or timing of delivery]
Comparator	[if applicable: content, delivered by, duration, method, mode or timing of delivery, otherwise describe comparison e.g. higher midwife staffing ratios compared with lower ratios via regression analysis]
Outcomes and analysis	[[report not assessed/not reported if this is the case]] **Maternal/neonatal outcomes** [as listed in scope e.g. serious preventable events; may also include other outcomes; state if measures were objective or subjective or otherwise validated] **Process of care outcomes** [as listed in scope e.g. delivery of midwifery care; may also include other

	outcomes; state if measures were objective or subjective or otherwise validated] **Reported feedback** [as listed in scope e.g. experience and satisfaction, complaints; may also include other outcomes] **Other outcomes** [as listed in scope e.g. staff training, retention, sickness, vacancies, clinical appraisal and statutory review rates, or closure of unit to admissions; state if measures were objective or subjective or otherwise validated] **Analysis** Brief summary of analysis to aid interpretation
Results	**Maternal/neonatal outcomes** [give means with SE/SD/CI; median with IQR or range, regression coefficients, relative measures, effect sizes, CIs, p values, NNT and considerations of heterogeneity if applicable etc.] e.g. Mean C-section rate 18.0 per 100 deliveries (SD 3.84; range 8.0 to 33.4) **Process of care outcomes** **Reported feedback** **Other outcomes**
Notes/comments	**Author conclusions** **Author limitations** **Review team limitations** [include inadequately reported or missing data] **Other comments**

Narrative and quantitative summaries

These will follow the guidelines outlined in the draft unified NICE manual (2014). GRADE assessment will not be used, as agreed with NICE. They will be drafted by one analyst, with another analyst reading through for consistency and clarity.

8. Appendix C: Search Strategy

Note on the relationship with other maternity staffing searches

This appendix outlines the searches carried out for this review, which was carried out in order to inform NICE's safer staffing guidance for maternity services. It should be read in conjunction with the protocol for this review, and with the appendices for the associated reviews (i.e. those assessing approaches for identifying midwifery staffing requirements and skill mix at a local level and the economic/cost aspects of safe maternity staffing).

References which were identified during each of the associated reviews were shared with the other (maternity staffing) review groups if they were thought to be relevant to their review questions.

Database search strategies

Medline and Medline-in process

Platform: Ovid

Search date: 13/6/2014

1 Midwifery/
2 midwi*.tw.
3 Nurse Midwives/
4 (maternity adj3 worker*).tw.
5 (maternity adj3 staff*).tw.
6 (maternity adj3 assistant*).tw.
7 (midwi* adj3 assistant*).tw.
8 (midwi* adj3 staff*).tw.
9 (midwi* adj3 worker*).tw.
10 (msw* not "municipal solid").tw.
11 or/1-10
12 (staff* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
13 (skillmix* or "skill mix*").tw.
14 (staffmix* or "staff mix*").tw.
15 staffing.tw.
16 understaff*.tw.
17 "under staff*".tw.
18 "Personnel Staffing and Scheduling"/
19 Health Manpower/
20 manpower.tw,fs.
21 (workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity).tw.
22 Workload/
23 ("missed care" or "missing care").tw.
24 "care left undone".tw.
25 (hours adj2 day).tw.
26 (work* adj2 hours).tw.
27 (hours adj2 care).tw.
28 (caseload or "case load*").tw.
29 (turnover or "turn over").tw.
30 (FTE or "full-time equivalent").tw.
31 or/12-30
32 11 and 31
33 (midwi* adj3 assistant* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or

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adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
34 (midwi* adj3 worker* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
35 (maternity adj3 assistant* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
36 (maternity adj3 worker* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
37 (midwi* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
38 or/33-37
39 "named midwi*".tw.
40 32 or 38 or 39
41 40
42 limit 41 to (english language and yr="1998 -Current")
43 limit 42 to (comment or editorial or news or letter)
44 42 not 43
45 Animals/
46 Humans/
47 45 not 46
48 44 not 47
49 perinatal care/ma, og, ec, st
50 delivery rooms/ma, og, ec, st
51 birthing centers/ma, og, ec, st
52 Midwifery/ma, og, ec
53 Nurse midwives/ma, og, ec
54 or/49-53
55 limit 54 to (english language and yr="1998 -Current")
56 limit 55 to (comment or editorial or letter or news)
57 55 not 56
58 Animals/
59 Humans/
60 58 not 59
61 57 not 60
62 48 or 61

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Embase

Platform: Ovid

Search date: 13/6/2014

1 exp Midwife/
2 midwi*.tw.
3 Nurs Midwife/
4 (maternity adj3 worker*).tw.
5 (maternity adj3 staff*).tw.
6 (maternity adj3 assistant*).tw.
7 (midwi* adj3 assistant*).tw.
8 (midwi* adj3 staff*).tw.
9 (midwi* adj3 worker*).tw.
10 (msw* not "municipal solid").tw.
11 or/1-10
12 (staff* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
13 (skillmix* or "skill mix*").tw.
14 (staffmix* or "staff mix*").tw.
15 staffing.tw.
16 understaff*.tw.
17 "under staff*".tw.
18 skill mix/
19 personnel management/
20 exp health care personnel management/
21 manpower/
22 manpower planning/
23 work schedule/
24 workload/
25 working time/
26 shift worker/
27 manpower.tw.
28 (workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity).tw.
29 Workload/
30 magnet hospital/
31 burnout/
32 personnel shortage/
33 ("missed care" or "missing care").tw.
34 "care left undone".tw.
35 (hours adj2 day).tw.
36 (work* adj2 hours).tw.
37 (hours adj2 care).tw.
38 (caseload or "case load*").tw.
39 (turnover or "turn over").tw.
40 (FTE or "full-time equivalent").tw.
41 or/12-40
42 11 and 41
43 (midwi* adj3 assistant* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
44 (midwi* adj3 worker* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or

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adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
45 (maternity adj3 assistant* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
46 (maternity adj3 worker* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
47 (midwi* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
48 or/43-47
49 "named midwi*".tw.
50 42 or 48 or 49
51 limit 50 to (english language and yr="1998 -Current")
52 nonhuman/
53 human/
54 52 not 53
55 51 not 54
56 limit 55 to (editorial or letter or note)
57 55 not 56
58 limit 57 to embase

Health Management Information Consortium

Platform: Ovid

Search date: 13/6/2014

1 exp midwives/
2 midwi*.tw.
3 midwifery/
4 midwifery services/
5 (maternity adj3 worker*).tw.
6 (maternity adj3 staff*).tw.
7 (maternity adj3 assistant*).tw.
8 (midwi* adj3 assistant*).tw.
9 (midwi* adj3 staff*).tw.
10 (midwi* adj3 worker*).tw.
11 (msw* not "municipal solid").tw.
12 maternity support workers/
13 or/1-12
14 exp staffing levels/
15 skill mix/
16 staff allocation/
17 exp workload/
18 workload management/ or workload measurement/
19 workload analysis/
20 staff turnover/
21 occupational stress/
22 (staff* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate*

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or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
23 (skillmix* or "skill mix*").tw.
24 (staffmix* or "staff mix*").tw.
25 staffing.tw.
26 understaff*.tw.
27 "under staff*".tw.
28 manpower.tw.
29 (workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity).tw.
30 Workload/
31 ("missed care" or "missing care").tw.
32 "care left undone".tw.
33 (hours adj2 day).tw.
34 (work* adj2 hours).tw.
35 (hours adj2 care).tw.
36 (caseload or "case load*").tw.
37 (turnover or "turn over").tw.
38 (FTE or "full-time equivalent").tw.
39 or/14-38
40 13 and 39
41 (midwi* adj3 assistant* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
42 (midwi* adj3 worker* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
43 (maternity adj3 assistant* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
44 (maternity adj3 worker* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
45 (midwi* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)).tw.
46 or/41-45
47 "named midwi*".tw.
48 40 or 46 or 47
49 limit 48 to yr="1998 -Current"

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Cochrane Database of Systematic Reviews; Database of Abstracts of Reviews of Effects; Cochrane Central Register of Controlled Trials; Health Technology Assessment Database

Platform: Wiley

Search date: 13/6/2014

ID	Search
#1	MeSH descriptor: [Midwifery] this term only
#2	MeSH descriptor: [Nurse Midwives] this term only
#3	midwi*:ti,ab
#4	(maternity near/4 worker*):ti,ab
#5	(maternity near/4 staff*):ti,ab
#6	(maternity near/4 assistant*):ti,ab
#7	(midwi* near/4 assistant*):ti,ab
#8	(midwi* near/4 staff*):ti,ab
#9	(midwi* near/4 worker*):ti,ab
#10	(msw* not "municipal solid"):ti,ab
#11	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10
#12	(staff* near/4 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)):ti,ab
#13	(skillmix* or "skill mix*"):ti,ab
#14	(staffmix* or "staff mix*"):ti,ab
#15	staffing:ti,ab
#16	understaff*:ti,ab
#17	"under staff*":ti,ab
#18	MeSH descriptor: [Personnel Staffing and Scheduling] explode all trees
#19	MeSH descriptor: [Health Manpower] explode all trees
#20	manpower:ti,ab
#21	(workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity):ti,ab
#22	MeSH descriptor: [Workload] this term only
#23	("missed care" or "missing care"):ti,ab
#24	"care left undone":ti,ab
#25	(hours near/3 day):ti,ab
#26	(work* near/3 hours):ti,ab
#27	(hours near/3 care):ti,ab
#28	(caseload or "case load*"):ti,ab
#29	(turnover or "turn over"):ti,ab
#30	(FTE or "full-time equivalent"):ti,ab
#31	#12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30
#32	#11 and #31
#33	(midwi* near/4 assistant* near/4 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)):ti,ab
#34	(midwi* near/4 worker* near/4 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)):ti,ab
#35	(maternity near/4 assistant* near/4 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or

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inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)):ti,ab
#36 (maternity near/4 worker* near/4 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)):ti,ab
#37 (midwi* near/4 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage* or efficient* or efficienc* or inefficien* or burnout or stress or fatigue or magnet)):ti,ab
#38 "named midwi*":ti,ab
#39 #33 or #34 or #35 or #36 or #37 or #38
#40 #32 or #39 Publication Year from 1998
#41 MeSH descriptor: [Perinatal Care] this term only and with qualifier(s): [Economics - EC, Manpower - MA, Organization & administration - OG, Standards - ST]
#42 MeSH descriptor: [Delivery Rooms] this term only and with qualifier(s): [Economics - EC, Manpower - MA, Organization & administration - OG, Standards - ST]
#43 MeSH descriptor: [Birthing Centers] this term only and with qualifier(s): [Economics - EC, Manpower - MA, Organization & administration - OG, Standards - ST]
#44 MeSH descriptor: [Midwifery] this term only and with qualifier(s): [Economics - EC, Manpower - MA, Organization & administration - OG]
#45 MeSH descriptor: [Nurse Midwives] this term only and with qualifier(s): [Economics - EC, Organization & administration - OG]
#46 #40 or #41 or #42 or #43 or #44 or #45 Publication Year from 1998

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Cumulative Index to Nursing and Allied Health (CINAHL)

Platform: Ebsco

Search date: 17/6/2014

#	Query	Limiters/Expanders
S48	s47	Limiters - Exclude MEDLINE records Search modes - Boolean/Phrase
S47	s46	Limiters - Published Date: 19980101-; Language: English Search modes - Boolean/Phrase
S46	S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S45	Search modes - Boolean/Phrase
S45	S18 AND S44	Search modes - Boolean/Phrase
S44	S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28	Search modes - Boolean/Phrase
S43	(MH "Midwives+/EC/ST")	Search modes - Boolean/Phrase
S42	(MH "Delivery Rooms+/EC/ST")	Search modes - Boolean/Phrase
S41	(MH "Intrapartum Care/EC/ST")	Search modes - Boolean/Phrase
S40	AB "named midwi*"	Search modes - Boolean/Phrase
S39	TI "named midwi*"	Search modes - Boolean/Phrase
S38	AB (midwi* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S37	TI (midwi* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase

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S36	AB (maternity N3 worker* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S35	TI (maternity N3 worker* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S34	AB (maternity N3 assistant* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S33	TI (maternity N3 assistant* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S32	AB (midwi* N3 worker* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S31	TI (midwi* N3 worker* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S30	AB (midwi* N3 assistant* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S29	TI (midwi* N3 assistant* N3 (level* OR ratio* OR resourc* OR	Search modes -

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	model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Boolean/Phrase
S28	AB (skillmix* OR "skill mix*" OR staffmix* OR "staff mix*" OR staffing OR understaff* OR manpower OR workload* OR workforce* OR shift OR shiftwork* OR shifts OR overtime OR capacity OR "missed care" OR "missing care" OR "care left undone" OR (hours N2 day) OR (work* N2 hours) OR (hours N2 care) OR caseload OR "case load*" OR turnover OR "turn over" OR FTE OR "full-time equivalent")	Search modes - Boolean/Phrase
S27	TI (skillmix* OR "skill mix*" OR staffmix* OR "staff mix*" OR staffing OR understaff* OR manpower OR workload* OR workforce* OR shift OR shiftwork* OR shifts OR overtime OR capacity OR "missed care" OR "missing care" OR "care left undone" OR (hours N2 day) OR (work* N2 hours) OR (hours N2 care) OR caseload OR "case load*" OR turnover OR "turn over" OR FTE OR "full-time equivalent")	Search modes - Boolean/Phrase
S26	AB (staff* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S25	TI (staff* N3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))	Search modes - Boolean/Phrase
S24	MH "MAGNET HOSPITALS"	Search modes - Boolean/Phrase
S23	MH "PERSONNEL TURNOVER"	Search modes - Boolean/Phrase
S22	MH "BURNOUT,PROFESSIONAL"	Search modes - Boolean/Phrase
S21	MH "PERSONNEL SHORTAGE"	Search modes - Boolean/Phrase
S20	MH "WORKLOAD"	Search modes - Boolean/Phrase
S19	MH "PERSONNEL STAFFING AND SCHEDULING+"	Search modes - Boolean/Phrase

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S18	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17	Search modes - Boolean/Phrase
S17	AB (msw* NOT "municipal solid")	Search modes - Boolean/Phrase
S16	AB (midwi* N3 assistant*)	Search modes - Boolean/Phrase
S15	AB (midwi* N3 staff*)	Search modes - Boolean/Phrase
S14	AB (midwi* N3 worker*)	Search modes - Boolean/Phrase
S13	AB (maternity N3 assistant*)	Search modes - Boolean/Phrase
S12	AB (maternity N3 staff*)	Search modes - Boolean/Phrase
S11	AB (maternity N3 worker*)	Search modes - Boolean/Phrase
S10	AB midwi*	Search modes - Boolean/Phrase
S9	TI (msw* NOT "municipal solid")	Search modes - Boolean/Phrase
S8	TI (midwi* N3 assistant*)	Search modes - Boolean/Phrase
S7	TI (midwi* N3 staff*)	Search modes - Boolean/Phrase
S6	TI (midwi* N3 worker*)	Search modes - Boolean/Phrase
S5	TI (maternity N3 assistant*)	Search modes - Boolean/Phrase
S4	TI (maternity N3 staff*)	Search modes - Boolean/Phrase
S3	TI (maternity N3 worker*)	Search modes - Boolean/Phrase
S2	TI midwi*	Search modes - Boolean/Phrase
S1	MH "MIDWIVES+"	Search modes - Boolean/Phrase

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British Nursing Index (BNI)
Platform: ProQuest
Search date: 17/6/2014

((SU.EXACT.EXPLODE("Midwifery") OR TI,AB((midwi*) OR (maternity NEAR/3 worker*) OR (maternity NEAR/3 staff*) OR (maternity NEAR/3 assistant*) OR (midwi* NEAR/3 worker*) OR (midwi* NEAR/3 staff*) OR (midwi* NEAR/3 assistant*) OR (msw* NOT "municipal solid"))) AND (TI,AB(skillmix* OR "skill mix*" OR staffmix* OR "staff mix*" OR staffing OR understaff* OR "under staff*" OR manpower OR workload* OR workforce* OR shift OR shiftwork* OR shifts OR overtime OR capacity OR "missed care" OR "missing care" OR "care left undone" OR (hours NEAR/2 day) OR (work* NEAR/2 hours) OR (hours NEAR/2 care) OR caseload OR "case load*" OR turnover OR "turn over" OR FTE OR "full-time equivalent") OR (SU.EXACT("SKILL MIX") OR SU.EXACT("STAFFING LEVELS") OR SU.EXACT("OCCUPATIONAL STRESS") OR SU.EXACT("STAFF : RECRUITMENT AND TURNOVER")) OR ((staff* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))))) OR ((midwi* NEAR/3 assistant* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))) OR ((midwi* NEAR/3 worker* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))) OR ((maternity NEAR/3 assistant* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))) OR ((maternity NEAR/3 worker* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))) OR ((midwi* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet))) OR TI,AB("named midwi*")

The briefer sets below give a slightly more readable record of the above search – the Boolean logic is…

(20 AND (21 OR 22 OR 29))

OR

23 OR 24 OR 25 OR 26 OR 27 OR 28

…

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29 **Name:** SS - mat - line 12 Edit name

Searched for: ((staff* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet)))

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

Modify Search Delete Create alert Create RSS feed Get link

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28 **Name:** SS - mat - line 39 Edit name

Searched for: TI,AB("named midwi*")

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

Modify Search Delete Create alert Create RSS feed Get link

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27 **Name:** SS - mat - line 37 Edit name

Searched for: ((midwi* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet)))

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

Modify Search Delete Create alert Create RSS feed Get link

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26 **Name:** SS - mat - line 36 Edit name

Searched for: ((maternity NEAR/3 worker* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet)))

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

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25 **Name:** SS - mat - line 35 Edit name

Searched for: ((maternity NEAR/3 assistant* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet)))

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

Modify Search Delete Create alert Create RSS feed Get link

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24 **Name:** SS - midwifery - line 34 Edit name

Searched for: ((midwi* NEAR/3 worker* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet)))

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

Modify Search Delete Create alert Create RSS feed Get link

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23 **Name:** SS - mat - line 33 Edit name

Searched for: ((midwi* NEAR/3 assistant* NEAR/3 (level* OR ratio* OR resourc* OR model* OR number* OR mix* OR rota* OR rosta* OR roster* OR schedul* OR overtime OR supervision OR supervisory OR sufficient* OR sufficiency OR adequate* OR adequac* OR target* OR insufficient* OR insufficienc* OR inadequate* OR inadequac* OR short OR shortage* OR efficient* OR efficienc* OR inefficien* OR burnout OR stress OR fatigue OR magnet)))

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

Modify Search Delete Create alert Create RSS feed Get link

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22 **Name:** SS - Mat - BNI - Emtree Edit name

Searched for: SU.EXACT("SKILL MIX") OR SU.EXACT("STAFFING LEVELS") OR SU.EXACT ("OCCUPATIONAL STRESS") OR SU.EXACT("STAFF : RECRUITMENT AND TURNOVER")

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

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21 **Name:** SS - mat - BNI - lines 13-30 Edit name

Searched for: TI,AB(skillmix* OR "skill mix*" OR staffmix* OR "staff mix*" OR staffing OR understaff* OR "under staff*" OR manpower OR workload* OR workforce* OR shift OR shiftwork* OR shifts OR overtime OR capacity OR "missed care" OR "missing care" OR "care left undone" OR (hours NEAR/2 day) OR (work* NEAR/2 hours) OR (hours NEAR/2 care) OR caseload OR "case load*" OR turnover OR "turn over" OR FTE OR "full-time equivalent")

Databases: British Nursing Index

Notes: Add notes

Saved: June 16 2014

Modify Search Delete Create alert Create RSS feed Get link

20 **Name:** Safer staffing - maternity - effects and modifiers - BNI Edit name

Searched for: SU.EXACT.EXPLODE("Midwifery") OR TI,AB((midwi*) OR (maternity NEAR/3 worker*) OR (maternity NEAR/3 staff*) OR (maternity NEAR/3 assistant*) OR (midwi* NEAR/3 worker*) OR (midwi* NEAR/3 staff*) OR (midwi* NEAR/3 assistant*) OR (msw* NOT "municipal solid"))

Databases: British Nursing Index

Notes: 16th June 2014

Saved: June 16 2014

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Website searches

Note: where more than three pages of search results were retrieved only the first three pages of results were examined.

Website	Keywords
King's Fund	Searched for single words: midwife; midwifery; midwives; maternity Note – searched for each term separately
Royal College of Midwives	Browsed research, guidelines sections. Initially searched for: (staff* OR workforce) AND (ratio* OR shortage* OR sufficien* OR number*) – zero results Searched for single words: staffing; ratio*. Some results inaccessible due to paywall.
Royal College of Paediatrics and Child Health	Boolean search for: (staff* OR workforce) AND (ratio* OR shortage* OR sufficien* OR number*) Also searched for single words: staffing; workforce; midwife; midwifery; midwives; maternity. Some results inaccessible due to paywall. News stories tracked to source
Department of Health	Searched publications section for words… maternity; midwi* … in … guidance; impact assessments; independent reports; research; analysis; policy documents … publication types
NHS England	Searched for key phrases: maternity staffing; midwife staffing; midwifery staffing; midwives staffing
NHS Scotland	(maternity OR midwi*) AND (staffing OR workforce OR ratio* OR shortage* OR sufficien* OR number*)
Scottish Government	Searched publications section for: (maternity OR midwi*) AND staffing
Welsh Government	(maternity OR midwi*) AND staffing
NICE Evidence	(maternity OR midwi*) AND (staffing OR workforce OR shortage* OR sufficien* OR number*)
Google Scholar	(maternity OR midwi*) AND (staffing OR workforce OR shortage* OR sufficien* OR number*)

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Citation searching

The following systematic reviews, identified from the main "influences and outcomes" searches, were used as a basis for (backwards) citation searching in Web of Science. Citation searching was carried out on the 16th June 2014. Only those citations which could be downloaded directly from the Web of Science database were added to the main search results.

Butler M, Collins R, Drennan J et al. (2011) Hospital nurse staffing models and patient and staff-related outcomes. [Review]. *Cochrane Database of Systematic Reviews*. (7): CD007019-.

Colvin CJ, Heer J, Winterton L et al. (2013) A systematic review of qualitative evidence on barriers and facilitators to the implementation of task-shifting in midwifery services (Provisional abstract). *Midwifery*. 29 (10).

Hatem M, Sandall J, Devane D et al. (2008) Midwife-led versus other models of care for childbearing women. *Cochrane Database of Systematic Reviews*. (4).

Hodnett ED, Gates S, Hofmeyr GJ et al. (2007) Continuous support for women during childbirth. [Review] [48 refs][Update in Cochrane Database Syst Rev. 2011;(2):CD003766; PMID: 21328263], [Update of Cochrane Database Syst Rev. 2003;(3):CD003766; PMID: 12917986]. *Cochrane Database of Systematic Reviews*. (3): CD003766-.

Homer-Caroline SE, Ryan C, Leap N et al. (2012) Group versus conventional antenatal care for women. *Cochrane Database of Systematic Reviews*. (11).

Humphreys A, Johnson S, Richardson J et al. (Oct. 2007) A systematic review and meta-synthesis: evaluating the effectiveness of nurse, midwife/allied health professional consultants. [Review] [52 refs]. *Journal of Clinical Nursing*. 16 (10): 1792-1808.

Johantgen M, Fountain L, Zangaro G et al. (Jan. 2012) Comparison of labor and delivery care provided by certified nurse-midwives and physicians: a systematic review, 1990 to 2008. [Review]. *Womens Health Issues*. 22 (1): e73-e81.

Muthu V, Fischbacher C (2004) Free-standing midwife-led maternity units: a safe and effective alternative to hospital delivery for low-risk women? (Structured abstract). *Evidence-Based Healthcare and Public Health*. 8 (4): 325-331.

Sandall J, Devane D, Soltani H et al. (May 2010) Improving quality and safety in maternity care: the contribution of midwife-led care. *Journal of Midwifery & Women's Health*. 55 (3): 255-261.

Sandall J, Soltani H, Gates S et al. (2013) Midwife-led continuity models versus other models of care for childbearing women. [Review][Update of Cochrane Database Syst Rev. 2008;(4):CD004667; PMID: 18843666]. *Cochrane Database of Systematic Reviews*. 8: CD004667-.

Sutcliffe K, Caird J, Kavanagh J et al. (Nov. 2012) Comparing midwife-led and doctor-led maternity care: a systematic review of reviews. [Review]. *Journal of Advanced Nursing*. 68 (11): 2376-2386.

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9. Appendix D: Evidence tables

Contents

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List of abbreviations

AMU	Alongside midwifery unit
AR	Absolute risk
AUC	Area under curve
BMI	Body mass index
CEFM	Continuous Electronic Fetal Monitoring
CI	Confidence interval
CTG	Cardiotocography
DH	Department of Health
DwBI	Delivery with bodily integrity
FMU	Free standing midwifery unit
FTE	Full time equivalent
GP	General practitioner
HES	Hospital Episode Statistics
IMD	Index of Multiple Deprivation
ICD	International Classification of Diseases
IPPV	Invasive positive pressure ventilation
IQR	Interquartile range
IVD	Instrumental vaginal delivery
LW:MW	Labouring women: midwives
LOS	Length of stay
MIMAS	Manchester Information and Associated Services
NHS	National Health Service
NICE	National Institute for Heath and Care Excellence
NICU	Neonatal Intensive Care Unit
NIHR	National Institute for Health Research
NNU	Neonatal unit
O&G	Obstetrics and gynaecology
OR	Odds ratio
OU	Obstetric unit
ONS	Office for National Statistics
OPCS	Office of Population Censuses and Surveys Classification of Interventions and Procedures
RCT	Randomised controlled trial
PCT	Primary Care Trust
Q	Quintile
RCOG	Royal College of Obstetrics and Gynaecology
SCBU	Special Care Baby Unit
SD	Standard deviation
SE	Standard error
SHA	Strategic health authority
SNNM	Birth weight standardised neonatal mortality
SSBR	Birth weight standardised stillbirth rate
SVD	Spontaneous vaginal delivery

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Sandall et al. (in press)	
Study details	Sandall J, Murrells T, Dodwell M et al. The efficient use of the maternity workforce and the implications for safety and quality in maternity care: a population-based, cross-sectional study. Health Serv Deliv Res 2014;2(X) (in press) **Study aim** To understand the relationship between organisational factors, maternity workforce staffing and skill mix, cost and indicators of safe and high quality care. **Study type** Correlational study **Source of funding** The National Institute for Health Research Health Services and Delivery Research programme. **Time period** 2010 to 2011 **Country** England **Quality score** **Internal validity** ++ **External validity** ++ **Overall score** ++
Population and setting	**Setting** NHS trusts in England in 2010-11. **Stage of care** Not stated. Analysis was at the trust level, so would include midwives deployed at all stages of care. Outcomes were largely in the intrapartum period, along with some neonatal outcomes. **Number of trusts/hospitals/units** 143 NHS trusts. Data was obtained from the Hospital Episode Statistics database (HES), which contains data for all 143 trusts in England. Data for 134 NHS trusts and 2 PCTs were analysed in regression models. Trusts or PCTs which provided only midwifery services were excluded due to differences in costs and patterns of care, as were trusts with atypical or inconsistent data or data which was overly influential in the analyses.

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	Number of women/births 656,969 delivery records (all records in HES database for the study period). Data from trusts with <80% of women coded for any outcome were excluded. Missing outcome or postcode data left between 431,391 and 584,435 delivery records for the individual multilevel models. **Skill mix/type/duties of midwives** Not reported. **Key characteristics of trusts/hospitals/units assessed** *Type of units in each trust:* 42% of trusts had obstetric units (OU) only 31.5% had OU plus alongside midwifery units (AMU) 12.6% had OU plus freestanding midwifery units (FMU) 14.0% had OU and AMU and FMU 29.4% were university trusts *Mean characteristics in 2011 (SD; range):* Maternities: 4,620 (1,990; 1,210 to 10,680) Full time equivalent (FTE) midwives/100 maternities: 3.08 (0.50; 1.11 to 4.71) FTE doctors/100 maternities: 0.82 (0.22; 0.21 to 1.65) FTE support workers/100 maternities: 0.90 (0.35; 0.05 to 2.88) FTE all staff/100 maternities: 4.80 (0.77; 2.43 to 8.66) Doctor/midwife ratio: 0.27 (0.07; 0.07 to 0.50) Support worker/midwife ratio: 0.30 (0.11; 0.02 to 0.85) **Key characteristics of participants assessed** *Age:* 5.0% aged ≤19 years; 67% aged between 20 and 34 years; 14.2% aged 35 to 39 years; 3.4% aged 40 years and over; 10.4% unknown *Parity:* 42.9% nulliparous, 31.8% one previous birth, 25.3% more than one previous birth *Clinical risk:* 54.7% at higher clinical risk of complications based on National Institute for Health and Care Excellence (NICE) intrapartum guidelines; 45.3% at lower risk *Ethnicity:* 65.3% white British, 8.6% any other white ethnicity, 4.0% Pakistani, 3.5% African, 3.1% Indian, other categories less common *Deprivation:* 27.7% were from the most deprived areas (quintile [Q] 1), 22.3% from Q2, 18.3% from Q3, 15.8% from Q4, and 15.1% from the least deprived (Q5) *Rural/urban classification:* 85.5% from denser urban areas **Data sources** The Hospital Episode Statistics (HES) database (inpatient records 2000/01 to 2010/11; outpatient records 2003/4 to 2010/11; A&E records 2007/8 to 2010/11), Office for National Statistics (ONS)-HES linked mortality statistics (including neonatal deaths) 2000/01 to 2010/11, and the NHS

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	National Workforce Dataset 2010.
Factors assessed	**Midwife staffing** FTE midwives/100 maternities, FTE doctor/FTE midwife ratio, and FTE midwife/FTE support worker ratio (all assessed at trust level). Midwife types/grades included not specified, would include all midwives working for the trust. **Other staffing factors** FTE all staff, obstetric medical staff (all levels), and maternity support staff/100 maternities (assessed at trust level) **Maternal and neonatal factors** Maternal age, parity, clinical risk at the end of pregnancy, ethnicity. Clinical risk was assessed based on the presence or absence of medical conditions or situations listed in NICE intrapartum care guidelines as increasing risk for the woman or baby during or shortly after labour, as well as additional conditions that might also increase risk. Women were classed as being at higher risk (having conditions listed by NICE as increasing risk or requiring individual assessment) or lower risk (none of the conditions increasing risk of requiring individual assessment), based on International Classification of Diseases (ICD) -10 codes, Office of Population Censuses and Surveys Classification of Interventions and Procedures (OPCS) or HES Data Dictionary items recorded in each woman's HES records for the past 10 years. **Environmental factors** Individual level characteristics: area socio-economic deprivation (Index of Multiple Deprivation), geographic location (urban/rural), region Trust level characteristics: trust size/number of deliveries, teaching status (university trusts), maternity configuration (i.e. OU, AMU, FMU provision) **Management factors** None **Organisational factors** None **Control variables/adjustment** All of the variables described above were included in the model as independent variables. No additional variables were adjusted for.
Comparison	Higher versus lower levels of midwife staffing (midwives/100 maternities) or other factors in the trust, compared using regression
Outcomes and analysis	Quality indicators used in maternity care were reviewed and 10 outcome indicators (some composite) were selected. **Maternal/neonatal outcomes** *Healthy mother and baby outcomes:*

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	Healthy mother (composite of: delivery with bodily integrity, return home in ≤2 days, and no instrumental delivery, maternal sepsis, anaesthetic complication, or readmission within 28 days) Healthy baby (composite of: baby's weight 2.5 to 4.5 kg, gestational age 37 to 42 weeks, and live baby) Healthy mother and baby (composite of the above) *Mode of birth outcomes:* Delivery with bodily integrity (DwBI, composite of: no uterine damage, $2^{nd}/3^{rd}/4^{th}$ degree tear, stitches, episiotomy, or caesarean) Normal birth (composite of: no induction, instrumental delivery, caesarean, episiotomy or general or regional anaesthetic) Spontaneous vaginal delivery Intact perineum *Caesarean outcomes:* Elective caesarean Emergency caesareans All caesareans **Process of care outcomes** None **Reported feedback outcomes** None **Other outcomes** None **Analysis** Analysis was at the trust level. Multilevel logistic regression models were used, with mothers nested within trusts, and fitted to 10 dichotomous outcome indicators. Results were reported as residual variance (σ^2), relative chi squared (which was categorised as minor: 1 to <100, moderate: 100 to <1000, strong: 1000 to <10000, or dominant: ≥10,000). Relationships between continuous predictors and outcomes were classified as positive monotonic (consistently increasing in a linear or non-linear way), negative monotonic (consistently decreasing in a linear or non-linear way), non-monotonic (direction of effect not consistent e.g. increases initially and then decreases). Independent variables were added in blocks, with maternal level variables added first, then socio-demographics, trust level variables, and then staffing variables. Staffing variables were added into two models: the first (set 1) included FTE/100 maternities for midwives, doctors, and support staff, and the second (set 2) used FTE/100 maternities for all staff and the ratio measures (doctors: midwives, support workers:midwives), these tested the effect of substitution of these staff for each other. The intercept was allowed to vary between trusts to account for clustering. Funnel plots were used to plot proportion with outcomes (Y-axis; unadjusted or adjusted for set 1 staffing variables) against deliveries (X-axis). These were used to assess the effect of the independent variables on variation in the outcome rates across trusts.

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	Sensitivity analyses assessed the interactions between parity and clinical risk and the 3 types of FTE staff variables/100 maternities, as well as the effect in the 50 trusts with only one OU, and the effect of splitting clinical risk into 3 categories instead of 2 (lower risk, individual assessment and higher risk).
Results	**Maternal/neonatal outcomes** *Mean (SD; range) results by trust:* Healthy mother 28.0% (5.4%; 13.6% to 48.5%) Healthy baby 85.2% (3.0%; 76.9% to 90.3%) Healthy mother and healthy baby 24.9% (4.9%; 12.0% to 44.7%) Delivery with bodily integrity 32.6% (5.9%; 19.6% to 52.8%) Normal birth 40.1% (4.8%; 26.0% to 51.1%) Spontaneous vaginal delivery 62.7% (4.5%; 46.6% 73.8%) Intact perineum 43.6% (6.8%; 25.7% to 66.2%) Elective caesarean 10.0% (1.7%; 5.6% to 16.6%) Emergency caesarean 14.6% (2.5%; 9.0% to 24.9%) All caesareans 24.6% (3.5%; 15.2 to 36.1%) *Descriptive unadjusted analysis* Looking at the distribution of the unadjusted figures, higher levels of midwifery staffing were associated with a higher chance of DwBI (lowest quintile [Q1] of staffing [1.11 to 2.65 per 100 maternities] 29.6% vs. highest quintile [Q5, 3.40 to 4.71 per 100 maternities] 33.7%) and intact perineum (Q1 39.9% vs. Q5 44.5%) and having a birth where the mother was healthy (Q1 25.5% vs. Q5 28.5%; statistical comparisons not reported). Patterns of variation were less clear for other outcomes (Q1 vs. Q5 for: healthy baby 85.8% vs. 85.2%; healthy mother and baby 22.6% vs. 25.4%; normal birth 39.0% vs. 40.8%; spontaneous vaginal delivery 61.8% to 63.5%; elective caesarean 9.8% in Q1 and Q5; emergency caesarean 15.5% vs. 14.0%; all caesareans 25.3% vs. 23.7%). A doctor:midwife ratio of 0.22 to 0.25 (Q2) generally seemed to be associated with the most beneficial pattern of outcomes. Overall, a large amount of the variation in the 10 outcome indicators observed at the level of the individual was attributable to mothers' age, parity and level of clinical risk, with less variation by socio-demographic, trust level and staffing variables (statistical comparisons not reported). *Multilevel models* In multilevel models, about 1 to 2% of variation in the outcomes was attributable to differences between trusts, and 98 to 99% due to variation between mothers within trusts. <u>Overall magnitude of effects</u> Based on the relative chi squared values obtained for the different variables, the effect of maternal characteristics were stronger than other variables. The effect of staffing variables was small by comparison (e.g. for the healthy mother outcome maternal clinical risk had a chi squared value of 15,841 while the largest chi squared for staffing variables was 3).

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	The magnitude of effect (i.e. relative chi squared) of FTE midwives/100 maternities (with largest effect seen for this outcome across all variables reported in brackets for comparison) was 0 for healthy baby (26,718 for clinical risk), spontaneous vaginal delivery (49,583 for clinical risk), elective caesarean (20,858 for clinical risk), emergency caesarean (18,388 for clinical risk), and all caesareans (54,882 for clinical risk); 2 for healthy mother (15,841 for clinical risk), healthy mother and baby (23,436 for clinical risk), and normal birth (63,030 for clinical risk); 4 for delivery with bodily integrity (17,470 for clinical risk), and 5 for intact perineum (13,310 for parity). The magnitude of effect of doctor to midwife ratio was 0 for healthy mother, delivery with bodily integrity, normal birth, spontaneous vaginal delivery, and intact perineum; 1 for healthy baby, healthy mother and baby, and emergency caesarean; and 2 for elective caesarean and all caesareans. The magnitude of effect of support worker to midwife ratio was 0 for delivery with bodily integrity, normal birth, intact perineum, and emergency caesarean; 1 for healthy baby, spontaneous vaginal delivery, elective caesarean, and all caesareans; and 2 for healthy mother and healthy mother and baby. <u>Overall predictive ability</u> The multivariable models had fair (area under curve [AUC] 0.70 to 0.80) to good (AUC 0.80 to 0.90) predictive ability. The model for elective caesarean had the best predictive ability (AUC 0.814) and the model for emergency caesarean the least (AUC 0.698). The addition of socio-demographic, trust level and staffing variables only led to marginal improvement in the models' ability to predict outcomes, with the greatest improvement seen for the outcome of intact perineum (AUC increased from 0.722 to 0.732). Adding staffing variables made negligible difference to the AUCs of the models. <u>Healthy mother and baby outcomes (113 trusts; 431,391 deliveries; significant associations in bold)</u> Midwife staffing variables (and other staffing variables) were not statistically related to any of the healthy mother and baby outcomes. Results for midwife variables are below: • FTE midwives/100 maternities: healthy mother OR 1.088, 95% CI 0.963 to 1.230, p=0.1759; healthy baby OR 1.029, 95% CI 0.912 to 1.161, p=0.6456; healthy mother and baby OR 1.093, 95% CI 0.967 to 1.234, p=0.1536 • Doctor-midwife ratio: healthy mother OR 1.316, 95% CI 0.608 to 2.846, p=0.4860; healthy baby OR 1.363, 95% CI 0.638 to 2.914, p=0.4239; healthy mother and baby OR 1.437, 95% CI 0.669 to 3.088, p=0.3526 • Support worker-midwife ratio: healthy mother OR 0.716, 95% CI

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	0.452 to 1.135, p=0.1552; healthy baby OR 0.758, 95% CI 0.482 to 1.191, p=0.2296; healthy mother and baby OR 0.693, 95% CI 0.439 to 1.094, p=0.1152 On multilevel models there was some indication of a negative effect of support worker per 100 maternities on healthy mother (OR 0.892, 95% CI 0.776 to 1.026, p=0.11), and healthy mother and baby outcome (OR 0.897, 95% CI 0.781 to 1.031, p=0.13), and of support worker: midwife ratio for healthy mother and baby outcome (OR 0.693, 95% CI 0.439 to 1.094, p=0.12). Overall, the largest associations were with maternal clinical risk and parity. Higher clinical risk was associated with reduced likelihood of healthy mother and baby outcomes (dominant monotonic negative relationship). Higher parity was associated with an increased likelihood of a healthy mother (dominant monotonic positive relationship) and healthy mother and baby (strong monotonic positive relationship). Higher mother's age was associated with a reduced likelihood of healthy mother (strong monotonic negative relationship). <u>Perineal and mode of birth outcomes (119 to 143 trusts; 467,022 to 584,435 deliveries; significant associations in bold)</u> Increased midwife staffing was significantly associated with increased likelihood of delivery with bodily integrity and increased likelihood of intact perineum. All other associations with midwife staffing variables were non-significant. • FTE midwives/100 maternities: **Delivery with bodily integrity** (DwBI) **OR 1.110, 95% CI 1.005 to 1.227, p=0.0399**; normal birth OR 1.062, 95% CI 0.968 to 1.166, p=0.2048; spontaneous vaginal delivery (SVD) OR 1.025, 95% CI 0.948 to 1.109, p=0.5362; **intact perineum OR 1.132, 95% CI 1.010 to 1.268, p=0.0324** • Doctor-midwife ratio: DwBI OR 1.149, 95% CI 0.606 to 2.180, p=0.6702; normal birth OR 0.849, 95% CI 0.448 to 1.608, p=0.6150; spontaneous vaginal delivery (SVD) OR 1.018, 95% 0.615 to 1.685, p=0.9441; intact perineum OR 1.001, 95% CI 0.482 to 2.078, p=0.9981 • Support worker-midwife ratio: DwBI OR 0.884, 95% CI 0.610 to 1.280, p=0.5137; normal birth OR 1.031, 95% CI 0.729 to 1.457, p=0.8649; SVD OR 0.876, 95% CI 0.655 to 1.171, p=0.3706; intact perineum OR 0.911, 95% CI 0.597 to 1.389, p=0.6640 Overall, the largest associations were with maternal clinical risk, parity, and maternal age. Higher maternal clinical risk was associated with reduced likelihood of DwBI, normal birth and SVD (dominant monotonic negative relationship). Higher parity was associated with increased likelihood of DwBI and intact perineum (dominant monotonic positive relationship), and of normal birth and SVD (strong monotonic positive relationship). Increased maternal age was associated with reduced likelihood of DwBI and SVD ((strong monotonic negative relationship).

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	On multilevel models higher levels of overall staffing were associated with increased the likelihood of DwBI (OR 1.079, 95% CI 1.016 to 1.147) and intact perineum (OR 1.092, 95% CI 1.019 to 1.170). Caesarean outcomes (143 trusts; 584,435 deliveries; significant associations in bold) There were no significant associations between midwife staffing and caesarean outcomes. • FTE midwives/100 maternities: elective caesarean OR 1.032, 95% CI 0.936 to 1.137, p=0.5303; emergency caesarean OR 0.978, 95% CI 0.897 to 1.066, p=0.6085; all caesareans OR 1.000, 95% CI 0.919 to 1.087, p=0.9962 • Doctor-midwife ratio: elective caesarean OR 0.652, 95% CI 0.349 to 1.220, p=0.1809; emergency caesarean OR 0.760, 95% 0.437 to 1.322, p=0.3314; all caesareans OR 0.650, 95% CI 0.380 to 1.114, p=0.1172 • Support worker-midwife ratio: elective caesarean OR 1.209, 95% CI 0.842 to 1.734, p=0.3035; emergency caesarean OR 1.082, 95% CI 0.786 to 1.489, p=0.6296; all caesareans OR 1.182, 95% CI 0.866 to 1.613, p=0.2914 Overall, the largest associations were with maternal clinical risk, parity, and maternal age. Higher maternal clinical risk was associated with increased likelihood of elective, emergency, and any caesarean (dominant monotonic positive relationship). Higher parity was associated with reduced likelihood of emergency and any caesarean (dominant monotonic negative relationship). Increased maternal age was associated with increased likelihood of any caesarean (strong monotonic positive relationship), this appeared to be due to emergency caesarean which showed an effect in this (positive) direction, while elective caesareans showed an effect in the opposite (negative) direction. In multilevel models there was a non-significant trend for higher numbers of doctors per 100 maternities to be associated with increased rate of all caesareans (OR 0.857, 95% CI 0.709 to 1.036, p=0.1110) Sensitivity analyses It was not possible to fit interaction models for some of the sensitivity analyses looking at midwife staffing (midwives x parity for healthy mother and baby outcomes; normal birth outcome). In the analyses looking at the interactions with midwife staffing there was significant interaction: • with clinical risk for all of the healthy mother and baby outcomes. Midwife staffing level had a more positive effect on the outcomes of mothers at lower clinical risk and their babies (OR for outcome in lower risk vs. higher risk, p for interaction: healthy mother OR 1.12 vs. 1.06, p<0.001; healthy baby OR 1.09 vs. OR 1.02, p=0.009; healthy mother and baby OR 1.12 vs. 1.06, p=0.007)

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	• with parity for intact perineum, the positive effect was greatest for women with 4 or more previous babies (OR 1.25 vs. OR 1.11 to 1.18 for lower parities; p for interaction =0.007) • with clinical risk for all caesareans; increased midwife staffing reduced likelihood of caesarean more in women of lower clinical risk (OR 0.96 vs. OR 1.00, p=0.027) There were no other significant interactions between midwife staffing and clinical risk and parity for other mode of birth or caesarean outcome. In sensitivity analyses of the healthy baby outcome excluding preterm births and antepartum stillbirths, midwife staffing levels were associated with a greater effect on healthy baby outcome although this did not quite reach significance (main analysis OR 1.029, 95% CI 0.912 to 1.161, p=0.65; sensitivity analysis OR 1.172, 95% CI 0.991 to 1.387, p=0.063). In the analyses looking at the interactions between doctor staffing levels, parity and clinical risk, higher doctor staffing was associated with: • more benefit for nulliparous women, with reducing benefit for higher parities for healthy mother and baby outcomes (OR for increased doctor staffing/100 maternities for nulliparous vs. parity of ≥4: healthy mother OR 1.14 vs. 0.95, p=0.041; healthy baby OR 1.25 vs. OR 1.07, p=0.005; healthy mother and baby OR 1.20 vs. 0.99, p=0.014) • more benefit for nulliparous women for delivery with bodily integrity (DwBI), and the opposite for normal birth and spontaneous vaginal delivery (DwBI: OR 1.13 vs. 1.07, p=0.014; normal birth: OR 0.88 vs. 1.30, p<0.001; spontaneous vaginal delivery: OR 0.98 vs. 1.27, p=0.002) • less benefit for nulliparous women for the outcome of elective C-section (OR 1.00 vs. 0.78, p=0.001) • less benefit for higher risk women for healthy mother outcome (OR 1.14 for lower risk vs. 1.00 for higher risk, p<0.001) • more benefit for higher risk women for spontaneous vaginal delivery (OR 0.94 vs. 1.06, p<0.001) • greater reduction in normal birth for lower risk women (OR 0.88 vs. 0.99, p=0.001) • more benefit for higher risk women for elective C-section (OR 1.43 vs. 0.84, p<0.001) and all C-section (OR 0.96 vs. 0.83, p<0.001). Other interactions were not significant. There were also significant interactions between level of support worker staffing and parity for some outcomes; higher support worker staffing levels were associated with: • greater benefit for women with higher parity for intact perineum (OR 1.00 for nulliparous vs. 1.15 for parity of ≥4, p<0.001) • worse healthy mother and baby, mode of delivery outcome, and emergency and all C-section outcomes for higher clinical risk women (lower risk vs. higher risk: healthy mother OR 0.92 vs.

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	0.85, p<0.001; healthy baby OR 1.04 vs. 0.95, p=0.018; healthy mother and baby OR 0.93 vs. OR 0.86, p<0.001; delivery with bodily integrity OR 1.04 vs. OR 0.96, p<0.001; normal birth OR 1.06 vs. OR 0.96, p<0.001; spontaneous vaginal delivery OR 0.98 vs. OR 0.95, p=0.044; intact perineum OR 1.04 vs. OR 0.99, p=0.017; emergency C-section OR 0.95 vs. 1.01, p=0.033; all C-section OR 0.98 vs. OR 1.06, p=0.001) Other interactions were not significant. <u>Influence of local geography and demography on outcomes</u> Of all SHAs London had the lowest rates of: healthy mother (23.1%), healthy mother and baby (20.5%), delivery with bodily integrity (27.4%), and spontaneous vaginal delivery (58.5%) and highest rates of emergency caesareans (17.3%) and caesareans overall (28.1%) (statistical comparisons not provided). Maternal and neonatal outcomes by SHA compared with South West SHA: • Healthy mother: ORs ranged from 1.228 (Yorkshire and Humber, p=0.0361, only significant difference) to 0.891 (London, p=0.2544) • Healthy baby outcome: ORs ranged from 1.301 (London, p=0.0088) to 0.915 (North East, p=0.4511) • Healthy mother and baby outcome: ORs ranged from 1.253 (East Midlands, p=0.0480) to 0.907 (London, p=0.3329) • Delivery with bodily integrity: ORs ranged from 1.108 (East Midlands, p=0.3366) to 0.835 (London, p=0.0479, only significant difference) • Normal birth: ORs ranged from 1.266 (East Midlands, p=0.0136) to 0.967 (London, p=0.7045) • Spontaneous vaginal delivery: ORs ranged from 1.096 (North West, p=0.1576) to 0.905 (London, p=0.1642) • Intact perineum: ORs ranged from 1.105 (North East, p=0.4085) to 0.832 (South East Coast, p=0.1003) • Elective caesarean: ORs ranged from 1.097 (London, p=0.2960) to 0.865 (East Midlands, p=0.1638) • Emergency caesarean: ORs ranged from 1.127 (East of England, p=0.1322) to 0.914 (North West, p=0.2083) • All caesarean: ORs ranged from 1.119 (London, p=0.143) to 0.875 (East Midlands, p=0.135) Maternal and neonatal outcomes by rural urban classification compared with Hamlet and Isolated Dwelling - less sparse: • Healthy mother outcome: ORs ranged from 1.115 (Town and Fringe – less sparse, p=0.0008) to 0.864 (Urban ≥10k - sparse, p=0.1296) • Healthy baby outcome: ORs ranged from 1.104 (Village – less sparse, p=0.0146) to 0.797 (Urban ≥10k - sparse, p=0.0478) • Healthy mother and baby outcome: ORs ranged from 1.120 (Town and Fringe – less sparse, p=0.0008) to 0.838 (Urban ≥10k - sparse,

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	p=0.0791) • Delivery with bodily integrity: ORs ranged from 1.185 (Village – sparse, p=0.0050) to 0.951 (Hamlet and isolated dwelling – sparse, p=0.5352) • Normal birth: ORs ranged from 1.221 (Village – sparse, p=0.0024) to 0.921 (Urban ≥10k - sparse, p=0.3263) • Spontaneous vaginal delivery: ORs ranged from 1.244 (Village – sparse, p=0.0004) to 0.970 (Urban ≥10k - sparse, p=0.6986) • Intact perineum: ORs ranged from 1.167 (Village – sparse, p=0.0207) to 0.952 (Hamlet and isolated dwelling – sparse, p=0.5826) • Elective caesarean: ORs ranged from 1.066 (Hamlet and isolated dwelling – sparse, p=0.5885) to 0.865 (Village – sparse, p=0.1256) • Emergency caesarean: ORs ranged from 1.039 (Hamlet and isolated dwelling – sparse, p=0.7182) to 0.928 (Village – sparse, p=0.3703) • All caesarean: ORs ranged from 1.061 (Hamlet and isolated dwelling – sparse, p=0.495) to 0.879 (Village – sparse, p=0.060) Maternal and neonatal outcomes by Index of Multiple Deprivation, most deprived (Q1) compared with least deprived (Q5): • Healthy mother: OR 1.382 (p<0.0001) • Healthy baby outcome: OR 0.854 (p<0.0001) • Healthy mother and baby outcome: OR 1.323 (p<0.0001) • Delivery with bodily integrity: OR 1.457 (p<0.0001) • Normal birth: OR 1.125 (p<0.0001) • Spontaneous vaginal delivery: OR 1.100 (p<0.0001) • Intact perineum: OR 1.546 (p<0.0001) • Emergency caesarean: OR 1.113 (p<0.0001) • Elective caesarean: OR 0.816 (p<0.0001) • Overall caesarean: OR 0.971 (p=0.019). Maternal and neonatal outcomes by trust configuration compared with trusts with OUs or FMUs: • Healthy mother outcome: ORs ranged from 1.006 (OU alone, p=0.9336) to 0.950 (OU/AMU, p=0.5252) • Healthy baby outcome: ORs ranged from 0.961 (OU alone, p=0.5756) to 0.846 (OU/AMU/FMU, p=0.0855) • Healthy mother and baby outcome: ORs ranged from 0.999 (OU alone, p=0.9871) to 0.926 (OU/AMU, p=0.3437) • Delivery with bodily integrity: ORs ranged from 1.050 (OU/AMU/FMU, p=0.5645) to 0.978 (OU/AMU, p=0.7531) • Normal birth: ORs ranged from 0.927 (OU/AMU, p=0.2578) to 0.885 (OU alone, p=0.0362) • Spontaneous vaginal delivery: ORs ranged from 0.988 (OU/AMU/FMU, p=0.852) to 0.971 (OU alone, p=0.560) • Intact perineum: ORs ranged from 1.072 (OU/AMU/FMU, p=0.4697) to 0.964 (OU/AMU, p=0.6490) • Elective caesarean: ORs ranged from 1.039 (OU alone, p=0.5431)

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	to 0.965 (OU/AMU, p=0.6111) • Emergency caesarean: ORs ranged from 0.973 (OU/AMU/FMU, p=0.7036) to 0.941 (OU/AMU, p=0.3260) • All caesarean: ORs ranged from 0.994 (OU alone, p=0.912) to 0.940 (OU/AMU, p=0.301) Larger trusts were associated with reduced likelihood of delivery with bodily integrity (OR 0.975, 95% CI 0.952 to 0.999, p=0.0411) and an intact perineum (OR 0.971, 95% CI 0.945 to 0.998, p=0.0335), and just missed significance for the healthy mother outcome (OR 0.972, 95% CI 0.944 to 1.001, p=0.060). Compared to a university trust, women in a non-university trust were slightly more likely to have a healthy baby (OR 1.134, 95% CI 1.016 to 1.265, p=0.0253) and to have a spontaneous vaginal delivery (OR 1.090, 95% CI 1.012 to 1.175, p=0.024). <u>Maternal characteristics</u> Maternal and neonatal outcomes by ethnicity compared with "any other ethnic group": • Healthy mother outcome: ORs ranged from 1.776 (mixed White and Black Caribbean, p<0.0001) to 0.605 (Indian, p<0.0001) • Healthy baby outcome: ORs ranged from 1.189 (Chinese, p=0.0121) to 0.835 (any other Black/African/Caribbean background, p=0.0007) • Healthy mother and baby outcome: ORs ranged from 1.657 (Caribbean, p<0.0001) to 0.597 (Indian, p<0.0001) • Delivery with bodily integrity: ORs ranged from 1.799 (Caribbean, p<0.0001) to 0.594 (Indian, p<0.0001) • Normal birth: ORs ranged from 1.249 (Caribbean, p<0.0001) to 0.731 (Irish, p<0.0001) • Spontaneous vaginal delivery: ORs ranged from 1.304 (mixed White and Black Caribbean, p<0.0001) to 0.830 (Indian, p<0.0001) • Intact perineum: ORs ranged from 2.242 (Caribbean, p<0.0001) to 0.563 (Chinese, p<0.0001) • Elective caesarean: ORs ranged from 1.223 (Irish, p=0.0024) to 0.692 (mixed White and Black Caribbean, p<0.0001) • Emergency caesarean: ORs ranged from 1.453 (African, p<0.0001) to 0.841 (any other White background, p<0.0001) • All caesarean: ORs ranged from 1.265 (African, p<0.0001) to 0.826 (Chinese, p<0.0001) <u>Maternal clinical risk</u> Clinical risk had a dominant significant effect for all outcomes except intact perineum (chi squared range from 945 for intact perineum to 54,882 for all caesareans). Increasing clinical risk was associated with reduced chances of positive outcomes (healthy mother and baby outcomes and mode of birth outcomes) and increased chance of caesarean outcomes.

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	Parity Parity had a strong or dominant significant effect for all outcomes except healthy baby (chi squared range from 615 for healthy baby to 14,185 for delivery with bodily integrity, 3 effects dominant: healthy mother, intact perineum, and delivery with bodily integrity). Increasing parity was associated with increased chances of positive outcomes (mode of birth outcomes, healthy mother, and healthy mother and baby) and reduced chances of emergency and all caesarean, while the relationship was not linear (monotonic) across all parities for healthy baby (least likely for nulliparous women and most likely for women with 1 previous baby) and elective caesarean (least likely for nulliparous women and most likely for women with 2 children). Maternal age Maternal age group had moderate to strong significant effects for all outcomes except healthy baby (range 14 for healthy baby to 1,746 for spontaneous vaginal delivery, 4 strong effects: healthy mother, delivery with bodily integrity, spontaneous vaginal delivery, and all caesareans). Increasing age was associated with reduced chances of most positive outcomes (healthy mother and baby and mode of delivery outcomes) and elective caesareans, and increased likelihood of emergency and all caesareans. The relationship was not linear (monotonic) across all ages for healthy baby (increasing likelihood up to age 40 to 44, but lowest for women aged 45 and over) and intact perineum (most likely for age 19 and under and reducing likelihood to age 39, then increasing slightly from age 40). The only other factors showing relative chi squared values over 10 were maternal ethnicity (range 6 for healthy baby to 158 for intact perineum) and deprivation of the area of residence (range 2 for all caesarean to 337 for intact perineum. **Process of care outcomes** None **Reported feedback outcomes** None **Other outcomes** None
Notes/comments	**Author conclusions** “Staffing levels have positive and negative effects on some outcomes, and deployment of doctors and midwives where they have most beneficial impact is important. Managers may wish to exercise caution in increasing the number of support workers who care for higher-risk women. There also appear to be limited opportunities for role substitution.”

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	"Approximately 1–2% of the total variation in the outcome indicators was attributable to differences between trusts whereas 98–99% of the variation was attributable to differences between mothers within trusts. There was less variation in staffing level, possibly because of existing staffing standards for the midwifery and obstetric workforce. Levels of midwifery staffing were associated with only 2 of the 10 indicators, delivery with bodily integrity and intact perineum. The models estimated population effects, which may not be a true reflection for all trusts particularly those with more diverse characteristics. Certain multiplicative effects revealed themselves and showed that the effect of staffing upon outcomes sometimes varied according to mother's parity and clinical risk. However there is potential here for reverse causation where units with higher proportions of high-risk women staff to meet that demand." "Much of the variation in outcomes which was measured at trust level was explained by clinical risk and parity." "In sum, it is very hard to say what a 'staffing' ratio or model is, when the most cost-effective care is continuity of midwifery care antenatally/ intrapartum/ postnatally where midwives provide care for women either in the community or in an acute trust facility, which could be an obstetric or midwife-led setting. Thus staffing measures that focus on ratios on a ward will miss this, especially when the care takes place over 6 months both in and out of hospital." **Author limitations** The cross sectional nature of the data makes drawing causal inferences difficult if not impossible. Potential endogeneity between staffing levels and the outcomes assessed is a major problem. The study relied on HES data, and missing or poorly recorded data could cause bias. The analyses could not include risk factors such as smoking status or BMI, or look at bank and agency staff usage, due to lack of good quality data. The analyses were not able to include organisational variables such as organisational climate or models of care, and these and other omitted variables may contribute to outcomes. It is not possible to say how much of the variation could be due to these unmeasured characteristics or variation within trusts in quality of care or difference models of care. The staffing data came from a census undertaken annually in September, and this may hide any variation over time. Staffing data were not available at unit level, and aggregated trust level data may hid unit level effects. The data analysed were aggregated over the year and this also may miss fluctuations during periods where the system is under strain. Unadjusted results should be interpreted with caution due to the effect of confounding factors. There is potential for reverse causation in the interaction analyses, as units with higher proportions of high risk women

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	may staff themselves accordingly, and therefore differently to those with primarily lower risk women. Any extrapolation of the findings to staffing levels not commonly seen in this sample should be done with a high degree of caution. Analyses of medical staff could not be disaggregated to look at obstetric care over the pregnancy and during delivery, and gynaecology care. This may bias estimated effects of medical care. **Review team limitations** The use of composite outcomes limits ability to identify effects on individual outcomes where these were not assessed separately. **Other comments** Dataset was large, used nationally collected data, and covered England as a whole, and was relatively complete, therefore selection bias is unlikely.
Rowe et al. 2014	
Study details	Rowe RE, Townend J, Brocklehurst P et al. Service configuration, unit characteristics and variation in intervention rates in a national sample of obstetric units in England: an exploratory analysis. BMJ Open, 2014;4:e005551. **Study aim** To explore whether service configuration and obstetric unit characteristics explain variation in obstetric unit intervention rates in 'low risk' women with a full term pregnancy planning vaginal birth **Study type** Correlational study **Source of funding** National Institute for Health Research (NIHR) Health Services and Delivery Research programme. No competing interests reported. **Time period/length of follow up** April 2009 to March 2010 (period of births in obstetric units; full period of data collection described as April 2008 to April 2010) **Country** UK (England) **Quality score** **Internal validity** + **External validity** ++ **Overall score** +

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Population and setting	**Setting** Obstetric units **Stage of care** Not stated. Outcomes assessed were in the intrapartum period. **Number of hospitals/units** 36 obstetric units (random sample stratified by size [<2,600; 2,600-4,850; >4,850 births/year] and geographical location [northern or southern England]) **Number of women/births** 32,257 planned vaginal births in obstetric units by women with a term pregnancy (37 to 42 +0 weeks gestation) considered 'low risk' (i.e. not known to have any medical or obstetric risk factors listed in national intrapartum care guidelines in England/Wales). Women were excluded if they had a caesarean section before labour, presented in preterm labour (<37 weeks' gestation), had multiple pregnancy, received no antenatal care or had a stillbirth before the start of care in labour. **Skill mix/type/duties of midwives** Not reported **Key characteristics of hospitals/units assessed** 9 of 36 obstetric units had an alongside midwifery unit (AMU) in the same hospital. Number of births in the obstetric units (excluding those in any AMU): Median 2,919 (interquartile range [IQR] 2,361 to 3,849; minimum 1,380, maximum 6,490) (data based on 35 obstetric units) Number of delivery beds in the obstetric units: Median 10 (IQR 8 to 12; minimum 5, maximum 19) (data based on 36 obstetric units) Percentage of midwifery 'under' staffing (see factors for definition): Median 29.6 (IQR 20.5 to 41.8; minimum 4.4, maximum 83.6) (data based on 30 obstetric units) Percentage of planned non-obstetric unit births (% of births in the NHS trust planned to take place at home, in an free standing midwifery unit [FMU] or AMU): Median 3.0 (IQR 2.3 to 7.9; minimum 0.4, maximum 37.2) (data based on 30 obstetric units) Percentage of planned 'out of hospital' births (% of births in the NHS trust

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	planned to take place at home or in an FMU): Median 2.4 (IQR 1.4 to 4.1; minimum 0.4, maximum 10.2) (data based on 30 obstetric units) **Key characteristics of participants assessed** Not reported **Data sources** Data on births collected by midwives attending the birth. Data on unit and configuration of care from: Birthplace national prospective cohort collected between April 2008 and April 2010 (its sources included mapping surveys 2007-2010; monthly logs recording number of births planned in each unit; data on openings and closures of maternity units collected from all participating NHS trusts; staffing and activity logs completed twice/day by midwives); and Office for National Statistics for data on number of births per year in each hospital for 2009/2010.
Factors assessed	**Midwife staffing** Midwife 'under' staffing ('under' staffing defined as the percentage of shifts where there was less than 1 midwife on duty per woman on the delivery or labour suite). Staffing data were available for 30 of the 36 obstetric units. **Other staffing factors** None **Maternal and neonatal factors** None **Environmental factors** Size of the obstetric unit: number of births per year in each hospital (where there was an AMU in the same hospital as the obstetric unit, this data included births in both settings); annual number of births in each obstetric unit (by estimating the annual number of births in each AMU and subtracting this from the total number of births in the hospital). One AMU had insufficient data to estimate births in the associated obstetric unit. Proportion of births in each NHS trust planned outside an obstetric unit (e.g. AMU, FMU, or at home) and 'out of hospital' (e.g. in an FMU or at home). Number of delivery beds ('bed spaces') in each obstetric unit (using data from 2010 mapping survey, 2007 data was used where 2010 was not available) Presence of an AMU in each hospital (defined as if the associated AMU was open for the whole of the period when cohort study data for the obstetric

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	unit were being collected). One AMU was excluded from analysis for being open for only part of the study period. **Management factors** None **Organisational factors** None **Control variables/adjustment** Adjustments were made for maternal age, ethnicity, English language fluency, marital status, Index of Multiple Deprivation (IMD) quintile, and BMI; gestational age; and presence of 1 or more of: prolonged rupture of membranes >18 hours, meconium-stained liquor, proteinuria 1+ or more, hypertension, abnormal vaginal bleeding, non-cephalic presentation, abnormal fetal heart rate.
Comparison	More versus less understaffing of the delivery suite/labour ward (% shifts where midwife: woman ratio <1:1) compared using regression
Outcomes and analysis	**Maternal/neonatal outcomes** Adjusted rates of intrapartum caesarean section (caesareans carried out before labour were excluded, this would exclude elective caesarean sections) Instrumental delivery (forceps or ventouse)Rates of two composite measures of low medical intervention: straightforward birth (defined as birth without forceps or ventouse, intrapartum caesarean section, third or fourth degree perineal trauma or blood transfusion); and normal vaginal birth (defined as birth without induction of labour, epidural or spinal analgesia, general anaesthetic, forceps or ventouse, caesarean section or episiotomy) Rates of augmentation (secondary outcome), rates of epidural use (secondary outcome) **Process of care outcomes** None **Reported feedback outcomes** None **Other outcomes** None **Analysis** Adjusted unit level event rates were calculated using an indirect standardisation procedure. Each unit's rate was standardised by dividing the observed rate for births planned to take place in the unit by its expected outcome rate, and multiplying by the average rate across the units (weighted by duration of participation and probability of selection for the cohort). Expected outcome rates were calculated based on a

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	multiple logistic regression model based on maternal/fetal demographic and clinical characteristics (age, ethnicity, English language fluency, marital status, IMD quintile, body mass index (BMI), gestational age and presence of any of 7 specified complicating conditions at the start of care in labour. Simple linear regression used to investigate whether unit characteristics were associated with variations in outcomes. All analyses were stratified by parity and significance considered $p<0.05$.
Results	**Maternal/neonatal outcomes** Adjusted rates of intrapartum caesarean section There was a significant association between midwife 'under' staffing and intrapartum caesarean section rate in planned obstetric units for nulliparous women (R^2 17.6%, coefficient -0.10, p=0.03) but not multiparous women (R^2 12.6%, coefficient -0.05, p=0.11). Other factors significantly associated with rates of intrapartum caesarean section (R^2, coefficient, p): • Size of the unit: significant for multiparous women (10.6%, -0.07, 0.01) and borderline significant for nulliparous women (5.8, -0.08, 0.05) • Presence of an AMU: significant for nulliparous women (22.8%, 4.99, 0.03) but not multiparous women (23.1%, 3.23, 0.06) • Presence of planned non-obstetric unit births: for nulliparous (31.8%, 0.31, 0.02) and multiparous women (43.2%, 0.23, 0.01) No significant associations were found for number of delivery beds, and percentage of planned out of hospital births for both nulliparous and multiparous women. Instrumental delivery (forceps or ventouse) There was no significant association between instrumental delivery and percentage of midwife under staffing for nulliparous (R^2 0.2%, coefficient 0.02, p=0.80) or multiparous women (R^2 5.6%, coefficient -0.04, p=0.07). There was also no significant associations found between instrumental delivery and any of the other factors (size of the unit, number of delivery beds, percentage, presence of an AMU, percentage of planned non-obstetric unit births and percentage of planned out of hospital births) for nulliparous or multiparous women Straightforward birth There was a significant association between percentage of midwife under staffing and straightforward birth for multiparous women (R^2 15.1%, coefficient 0.08, p=0.01) but not for nulliparous women (R^2 3.5%, coefficient 0.06, p=0.31). Other significant associations found for straightforward birth were (R^2,

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	coefficient, p): • Presence of an AMU: significant for multiparous (14.8%, -3.14, 0.04) but not for nulliparous women (1.4%, -1.40, 0.55) • Percentage of planned non-obstetric unit births: significant for multiparous (26.3%, -0.22, 0.01) but not nulliparous women (8.2%, -0.17, 0.06) • Size of the unit: borderline significant for multiparous (8.8%, 0.08, 0.05) but not for nulliparous women (0.1%, -0.01, 0.88) No significant associations were found for number of delivery beds and percentage of planned out of hospital births for nulliparous or multiparous women. <u>Normal vaginal birth</u> There was no significant association found between percentage of midwife under staffing and normal vaginal births for nulliparous (R^2 0.1%, coefficient -0.01, p=0.89) or multiparous women (R^2 1.7%, coefficient 0.05, p=0.48) Other significant associations found for normal vaginal birth were (R^2 %, coefficient, p): • Presence of an AMU: significant for multiparous (21.1%, -6.35, 0.02) but not for nulliparous women (10.1%, -5.16, 0.08) • Percentage of planned non-obstetric unit births: significant for multiparous (17.4%, -0.25, 0.01) but not for nulliparous women (6.1%, -0.20, 0.08) No significant associations were found for size of the unit, number of delivery beds, and percentage of planned out of hospital births for nulliparous or multiparous women. Secondary outcomes <u>Rates of epidural</u> There was no significant association found between percentage of midwife under staffing and rates of epidural for nulliparous (R^2 0.9%, coefficient 0.05, p=0.59) or multiparous women (R^2 0.0%, coefficient 0.00, p=0.94). No significant associations were found for any of the other factors (size of the unit, number of delivery beds, presence of an AMU, percentage of planned non-obstetric unit births, percentage of planned out of hospital births) for nulliparous or multiparous women. <u>Rates of augmentation</u> Percentage of midwife under staffing was borderline significantly associated with rates of augmentation for multiparous women (R^2 11.1%, coefficient -0.09, p=0.05) but not significant for nulliparous women (R^2

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	5.6%, coefficient -0.10, p=0.16). Other significant associations found for rates of augmentation were (R^2, coefficient, p): • Percentage of planned out of hospital births: significant for nulliparous (13.7%, -0.73, 0.02) but not for multiparous women (1.3%, -0.13, 0.43). • Presence of an AMU: borderline significant for nulliparous (14.0%, 5.59, 0.05) but not for multiparous women (9.6%, 2.73, 0.07) No significant associations were found for size of the unit, number of delivery beds and percentage of planned out of hospital births for both nulliparous and multiparous women.
Notes/comments	**Author conclusions** "Trusts with greater provision of non-obstetric unit intrapartum care may have higher intervention rates in planned 'low risk' obstetric unit births but at a trust level this is likely to be more than offset by lower intervention rates in planned obstetric unit births." **Author limitations** Exploratory association study using an ecological design; inter-relationships between potential explanatory variables were not explored; limited availability of data on the characteristics of maternity units in England - unable to take account of the dependency levels of women on the delivery ward when calculating midwifery staffing indicator; small number of obstetric units in the sample. **Review team limitations** The study design does not allow a temporal sequence of exposure (e.g. staffing levels) and outcome to be established, limiting ability to draw conclusions about the potential for causal links. Only limited methods were reported, as they had been reported in full in other publications. Data were collected by attending midwives, but no validity check processes were reported in this publication. Individual regression analyses were carried out for the factors of interest (e.g. midwife under staffing, presence of an AMU in the hospital etc.) and these were not combined in a multivariate analysis to determine which remained significant predictors of outcome. As the analysis only included low risk women with term pregnancies who planned to give birth vaginally in the OU results may not apply to women who do not fall into this group e.g. those with clinical risk factors or those planning to give birth in other settings.

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	Other comments Reported to be a nationally representative sample of obstetric units. Obstetric unit intervention rates were evaluated only in planned obstetric unit births, so rates are unaffected by women with complications transferring into the obstetric unit during labour from non-obstetric unit settings. The authors found that intervention rates in planned 'low-risk' OU births tend to be higher in OUs situated in trusts where a higher proportion of women planned birth in a non-OU setting (home, FMU or AMU). They suggest a number of possible explanations for this centring on the theory that in NHS trusts where the OU is known to have a high intervention rate, 'low risk' women may preferentially opt for a non-OU setting. Where a higher proportion of 'low risk' women plan birth in a non-OU setting, planned birth in the OU could be considered to be 'higher risk' and therefore given a more 'medicalised' approach. There is also the possibility for selection bias where women opting for a non-OU birth might be those most keen to have a 'normal birth' without medical intervention, resulting in the planned OU group being less 'intervention averse'.
Cerbinskaite et al. 2011	
Study details	Cerbinskaite A, Malone S, McDermott et al. Emergency caesarean section: influences on the decision to delivery interval. Journal of Pregnancy, 2011. Article ID 640379; pages 1-6. **Study aim** To measure the impact of workload and midwifery staffing levels on the length of time taken to transfer a women to the operating theatre and deliver her baby by grade 1 or 2 caesarean section. Secondary aims were to investigate particular factors (time of day, form of anaesthesia, time spent in operating theatre prior preparing for surgery, speed of surgery) that contribute to delay of delivery. **Study type** Cohort study (with cross sectional analysis of exposure and outcome) **Source of funding** Not reported **Time period/length of follow up** 12 months (2006) **Country** UK (England) **Quality score** **Internal validity** - **External validity** +

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	Overall score -
Population and setting	**Setting** Delivery suite of a tertiary referral hospital northern England **Stage of care** Intrapartum **Number of hospitals/units** 1 obstetric unit **Number of women/births** 333 grade 1 and 2 emergency caesareans were analysed. 5,581 women who gave birth during the study year (755 emergency caesareans, 414 elective caesareans). Of 755 emergency caesareans 122 were grade 1, 211 were grade 2 and 422 were grade 3. (Grade 1 performed for immediate threat to the life of the women or fetus; Grade 2 performed when there is maternal or fetal compromise which is not immediately life threatening; Grade 3 performed when there is no maternal or fetal concern but early delivery is required; and Grade 4 is elective caesarean.) Of 5,167 women who gave birth excluding elective caesareans 2,620 gave birth between during the day (between 08.31 and 20.30hrs) and 2,547 gave birth overnight (between 20.31 and 08.30hrs). **Skill mix/type/duties of midwives** Not reported **Key characteristics of hospitals/units assessed** Day-time staffing (between 08.31 and 20.30 hrs): junior doctors daytime delivery suite shifts with on-site cover provided by 1 Obstetric Registrar, 1 Obstetric Senior House Officer, 1 Anaesthetic Registrar, 1 Consultant Obstetrician and 1 Consultant Anaesthetist). Night-time staffing (between 20.31 and 08.30hrs): junior doctors night time delivery suite shifts with on-site cover provided by 2 Obstetric Registrars, 1 Obstetric Senior House Officer, 1 Anaesthetic Registrar, plus on-call cover from 1 Consultant Obstetrician and 1 Consultant Anaesthetist. 2 obstetric operating theatres were available throughout the day/night staffed by an anaesthetic nurse or an operating department assistant or practitioner.

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	Key characteristics of participants assessed Not reported **Data sources** An audit proforma was completed by the Obstetrician performing the grade 1 or 2 caesarean, in conjunction with the attending midwife. Forms were collated by the research team within 72 hours of the operation and any missing data was added at this time.
Factors assessed	**Midwife staffing** Ratio of the number of qualified midwives present on the delivery suite at the time of caesarean (not further defined) in relation to the number of labouring women (LW:MW ratio) **Other staffing factors** Time of day (staffing differed between day and night) **Maternal and neonatal factors** Total number of labouring women present on the delivery suite at the time of the caesarean, grade of C-section (analysis stratified for this factor), type of anaesthetic used **Environmental factors** None **Management factors** None **Organisational factors** None **Control variables/adjustment** None
Comparison	More than 1:1 ratio of labouring women: midwives (i.e. more women than midwives) vs. less than 1:1 ratio labouring women: midwives (i.e. more midwives than women) on the delivery suite
Outcomes and analysis	**Maternal/neonatal outcomes** None **Process of care outcomes** Decision to delivery interval Transfer times to theatre Time interval between arrival in theatre and commencement of the caesarean and delivery of the baby **Reported feedback outcomes** None **Other outcomes** None

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	Analysis Chi squared analyses used to compare categorical variables and analysis of variance used to compare groups of continuous variables, with two tailed t-tests used to make more detailed comparisons. Values of p below 0.05 were taken as statistical significance.
Results	**Process of care outcomes** Mean decision to caesarean delivery interval (SD): Grade 1: 23 minutes (11) Grade 2: 32 minutes (13) Mean arrival in theatre to start of operation (SD): Grade 1: 19.1 (9.6) Grade 2: 20.4 (8.6) (p=0.201 for difference) Babies born within 30 minutes of operation being requested (NICE recommend that for confirmed or suspected fetal compromise delivery should ideally be performed within 30 minutes): Grade 1: 82.0% Grade 2: 45.0% Babies being born within 75 minutes of operation being requested (previous studies have demonstrated maternal and perinatal outcomes deteriorate when the interval exceeds 75 minutes): Grade 1: 99.2% Grade 2: 98.1% Decision to delivery interval in relation to LW:MW ratio: Grade 1: decision to delivery intervals were less than 30 minutes in 77/82 (93.9%) caesareans when the ratio was 1:1 or more, but only 22/40 (55.0%) when the ratio was less than 1:1 (p<0.001). Grade 2: decision to delivery intervals were less than 30 minutes in 90/168 (53.6%) caesareans when the ratio was 1:1 or more, but only 5/43 (11.6%) when the ratio was less than 1:1 (p<0.001). Transfer times to theatre in relation to the LW:MW ratio: Grade 1: transfer to theatre times were within 15 minutes for 81/82 (98.8%) caesareans when the ratio was 1:1 or more, but only 34/40 (85.0%) when the ratio fell below 1:1 (p<0.001). Grade 2: transfer to theatre times were within 15 minutes for 155/168 (92.3%) caesareans when the ratio was 1:1 or more, but only 29/43 (67.4%) when the ratio fell below 1:1 (p<0.001). Time interval between arrival in theatre and commencement of the caesarean and delivery of the baby: LW:MW ratio was reported to have “no discernible bearing” (figures and p value not reported). Decision to delivery interval in relation to the number of women in active labour:

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	Grade 1: the 30 minute cut off was rarely breached until the number of labouring women on the delivery unit exceeded 8; above 8, the 30 minute time limit was frequently exceeded (figures and p value not reported). Grade 2: as the number of women increased, the decision to deliver interval also increased (figures and p value not reported). Decision to perform caesarean during daytime vs. overnight: Grade 1: the decision to perform a grade 1 caesarean was as likely to be made during the daytime (59/2,620) as overnight (63/2547) (p=0.104). Individually measured indications for grade 1 caesareans (low pH on fetal blood sampling, failure to progress in the first or second stages of labour, failed instrumental vaginal delivery including forceps, ventouse or both) did not differ between the 2 timeframes. Grade 2: significantly less grade 2 caesareans were performed during the day (97/2,620) than overnight (114/2,547) (p=0.015). The greatest factor for this difference was a rise in number of procedures performed in response to a pathological cardiotocographic abnormality (CTG) overnight without recourse to fetal blood sampling (37 daytime incidences vs. 62 overnight, p<0.001), and a rise in procedures performed for non-progressive second stage of labour (11 daytime vs. 20 overnight, p=0.01). There was no significant association between the time of day at which the decision was made and decision to delivery interval (figures and p value not reported). Choice of anaesthesia was significantly associated with decision to delivery interval for grade 1 caesareans: 19.7mins (SD 8.5) under general anaesthesia vs. 27.0mins (SD 8.2) under spinal blockade (p<0.001) (under epidural top-up 26.0mins [SD 18.7]; no pairwise comparison performed) Choice of anaesthesia was not associated with decision to delivery interval for grade 2 caesareans: 30.1mins (SD 19.4) under general anaesthesia, 34.7mins (SD 12.0) under spinal blockade, and 29.2mins [SD 15.4] under epidural top-up (p=0.681) Time of day at which the decision was made influenced the choice of anaesthesia for grade 1 caesarean, with general anaesthesia most common in the day (31/59 [52.5%] vs. 22/63 [34.9%], p=0.005) and spinal blockade most common at night (17/59 [28.8%] vs. 29/63 [46.0%], p=0.009). Time of day had no influence on choice of anaesthesia for grade 2 (p>0.07). The effect of type of anaesthesia on decision to delivery was influenced by time from arrival in theatre to start of the operation for grade 1 caesareans: it was shortest with general anaesthesia, mean 14.4 minutes (SD 6.0) vs. 24.6 minutes with spinal blockade (SD 9.6, p<0.001), vs. 20.0 minutes with epidural top up (SD 11.4, p=0.032). Anaesthetic had no influence on time from arrival to start for grade 2: 18.2 minutes (SD 14.9) with general, 21.1 minutes (SD 6.5) with spinal block, and 19.9 minutes (SD 10.3) with epidural top up (p=0.335).

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Notes/comments	**Author conclusions** "Midwifery staffing levels and the form of anaesthesia employed influence on decision to delivery intervals for the most urgent caesarean sections. " **Author limitations** Findings may not be applicable to smaller obstetric units, stand alone midwifery led units or alongside midwifery led units which deal with different case mix and which may face different organisational challenges than the tertiary level hospital studied here. Maternal or fetal outcomes were not assessed. Observational study design rather than interventional. **Review team limitations** Figures and significance values not reported for some outcomes. The analysis was relatively simplistic (chi squared comparison of the outcomes for LW:MW ratios <1:1 versus >1:1), and did not adjust for potential confounders. Limited information is available on the demographics of the area or the treated population, hospital characteristics or numbers of midwives. Only one hospital was included in the study, which may limit generalisability of the findings. The number of C-sections being analysed was small (333 grade 1 and 2 C-sections) which may limit reliability of the results. There were fewer grade 1 C-sections (122) than grade 2 (211), therefore results for grade 1 C sections may not be as robust and have less power. For each woman, midwife staffing levels (the woman's "exposure") were assessed at the point of delivery (the time of the outcome), rendering the analyses essentially cross sectional and limiting ability to draw conclusions about causality.
Gerova et al. 2010	
Study details	Gerova V, Griffiths P, Jones S et al. The association between midwifery staffing and outcomes in maternity services in England: observational study using routinely collected data. Preliminary report and feasibility assessment. Kings College London, 2010. **Study aim** To assess the feasibility of using routinely available data to measure the impact of midwifery staffing upon birth outcomes in maternity services at trust level in England. **Study type** Correlational study **Source of funding**

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	Department of Health England **Time period/length of follow up** April 2008 – March 2009 **Country** UK (England) **Quality score** **Internal validity** + **External validity** ++ **Overall score** +
Population and setting	**Setting** Hospital trusts **Stage of care** Not stated. Outcome assessed was in the postpartum period. **Number of hospitals/units** 144 out of 150 trusts which provide maternity care in England **Number of women/births** 615,042 women **Skill mix/type/duties of midwives** Not reported **Key characteristics of hospitals/units assessed** <u>Staff groups full time equivalent (FTE): birth ratio</u> Mean (SD; range; number of trusts data is from) Midwife consultant: birth ratio: 1,642.5 (1,322.7; 89 to 6,803; n=124) Midwife: birth ratio: 31.5 (7.9; 9 to 81; n=140) Consultant obstetrician and gynaecologist (O&G): birth ratio: 430.5 (131.0; 79 to 971; n=140) Associate Specialist and Staff Grade O&G: birth ratio: 1956.0 (1512.0; 190 to 8553; n=113) O&G registrar: birth ratio: 324.7 (163.7; 56 to 1133; n=140) O&G senior house officer: birth ratio: 1776.9 (1338.3; 273 to 7887; n=115) O&G junior house office: birth ratio: 1901.2 (1245.0; 311 to 5912; n=105) Registered nurse: birth ratio: 257.6 (521.5; 26 to 5070; n=133) Nursery nurse: birth ratio: 1598.9 (1291.5; 266 to 5992; n=63) Healthcare assistant: birth ratio: 144.2 (125.7; 18 to 1030; n=141) **Key characteristics of participants assessed**

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	Mean maternal age: 29 years (age group 26-30 years made up the largest group [28.4%] followed by 31-35 years [25.6%]) Ethnicity: 69.7% white, 8.2% Asian or Asian British, 5.5% Black or Black British, 0.6% Mixed, 6.3% other, 9.9% unknown. Charlson comorbidities: No comorbidity: 96.4% Deprivation: Lived in least deprived areas: 15.8% Lived in most deprived areas: 27.2% Delivery method: Normal deliveries without complications: 57.1% Normal deliveries with complications: 14.3% Assisted delivery without complications: 3.4% Assisted delivery with complications: 1.9% Caesarean section without complications: 8.8% Caesarean section with complications: 14.5% Births with midwife (rather than obstetrician) as the responsible clinician: 19% Length of stay (LOS): Percentage of women with a prenatal LOS of 1-4 days: 36.6% Percentage of women with a postnatal LOS of 1-4 days: 76.5% Percentage of women with admissions in the previous 12 months: 9.6% **Data sources** Data on staff variables from The 2008 Maternity Matters Benchmarking dataset Data on patients from the Admitted Patients HES data for England from Dr Foster for April 2008 to March 2009.
Factors assessed	**Midwife staffing** Midwife consultant FTE: birth ratio Midwife FTE: birth ratio (Ratios used in the analyses were standardised, i.e. converted to z scores) **Other staffing factors** Consultant obstetrician and gynaecologist (O&G) FTE: birth ratio; Associate Specialist and Staff Grade O&G FTE: birth ratio; O&G registrar FTE: birth ratio; O&G senior house officer FTE: birth ratio; number of O&G junior house office FTE: birth ratio; Registered nurse FTE: birth ratio; nursery nurse FTE: birth ratio; healthcare assistant FTE: birth ratio **Maternal and neonatal factors**

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	None **Environmental factors** None **Management factors** None **Organisational factors** None **Control variables/adjustment** Age of the mother; ethnicity; Carstairs deprivation index; Charlson comorbidity index; delivery method (normal delivery with and without complications, assisted delivery with and without complications, caesarean with and without complications [no information reported for elective and emergency]); professional delivering (midwife vs. consultant obstetrician + other); number of admissions in the previous 12 months (0,1,2,3); pre- and postnatal length of stay (0 days, 1-4, 5-16, >17 days).
Comparison	Higher versus lower midwife: birth ratios compared using Poisson regression
Outcomes and analysis	**Maternal/neonatal outcomes** None **Process of care outcomes** 28 day readmission, defined as the number of women readmitted to any hospital within 28 days after discharge from the postnatal ward **Reported feedback outcomes** None **Other outcomes** None **Analysis** A logistic regression model at patient level and Poisson regression at trust level. Expected readmissions were estimated from the patient level model and used as an offset in the trust level model.
Results	**Process of care outcomes** Number of maternal readmissions to any hospital within 28 days after discharge from the postnatal ward: Actual readmissions at 28 days: mean 33.6 (SD 21.3; range 0 to 137) Expected readmissions at 28 days: mean 33.4 (SD 16.9; range 0.01 to 92.0) Relative risk of being readmitted in each trust: mean 1.02 (SD 0.51; range 0 to 3.48) (actual number of readmissions at 28 days divided by number of expected readmissions, obtained from the logistic regression model) <u>Association between staffing and readmission (adjusted)</u> There was a significant association between all staffing variables and

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	readmissions (p<0.001 for all): Higher midwife FTE: birth ratio was associated with a lower probability of readmission: Beta -4.810 (SE 0.032), 95% Wald CI -4.873 to -4.746 Higher consultant midwife FTE: midwife FTE ratio was associated with a lower probability of readmission: Beta -4.348 (SE 0.031) 95% Wald CI -4.408 to -4.289 Higher consultant O&G FTE: midwife FTE ratio was associated with a lower probability of readmission: Beta -3.563 (SE 0.021) 95% Wald CI -3.605 to -3.522 Higher registered nurses FTE: midwives FTE ratio was associated with a higher probability of readmission: Beta 3.133 (SE 0.009) 95% Wald CI 3.115 to 3.151 The following maternal variables were associated with significantly increased risk of maternal readmission (beta [SE] p) • presence of ≥1 maternal comorbidities vs. no comorbidity: 0.168 [0.068], p=0.014 • ≥1 maternal admission in the past 12 months: 1 admission 0.499 [0.044]; 2 admissions 0.741 [0.083]; 3 admissions 0.995 [0.108] (p<0.001 for all) • Black or Black British vs. White ethnicity: 0.238 [0.056], p<0.001 • Longer pre-birth length of stay: 1-4 days 0.114 [0.03]; 5-16 days 0.452 [0.100]; 17+ days' 0.746 [0.223] (p≤0.001 for all) • Longer post-birth length of stay: 1-4 days 0.231 [0.047]; and 5-16 days' stay 0.437 [0.067] (p<0.001 for both) • Having a more complicated delivery: normal delivery with complications 0.360 [0.041]; assisted delivery with complications 0.444 [0.094]; caesarean 0.472 [0.050]; caesarean with complications 0.518 [0.041] (p<0.001 for all) Delivery by a consultant increased probability of readmission compared to delivery by a midwife: 0.98 [0.042], p=0.02
Notes/comments	**Author conclusions** "Higher numbers of full time equivalent (FTE) midwives per birth was associated with a lower probability of readmission. A higher ratio of consultant obstetrician FTE to midwives FTE was also associated with a lower probability of readmission, as was a higher ratio of consultant midwives FTE to midwives. A higher ratio of registered nurses FTE to midwives FTE was associated with a higher probability of readmission. The relationships demonstrated with our simple model are certainly plausible with better outcomes consistently associated with higher levels of more experienced and more highly qualified staff". **Author limitations**

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	Due to limitations in data availability, only one outcome measure was examined. Risk adjustment was reported to be limited in this model, and further risk adjustment might alter the relationships. The data available had information on the level of healthcare assistants FTE in maternity services, but did not differentiate between maternity support workers and maternity care assistants. In any case, healthcare assistants were excluded from the model because of colinearity with other staff groups. It was unclear whether readmissions could be a direct consequence of the original procedure/interventions, or to do with the level of aftercare, or the patient's actions. Future methods should include multilevel logistic regression model at trust and patient level and should strive to incorporate additional variables such as midwifery and other maternity staff workforce characteristics, midwifery grades, skill mix, job relevant training, supervision and turnover. Additional maternal characteristics such as previous mode of birth, parity, multiple births, gestational age, and co-morbidities such as diabetes, hypertension, renal disease, cardiac disease and obesity should be considered **Review team limitations** The study design does not allow a temporal sequence of staffing levels and outcome to be established, limiting ability to draw conclusions about potential causal links. Only 27 trusts had data on all staff groups assessed, it was not clear whether some trusts did not employ all of the staff groups or whether data was missing. The study would not be able to separate obstetric from gynaecologic work of consultants, therefore the FTE ratio for O&G physicians may effectively higher than it would be if only time spent on obstetrics was considered. As this study assessed outcomes at the trust level, it would not be able to identify the effect of variations in staffing at a more local level (e.g. at unit level). The analysis was part of a feasibility assessment, it did adjust for some potential confounders (maternal age, ethnicity, deprivation, comorbidity, delivery method, professional delivering, number of admissions in the previous year, pre and post-birth length of stay), but there were others which could not be adjusted for (e.g. parity, multiple pregnancies or births, gestational age, or previous delivery type). **Other comments** FTE: birth ratio defined as number of births per health professional FTE. Data were available on FTE at trust level (i.e. the total number of births per year in each trust is divided to the total FTE for each professional

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	group).
Joyce et al. 2004	
Study details	Joyce R, Webb R, and Peacock J L. Associations between perinatal interventions and hospital stillbirth rates and neonatal mortality. Archives of Diseases in Childhood, Fetal and Neonatal Edition. 2004; 89:F51-F56. **Study aim** To examine the effect of obstetric, paediatric and special care baby unit factors (including staffing and department organisation) upon stillbirth rates and neonatal mortality **Study type** Correlational study **Source of funding** None reported **Time period/length of follow up** 1994 to 1996 **Country** UK (England) **Quality score** **Internal validity** + **External validity** ++ **Overall score** +
Population and setting	**Setting** All maternity units in hospitals in the Thames Region **Stage of care** Not specified. Outcomes assessed were in the intrapartum or neonatal period. **Number of hospitals/units** 64 hospital maternity units (one additional hospital was excluded due to absent data) **Number of women/births** 540,834 births (3,150 stillbirths and 537,684 live births, including 2088 neonatal deaths), including a mean 2.9% of babies at each hospital from multiple births. Number of women not reported.

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	Skill mix/type/duties of midwives Not described **Key characteristics of hospitals/units assessed** Data are mean (SD; range): Births in hospital/year: 2,877 (807.7; 872 to 4,214) Midwives/1000 deliveries/year: 29.6 (6.62, 18.3 to 47.0) Consultant O&G sessions on labour ward/week: 2.5 (2.45; 0 to 10) Number consultant O&G staff/1000 deliveries: 1.4 (0.63; 0.7 to 4.7) Number junior O&G staff/1000 deliveries: 4.3 (2.34; 0.5 to 18.3) Number consultant paediatricians/1000 births: 1.2 (0.53; 0.34 to 3.26) Number junior paediatricians/1000 births: 2.9 (1.03; 0.9 to 6.5) Consultant anaesthetist sessions on labour ward/week: 4.1 (1.78; 1 to 10) Number of delivery beds/ 1000 deliveries: 3.6 (0.80; 2.4 to 6.6) NICU beds/1000 deliveries: 1.3 (1.13; 0 to 6.8) SBCU beds (including NICU)/1000 deliveries: 6.1 (2.10; 2.6 to 17.0) **Key characteristics of participants assessed** Data are mean at each hospital (SD; range): % of births to nulliparous women: 41.0 (4.17; 32.4 to 58.6) % of births to teenage mothers: 5.0 (1.77; 2.0 to 10.0) % of births to women >40 years: 2.2 (0.75; 1.0 to 4.7) % of births to fathers of manual or “other’’ class: 50.4 (10.69; 27.0 to 72.3) Townsend deprivation score of babies born: 1.0 (2.34; -2.2 to 7.1) **Data sources** Four national: Office for National Statistics (ONS) birth and death registrations; the 1991 Census; Royal College of Obstetricians and Gynaecologists (RCOG) hospital recognition returns; and DH data on hospital staffing levels.

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	One regional: Thames risk management survey
Factors assessed	**Midwife staffing** Midwives /1000 deliveries/year **Other staffing factors** Number of consultant obstetric and gynaecological (O&G) staff and sessions on the labour ward, number of junior O&G staff, number of consultant and junior paediatricians, number of consultant anaesthetist sessions on labour ward **Maternal and neonatal factors** Births per year; mean birth weight; spontaneous vaginal deliveries, caesareans and instrumental deliveries per 100 births; vaginal births, emergency and elective caesareans per 100 breeches; inductions per 100 deliveries; epidurals per 100 deliveries; general anaesthetics per 100 caesareans; % teenage mothers, % mothers >40 years, % nulliparous, % multiple births **Environmental factors** Deprivation of birth district (mean Townsend score), social class of fathers (manual or 'other'), delivery bed rate, neonatal intensive care unit (NICU) rate, special care baby unit (SCBU)+NICU rate (indicator of unit level), dedicated maternity theatre, a 24-hour epidural service **Management factors** Not assessed **Organisational factors** Whether the unit has a risk manager, the grade of the risk manager, and frequency of perinatal meetings **Control factors/adjustment** Factors were grouped into four types: those related to facilities, staffing, interventions, and parental data, and analysed independently. All outcomes were standardised by birthweight, but no other factors were adjusted for.
Comparison	Higher versus lower midwife staffing ratios (midwives/1000 deliveries/year) compared using regression
Outcomes and analysis	**Maternal/neonatal outcomes** Stillbirth and neonatal mortality rates, crude and standardised per 500g birthweight band **Process of care outcomes** None **Reported feedback outcomes** None

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	Other outcomes None **Analysis** Factors were all assessed in simple linear regression or t-test analyses as appropriate, followed by multivariate regression models
Results	**Maternal/neonatal outcomes** Crude stillbirth rate 5.69 (SD 2.01; range 1.93 to 12.42) Standardised stillbirth rate 5.84 (SD 1.25; range 3.40 to 8.53) Crude neonatal mortality 3.54 (SD 2.29; range 1.11 to 11.73) Standardised neonatal mortality 3.48 (SD 0.83; range 1.90 to 5.39) Birthweight accounted for over 70% of the overall variability in crude stillbirth and neonatal mortality rates: Mean birthweight: R^2 0.708, p<0.001 % births <1.5kg: R^2 0.752, p<0.001 % births <2.5kg: R^2 0.719, p<0.001 In univariate linear regression analyses midwife staffing levels (midwives per 1000 deliveries) were not significantly associated with any outcome: Standardised stillbirth rate (SSBR): beta 0.012, R^2 0.004, p=0.65 Standardised neonatal mortality (SNNM): beta -0.012, R^2 0.010, p=0.50 Various other factors were significantly associated with SSBR in univariate analysis. In the four types of category examined these were (beta, R^2, p): <u>Facilities</u> NICU beds per 1000 births (-0.378, 0.123, 0.006) and SCBU and NICU beds per 1000 births (-0.153, 0.07, 0.04) <u>Staffing</u> Consultant O&Gs per 1000 deliveries (-0.681, 0.13, 0.006) <u>Interventions</u> Spontaneous vaginal deliveries per 100 births (0.088, 0.148, 0.002), caesareans per 100 deliveries (-0.091, 0.083, 0.026), forceps per 100 births (-0.176, 0.074, 0.035), instrumental deliveries per 100 births (-0.153, 0.114, 0.008), general anaesthetics per 100 caesareans (0.032, 0.161, 0.002), epidurals per 100 deliveries (-0.036, 0.167, 0.001), and epidurals for labour per 100 deliveries (-0.042, 0.130, 0.005) <u>Parental</u> % nulliparous (married) women (-0.079, 0.069, 0.037), % teenage mothers (0.183, 0.067, 0.038), % fathers of manual or “other” class (0.039, 0.108, 0.008), % babies from multiple births (-0.485, 0.173, 0.001)

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	The above facilities components explained 90% of the total variation in SSBR, interventional factors 78%, and parental factors 88%. On the final multiple regression model two factors were significantly associated with SSBR: Intervention score (beta -0.21, SE 0.07, R^2 0.27, p=0.003), and number of consultant O&Gs per 1000 births (beta -0.55, SE 0.23, p=0.019) An increase of one IQR (2.47 units) in the intervention score was associated with a 0.52 reduction in SSBR, and with one IQR increase in number of consultants per 1000 births was associated with a 0.26 reduction. Mean Townsend score was the only factor significantly associated with SNNM on univariate analysis (beta 0.106, R^2 0.090, p=0.016) Organisational factors of having a dedicated maternity theatre, 24 hour epidural service, risk manager, grade of risk manager, or frequency of perinatal meetings, were not associated with SSBR or SNNM.
Notes/comments	**Author conclusions** "Birthweight adjusted stillbirth rates were significantly lower in units that took a more interventionalist approach and in those with higher levels of consultant obstetric staffing. There were no apparent associations between neonatal death rates and the hospital factors measured". **Author limitations** Hospital level analysis was the only feasible approach, as RCTs would not be ethical or feasible, and individual level observational studies would be confounded. There was no data available on neonatal nurse staffing levels, which may have been associated with mortality. **Review team limitations** Numbers of midwives were only available rounded to the nearest 10. The study design does not allow a temporal sequence of staffing levels and outcome to be established, limiting ability to draw conclusions about potential causal links. ONS, Census, and DH staffing data were almost 100% complete. Not all hospitals provided all data, with RCOG data available for 95% of hospitals for at least one year (range 66% to 86% for each year assessed). Returns were 94% complete. The Thames risk management survey had an 84% response rate, though all returned surveys were fully complete. These response rates are relatively high, but missing data may reduce accuracy of analyses. Multiple comparisons were carried out and it was unclear whether this had

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	been taken into account (p value for significance was 0.05). The data being analysed was from 1994-1996 and may not be representative of current UK practice. Although a range of factors were assessed for association with outcomes there were relatively few maternal characteristics adjusted for (parity [% nulliparous], age [% teenagers and % >40], and multiple births). **Other comments** Study was large and included a large number of hospitals, over a few years, with a range of clinical risk, case mix, and organisational variety.
Tucker et al. 2003	
Study details	Tucker J, Parry G, Penney G et al. Is midwife workload associated with quality of process of care (continuous electronic fetal monitoring [CEFM]) and neonatal outcome indicators? A prospective study in consultant-led labour wards in Scotland. Paediatric and Perinatal Epidemiology. 2003; 17; 369-377. **Study aim** To assess the association between midwife workload and CEFM and neonatal outcome. **Study type** Cohort study **Source of funding** None reported **Time period/length of follow up** 4 weeks in September 2000 **Country** UK (Scotland) **Quality score** **Internal validity** + **External validity** + **Overall score** +
Population and setting	**Setting** All consultant-led labour wards in Scotland (midwife led units not included)

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	Stage of care Not specified. Outcomes assessed were in the intrapartum and neonatal periods. **Number of hospitals/units** 23 consultant-led labour wards **Number of women/births** 3,489 consecutive live births (representing 85% of births registered in Scotland for the 4-week study period); 1,561 consecutively delivered women were available for CEFM case review during the 2 of the study weeks **Skill mix/type/duties of midwives** Log recorded midwives as core labour midwives, midwives in rotation into labour ward, caseload carrying midwives, and bank/agency midwives. However, numbers of each not reported or analysed. **Key characteristics of hospitals/units assessed** 5 units had <1000 births annually, 7 units 1000-1999, 5 units 2000-2999, and 6 units 3000-6999. Occupancy, the proportion of observations when there were no women on the labour ward (95% CI): 31% (28 to 33) for units with <1000 births annually; 9% (9.0 to 9.7) for units 1000-1999; 2.8% (2.7 to 3) for units 2000-2999, and 0.14% (0.12 to 0.17) for units with 3000-6999 births annually. The proportion of observations for shortfall staffing where there was less than 1 midwife to 1 woman for all deliveries [as derived from the Framework for Maternity Services in Scotland] was: 21% for units with <1000 births annually; 10% for units 1000-1999; 13% for units 2000-2999; and 18% for units with 3000-6999 births annually. Overall proportion of observations with shortfall: 15%, with significant difference between units (p<0.001) The median midwife staffing ratio (IQR), observed/required was: 1.0 (1.0 to 2.0) for units with <1000 births annually; 1.3 (1.0 to 2.0) for units 1000-1999; 1.5 (1.1 to 2.0) for units 2000-2999; and 1.3 (1.0 to 1.8) for units with 3000-6999 births annually. The overall proportion of observations The proportion of observations for shortfall staffing where the midwife: woman ratio did not meet the requirement for case mix (as derived from Birthrate Plus: 1:1 for normal labour; 2.3:1 for high dependency group A [caesarean, instrumental delivery, intensive monitoring, general anaesthetic, baby with Apgar<5]; 1.5:1 for high dependency group B [induced or augmented labour, intravenous therapy, epidural, labour lasting >8 hours, perineal trauma requiring suture]; and 0.25:1 for transfer or others [early, not established labour; delivered awaiting transfer; spontaneous rupture of membranes not in labour]) was: 21% for units with <1000 births annually; 32% for units 1000-1999; 33% for

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	units 2000-2999; and 46% for units with 3000-6999 births annually. Overall proportion of observations with shortfall: 35%, with significant difference between units (p<0.001) The median midwife staffing ratio (IQR), observed/required for case mix was: 1.7 (1.0 to 4.0) for units with <1000 births annually; 1.3 (0.9 to 2.4) for units 1000-1999; 1.3 (0.9 to 2.2) for units 2000-2999; and 1.0 (0.8 to 1.6) for units with 3000-6999 births annually. **Key characteristics of participants assessed** Of the 1,561 cases for whom CEFM was analysed, 1,168 (75%) had CEFM. Of those who had CEFM, use was considered appropriate in 79% of cases (924) and inappropriate in the remaining 224, defined as women with no recorded risk characteristics having CEFM (45% [224/544] of women with no risk characteristics). Of the 393 who did not have CEFM, this was considered appropriate in 76% (300) and inappropriate in the remaining 93, defined as women with at least one recorded risk factor not having CEFM (9% [93/1017] with risk characteristics). No other participant characteristics reported. **Data sources** Workload data recorded by shift leaders 4 times daily using a log based on RCOG National Sentinel Caesarean Section Audit of England and Wales, and revised following pilot studies. Midwives were trained to record workload and CEFM data, and there was a helpline for queries. Telephone calls were used to check that logs were completed accurately and on time, and were checked for completeness and internal consistency when submitted weekly. CEFM was collected as part of a national audit in 2 of the study weeks, plus another 2 weeks. National routine data on maternal comorbidity (ICD-10) births and neonatal outcomes was obtained from Information and Statistics Division of NHS Scotland.
Factors assessed	**Midwife staffing** Ratio of observed midwives to 'required' number of midwives accounting for case mix (ratios <1 indicate fewer midwives than required) based on Birthrate Plus. **Other staffing factors** None reported **Maternal and neonatal factors** Fetal heart rate anomaly at admission or in labour, pre-eclampsia, suspected abruption, previous caesarean, no liquor, preterm labour,

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	meconium stained liquor, oyctocin to induce or accelerate labour, and epidural were associated with outcomes and adjusted for. Birthweight was tested as a confounder but did not show association. **Environmental factors** Unit occupancy (% beds empty) was assessed for potential association with outcomes along with midwife staffing, but it was unclear if it was adjusted for in the staffing analyses and vice versa. **Management factors** None reported **Organisational factors** None reported **Control variables/adjustment** Confounding variables were fitted as risk factors in the regression. The full list of potential confounders tested was not reported, but the ones showing links with outcomes are reported above.
Comparison	Higher versus lower midwife staffing ratios (midwives:women) compared using regression
Outcomes and analysis	**Maternal/neonatal outcomes** Apgar score <7 at 5 minutes, admission to neonatal unit (NNU) >48 hours, any neonatal resuscitation (bag and mask with no drugs, bag and mask with drugs, intubation for invasive positive pressure ventilation (IPPV) with or without drugs, or drugs only), resuscitations other than those with bag and mask only Adjusted rates of CEFM, appropriate or inappropriate CEFM (either use when not indicated by risk factor or no use when indicated), time to senior medical response (4th year specialist registrar or above) for a serious fetal heart trace abnormality **Process of care outcomes** None **Reported feedback** None **Other outcomes** None **Analysis** A random effects model was used to take into account clustering. For testing effect of staffing on CEFM, unit workload at the time of admission was used; for time to medical response outcome workload at time of first recording the serious heart trace abnormality was used, and

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	for neonatal outcomes the workload immediately at or before time of birth was used.
Results	**Maternal/neonatal outcomes** Neonatal health and resuscitation outcomes After adjusting for confounding variables, there was a trend for slight reductions in odds of neonatal outcomes with increasing midwife staffing ratio, but only one of these reached significance (resuscitations, not including bag and mask only resuscitations). OR (95% CI) for every 1 point increase in the midwife staffing ratio and the stated outcomes: Apgar <7 at 5 minutes 0.98 (0.94 to 1.04) (AR 67/3404, 1.9%) Any resuscitation (including 'lowest level' i.e. bag and mask with no drugs) 0.98 (0.96 to 1.00)(AR 411/3404, 12%; 228/411, 55% with bag and mask only) Resuscitations excluding bag and mask only 0.97 (0.94 to 0.99)(AR 183/3404, 5%) >48h admission to the NNU 0.97 (0.95 to 1.00)(AR not reported) Unit occupancy was not significantly related to any of these outcomes. CEFM outcomes After adjusting for confounding variables, there was no significant association between midwife staffing ratios (or unit occupancy) and overall use, appropriate or inappropriate use of CEFM, or lag time for senior medical response. OR (95% CI) for every 1 point increase in the midwife staffing ratio and the stated outcomes: Having CEFM 1.00 (0.77 to 1.29) Having inappropriate CEFM 1.44 (0.85 to 2.45) Having appropriate CEFM for high risk cases 0.90 (0.63 to 1.30) Having appropriate CEFM for low risk cases 1.12 (0.85 to 1.47) Difference in lag time for senior medical response for a 1 point increase in ratio -7.8 minutes (-52.4 to 36.8)
Notes/comments	**Author conclusions** "There were no associations between occupancy or staffing ratios and adjusted CEFM process, Apgar <7 at 5 minutes, or admission to NNU for >48

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	hours. However, there was association between increasing staffing ratios and lower odds of adjusted neonatal resuscitation (excluding bag and mask only). The direction of effect of increasing workload suggests detriment to outcome indicators, although the size of effect may be small". **Author limitations** Study recruitment was slightly lower than required to reach the planned level of power. The actual study size gave power to detect an OR for CEFM use of 1.33, smaller effects may not be detected. No information on maternal preferences for CEFM were collected, and this may impact use. **Review team limitations** The time period observed was relatively short (4 weeks) and may not be representative of a longer time period. The discussion mentioned medical staff availability in the labour ward being available for 95% of daytime periods, but this factor did not appear to be taken into account in the analyses. The study targeted recruitment to have about 80% power to detect difference in neonatal resuscitations of 3% (12% vs. 15%; n=4,204 needed) and a difference of 1.2% in Apgar<7 (1% vs. 2.2%; n=3,756 needed) at p=0.05. Actual livebirths were slightly lower (n=3,489) meaning that power was lower than planned (n=3,756). Workload logs were complete for 15/23 units (all units returned logs); only 23/2576 (0.9%) time point records had some missing midwife or woman data fields (1-8 records per unit). 99% of CEFM processes had complete data, and 3,083/3,489 (88%) neonates provided outcome data (elective caesarean, midwife birthing unit births, and multiple pregnancies excluded). Missing data may impact results. **Other comments** The main analyses utilised Birthrate Plus to determine required number of midwives accounting for the case mix/dependency. The relationship between achieving an unadjusted ratio of 1 midwife: 1 woman for all categories (as derived from Framework for Maternity Services in Scotland) and outcomes was only assessed for one outcome (having CEFM). The relationship between another set of requirements accounting for administrative tasks (derived from Towards Safer Childbirth) but not case mix (with midwife: woman requirement being 1.15 for normal and high dependency categories, and 0.25 midwives per woman for transfer and others) was not assessed. Case ascertainment for CEFM was judged complete based on the number of cases returned for the 4 week period as a proportion of per total annual

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	deliveries per unit.
Joyce et al. 2002	
Study details	Joyce R, Webb R and Peacock J. Predictors of obstetric intervention rates: case-mix, staffing levels and organisational factors of hospital of birth. Journal of Obstetrics and Gynaecology. 2002; 22 (6): 618-625. **Study aim** To determine if case mix, staffing levels, or organisational factors are associated with obstetric intervention rates **Study type** Correlational study **Source of funding** None reported **Time period/length of follow up** 1994-1996 **Country** UK (England) **Quality score** **Internal validity** + **External validity** ++ **Overall score** +
Population and setting	**Setting** All Thames region maternity units, all in hospitals (no midwife led units) **Stage of care** Not stated. Outcomes assessed were in the intrapartum period. **Number of hospitals/units** 64 hospital maternity units **Number of women/births** 540,834 births **Skill mix/type/duties of midwives** Not described **Key characteristics of hospitals/units assessed** Data are mean (SD; range)

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	Births in hospital/year: 2,877 (807.7; 872 to 4,214) Midwives/1000 deliveries/year: 29.6 (6.62, 18.3 to 47.0) Consultant O&G sessions on labour ward/week: 2.5 (1.86; 0 to 10) Number consultant O&G staff/1000 deliveries/year: 1.4 (0.63; 0.7 to 4.7) Number junior O&G staff/1000 deliveries/year: 4.3 (2.33; 0.5 to 18.3) Consultant anaesthetist sessions on labour ward/week: 4.1 (1.78; 1 to 10) Number of beds/ 1000 deliveries/year: 3.6 (0.80; 2.4 to 6.6) 92.5% had a dedicated maternity theatre NICU beds/1000 deliveries/year: 1.3 (1.13; 0 to 6.8) SBCU beds (including NICU)/1000 deliveries/year: 6.1 (2.10; 2.6 to 17.1) **Data sources** Four national data sources: Office of National Statistics (ONS) birth registrations; Manchester Information and Associated Services (MIMAS) Census data; Royal College of Obstetricians and Gynaecologists (RCOG) Hospital Recognition data returns; and the DH. Anonymised individual data were obtained for all live and stillbirths for all hospitals in North and South Thames for 1994–96.
Factors assessed	**Midwife staffing** Midwives /1000 deliveries/year **Other staffing factors** Number of consultant obstetric and gynaecological (O&G) staff and sessions on the labour ward, number of junior O&G staff **Maternal and neonatal factors** Births per year, instrumental vaginal delivery (IVD) rate, induction rate, epidural rate, mean birth weight, low birth weight (<1500g), % teenage mothers, % mothers >40 years, % nulliparous, % multiple births **Environmental factors** Deprivation of birth district (mean Townsend score), social class of fathers (manual or 'other'), delivery bed rate, neonatal intensive care unit (NICU) rate, special care baby unit (SCBU)+NICU rate (indicator of unit level), dedicated maternity theatre **Management factors** Not assessed **Organisational factors**

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	Not assessed **Control variables/adjustment** All factors described above were assessed as independent variables in the regression analysis, no additional factors controlled for
Comparison	Higher versus lower midwife staffing ratios (midwives:women) compared using regression
Outcomes and analysis	**Maternal/neonatal outcomes** IVD (included forceps or vacuum extraction), overall caesarean section (caesarean) rate, epidural rate for labour (not overall epidural rate as this included epidurals for caesareans) **Process of care outcomes** None **Reported feedback** None **Other outcomes** None **Analysis** Factors were all assessed in simple linear regression or t-test analyses as appropriate, followed by multivariate regression models
Results	**Maternal/neonatal outcomes** Mean caesarean rate 18.0 per 100 deliveries (SD 3.84; range 8.0 to 33.4) Mean IVD rate per 100 births 11.1 (SD 2.68; range 5.0 to 19.1) Mean labour epidural rate per 100 labour deliveries 20.3 (SD 10.53; range 2.6 to 55.5) In univariate linear regression analyses midwife staffing levels were not significantly associated with caesarean or IVD rates, but showed a significant inverse association with epidural rates: Caesarean: beta -0.117 (SE 0.086), R^2 0.038, p=0.181 IVD: beta -0.087 (SE 0.052), R^2 0.055, p=0.105 Epidural rate: beta -0.532 (SE 0.264), R^2 0.081, p=0.049 Various other factors were associated with these outcomes in univariate analysis. These were: <u>Interventional factors</u> *Associated with caesarean:* Epidural rate: beta 0.142 (SE 0.033), R^2 0.250, p<0.001 Epidural labour rate: beta 0.147 (SE 0.045), R^2 0.159, p=0.002 IVD rate: beta 0.407 (SE 0.180), R^2 0.081, p=0.028

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	Associated with IVD rates: Epidural rate: beta 0.155 (SE 0.016), R^2 0.610, p<0.001 Epidural labour rate: beta 0.195 (SE 0.022), R^2 0.574, p<0.001 Caesarean rate: beta 0.199, (SE 0.088), R^2 0.081, p=0.028 *Associated with epidural rates:* IVD rate: beta 3.942 (SE 0.418), R^2 0.610, p<0.001 Caesarean rate: beta 1.762 (SE 0.404), R^2 0.250, p<0.001 <u>Maternal factors</u> <u>*Associated with caesarean:*</u> Percentage mothers >40 years: beta 2.08 (SE 0.627), R^2 0.159, p=0.002 Percentage multiple births: beta 1.55 (SE 0.430), R^2 0.185, p=0.001 Percentage nulliparous: beta -0.32 (SE 0.148), R^2 0.076, p=0.033 *Associated with IVD rates:* Percentage mothers >40 years: beta 1.895 (SE 0.408), R^2 0.271 p<0.001 Percentage teenage mothers: beta -0.968 (SE 0.158) R^2 0.393, p<0.001 *Associated with epidural rates:* Percentage mothers >40: beta 12.87 (SE 1.737), R^2 0.490, p<0.001 Percentage teenage mothers: beta -4.66 (SE 0.828), R^2 0.357, p<0.001 <u>Neonatal factors</u> Low birth weight was associated with caesarean: Mean birthweight: beta -0.014 (SE 0.006), R^2 0.071, p=0.040 Births <1500g: beta 1.31 (SE 0.429), R^2 0.138, p=0.004 <u>Demographic factors</u> Mean Townsend score was not associated with any outcome: Caesarean rate: beta 0.337 (SE 0.211), R^2 0.042, p=0.116 IVD rate: beta -0.167 (SE 0.149), R^2 0.021, p=0.269 Epidural labour rate: beta 0.395 (SE 0.765), R^2 0.005, p=0.607 Father's professional class manual or 'other' was associated with IVD and epidural rates: Caesarean rate: beta -0.08 (SE 0.048), R^2 0.049, p=0.088 IVD rate: beta -0.193 (SE 0.024), R^2 0.539, p<0.001 Epidural labour rate: beta -0.96 (SE 0.120), R^2 0.530, p<0·001 <u>Unit structure</u> Units size was associated with caesarean: Delivery bed rate: beta 1.379 (SE 0.606), R^2 0.082, p=0.026 NICU rate: beta 1.073 (SE 0.424), R^2 0.100, p=0.014 SCBU +NICU rate: 0.542 (SE 0.229), R^2 0.088, p=0.022 Births per year was not associated: beta 0.0002 (SE 0.001), R^2 0.001, p=0.819 There were no significant associations between unit size and IVD and epidural rates. The presence of a dedicated maternity theatre was not associated with any outcomes:

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	Caesarean: t test for mean rate with a theatre 17.89 vs. 4.16 without (p=0.177) IVD rate: 10.90 with vs. 9.66 without (p=0.530) Epidural rate: 20.82 with vs. 11.16 (p=0.180) Other staffing factors: *Associated with caesarean:* Consultant O&G rate: beta 1.968 (SE 0.786), R^2 0.105, p=0.013 Junior O&G rate: beta 0.862 (SE 0.188), R^2 0.273, p<0.001 No significant associations with consultant O&G or consultant anaesthetic sessions on labour ward *Associated with epidural:* Consultant anaesthetic sessions labour: beta 2.013 (SE 0.993), R^2 0.067, p=0.047 Junior O&G rate: beta 1.539 (SE 0.765), R^2 0.069, p=0.049 No significant associations with consultant O&G rates or consultant O&G sessions on labour ward No significant associations between IVD rates and any staffing variable Midwife staffing was not one of the factors that remained associated in the final multivariate regression models for these outcomes. These were: Caesarean (beta, SE): labour epidural rate (0.126, 0.039), delivery bed rate (1.356, 0.504), and junior O&G rate (0.671, 0.178); R^2 0.435, p<0.001 IVD: labour epidural rate (0.123, 0.028), % manual or 'other' social class (-0.105, 0.029), R^2 0.644, p<0.001 Epidural rate: % manual or 'other' social class (-0.49, 0.094), % mothers 40+ years (6.30, 1.310); R^2 0.637, p<0.001
Notes/comments	**Author conclusions** "In contrast to recent media speculation, no association of caesarean section rates with midwifery staffing levels was found after adjustment for confounders. The only association with staffing was with levels of junior obstetric staffing, which could be a reflection of less experienced management of labour. Caesarean section rates were also associated positively with the levels of delivery beds, which could be a reflection of the closer monitoring of labour that may result from increased bed availability. Both caesarean section and instrumental vaginal delivery rates were associated with epidural rates, which was expected from the literature. Variations in epidural rates were mainly associated with variations in demographic case-mix, due possibly to patient demand. Demographic case-mix was also associated with instrumental vaginal deliveries but not the caesarean section rate". **Author limitations** Hospital level analysis was the only feasible approach, as RCTs would not

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	be ethical or feasible, and individual level observational studies would be confounded. Midwife numbers data was only available rounded to the nearest 10. **Review team limitations** The study design does not allow a temporal sequence of staffing levels and outcome to be established, limiting ability to draw conclusions about potential causal links. Not all hospitals provided all data, with RCOG data available for 95% of hospitals for at least one year (range 66% to 86% for each year assessed). Missing data may reduce accuracy of analyses. Multiple comparisons were carried out and it was unclear whether this had been taken into account (p value for significance was 0.05). The data being analysed was from 1994-1996 and may not be representative of current UK practice. A variety of factors were assessed for impact on outcomes, but relatively few maternal characteristics (parity [% nulliparity], age [% teenagers and % >40], and multiple births). **Other comments** Study was large and included a large number of hospitals, over a few years, with a range of clinical risk, case mix, and organisational variety.
The North Staffordshire Changing Childbirth Research Team (NSCCRT), 2000	
Study details	The North Staffordshire Changing Childbirth Research Team. A randomised study of midwifery caseload care and traditional 'shared-care'. Midwifery, 2000; 16:295-302. **Study aim** To compare caseload midwifery with traditional shared care on the level of "knowledge of carer at delivery" achieved and the effect that this has on maternal and neonatal health outcomes. **Study type** Cluster randomised controlled trial, with randomisation by geographic location (n=6). Randomisation was by one of the principal investigators, who was presented with 3 pairs of geographical location and randomised one of each to caseload care and the other to traditional shared care. The trial was not blinded, with both women and professionals aware of care group allocation.

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	Source of funding The North Staffordshire Health Authority **Time period/length of follow up** Data was collected up until the first 1500 deliveries, then for a further 6 months (dates not given) **Country** UK (North Staffordshire, England) **Quality score** **Internal validity** + **External validity** + **Overall score** +
Population and setting	**Setting** Primary care, 6 geographic regions, including an even mix of urban, rural, and mixed urban and rural areas, and their associated district general hospitals (not further described) **Stage of care** Not specified. Caseload midwives would be involved in all stages of care. Outcomes assessed were intrapartum and neonatal periods. **Number of hospitals/units** A total 35 GP practices in the 6 geographic regions. The number of hospital maternity units involved in care is not described. **Number of women/births** 1,505 women/deliveries (770 in caseload areas and 735 in shared care areas) 17 deliveries in the caseload areas, and 14 in the shared care areas, were in a “multiple and breech” category (total number of babies not reported) **Skill mix/type/duties of midwives** Caseload care 26 midwives (21 whole-time equivalent), including both senior (usually more than 5 years’ experience) and junior midwives (usually at least 2 years' experience) who were recruited from the community and from hospitals in North Staffordshire. Midwives were attached to 1-3 general practices and assigned 35-40 women at study start, for whom they provided the majority of care, in collaboration with medical colleagues. The number of midwives working in each of the 3 regions allocated to caseload care was 7, 9 and 10. Within these groups, midwives worked in groups of 2 or 3 to achieve high

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	continuity of care, with all antenatal sessions including the woman's "named midwife" and her partner midwife. Traditional shared care Number of midwives not reported. Nine midwives were reported as working in the shared care areas prior to the study. Three midwives withdrew before the study, but it was not clear which area they came from, and it not reported whether any additional midwives were recruited for the shared care areas. They continued to follow what was reported as the "current UK 'shared care' model", with a caseload of 100-150 women, with 10% of women expected to be delivered by her "named midwife". A project steering group negotiated the boundaries of care and assessed skill requirements in both groups of midwives at weekly meetings. An individualised skill enhancement programme was carried out at the start of the project to ensure confidence and competence of midwives in new roles. It was unclear whether this training was only offered to caseload midwives, although this is implied by the fact that the caseload approach was new and the comparator was the traditional approach to care. Each midwife kept a monthly audit sheet documenting continuity of care. **Key characteristics of hospitals/units assessed** 26 midwives in caseload care with a caseload of 35-40 women each 16 midwives in shared care with the shared care of 100-150 women each (no other information on primary or secondary care characteristics) **Key characteristics of participants assessed** Women in caseload areas (n=770): mean age 27.8; 32.4% primiparous; 22.8% current smokers; 63.8% married; 96.6% of white ethnicity; area of residence 38.4% rural, 27.3% urban, 34.3% mixed Women in shared care areas (n=735): mean age 27.7; 34% primiparous; 24.2% current smokers; 65.5% married; 96.8% of white ethnicity; area of residence 31.5% rural, 32.5% urban, 36% mixed No significant difference in maternal characteristics between groups **Data sources** Health outcome data for each individual woman was obtained from the hospital information system (CCL computer), supplemented by review of case records for missing data, or if there was intrauterine or neonatal death.
Intervention	Caseload care, with a caseload of 35-40 women per midwife
Comparator	Traditional shared care with a caseload of 100-150 women, the extent of overlap between midwives' caseloads or ratio of midwives to women was not reported.
Outcomes and analysis	**Maternal/neonatal outcomes** Normal vaginal delivery rate (primary outcome) – not formally defined, but

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	appeared to exclude instrumental vaginal delivery, emergency and elective caesarean section, and multiple and breech delivery (not further defined) as these were the alternative mode of delivery outcomes that were analysed together and if summed to give 100% of deliveries Perineal outcome (intact, episiotomy, laceration or tear), use of oxytocin (syntocinon) augmentation, epidural analgesia, induction of labour, duration of labour, duration of gestation (all secondary) Neonatal death, advanced neonatal resuscitation, admission to neonatal unit, birth weight <2.5 kg (all secondary) **Process of care outcomes** Attendance in labour by a known midwife or midwifery partner (primary outcome), as completed on the "results sheet" by delivering midwife. **Reported feedback outcomes** None **Other outcomes** None **Analysis** Categorical outcomes were analysed using chi squared tests with "correction where necessary" (not defined). Results were not adjusted for clustering because intra-class correlation coefficient (ICC) calculated for the outcome of normal delivery did not indicate clustering (ICC -0.0034). Only women completing the study were included (1% migration assumed). The data was combined for the areas allocated to each intervention (caseload care and shared care); separate analyses by area were reported to give similar results but were not shown.
Results	**Maternal/neonatal outcomes** *Modes of delivery:* no significant differences (p=0.15; note p value is for chi squared test across all modes of delivery) Normal vaginal delivery rate: caseload 70% (542/770) vs. and shared care 69% (509/735) Instrumental (ventouse/forceps): 10% (74/770) vs. 11.5% (84/735) Emergency caesarean: 8% (62/770) vs. 10.5% (76/735) Elective caesarean: 10% (75/770) vs. 7% (52/735) Multiple & breech delivery: 2% (17/770) vs. 2% (14/735) Duration of labour: (p=0.001; note p value is for chi squared test across all duration of labour) Less than 8 hours: caseload 58.5% (451/770) vs. and shared care 68.4% (503/735) 8 to 12 hours: caseload 36.35% (280/770) vs. and shared care 27% (198/735) More than 12 hours: caseload 5.2% (39/770) vs. and shared care 4.6% (34/735)

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	Epidural analgesia: significantly less common with caseload (10.4%; 80/770) than shared care (15%; 110/735) (p=0.01) Induction of labour: no significant difference between caseload (17.4%; 134/770) and shared care (18%; 133/735) (p=0.78) Syntocinon augmentation of labour: significantly less common with caseload (46%; 351/770) than shared care (53%; 387/735) (p=0.01) Intact perineum: no significant difference between caseload (48%; 370/770) and shared care (49%; 361/735) (p=0.72) Perineal laceration: no significant difference between caseload (24.6%; 197/770) and shared care (24.5%; 180/735) (p=0.67) Perineal tear: no significant difference between caseload (32.2%; 248/770) and shared care (30%; 221/735) (p=0.40) Episiotomy: no significant difference between caseload (23.5%; 181/770) and shared care (24%; 175/735) (p=0.94) Gestation length: no significant difference (p=0.16; note p value is for chi squared test across all gestations) <24 weeks: caseload 0.6% (5/770) vs. shared care 0.5% (4/735) 24 to 34weeks: 3.2% (25/770) vs. 3.2 (24/735) 34 to 40 weeks: 72.2% (557/770) vs. 69% (506/735) >40weeks: 24% (183/770) vs. 27.3% (201/735) No significant difference for any neonatal outcomes: Stillbirth and neonatal death: caseload 0.7% (6/770) vs. shared care 1.5% (11/735) (p=0.28) Advanced resuscitation: caseload 1.2% (10/770) vs. shared care 0.8% (6/735) (p=0.51) Neonatal unit admission: caseload 5.8% (45/770) vs. shared care 4.6% (34/735) (p=0.34) Birthweight <2.5kg: caseload 6.7% (52/770) vs. shared care 6.9% (51/735) (p=0.96) **Process of care outcomes** Attendance in labour by a known midwife or midwifery partner: significantly more common with caseload care (94.7%; 696/770) than with shared care (6.7%; 52/735) (p<0.001)
Notes/comments	**Author conclusions** “Caseload midwifery results in high levels of ‘known carer at delivery’ which appears to be associated with a reduction in augmentation and epidural rates but which were not associated with an increase in normal vaginal delivery rate.” **Author limitations**

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	The small number of only 6 areas randomised. An RCT where the unit of randomisation was the individual mother or GP was not possible due to the logistics of running caseload and shared care simultaneously in the same place. Insufficient power to reliably detect differences in neonatal outcomes Focus on delivery outcomes only (though maternal and professional feedback, and economic evaluation were to be reported separately) **Review team limitations** This RCT is primarily an assessment of continuity of care and whether caseload care improves the proportion of women who are attended in labour by a midwife who is known to them, and whether this improves other intrapartum outcomes compared to shared care, rather than an assessment of the impact of different staffing levels. The caseload midwives had care of 35 to 40 women (with care of any individual woman shared between only 2-3 midwives), compared to the shared care midwives who were involved in the shared care of 100 to 150 women (where women have less continuity of midwives involved in their care). While the division of care among the team of midwives differs, whether the staffing level (i.e. overall ratio of midwives: women) in each group differed was not reported. If staffing levels did differ between the groups, any effect of this could be confounded by the effect of the differences in division of care between midwives. The paper was published in 2000 and therefore the RCT would have been carried out prior to this. Therefore the study may not be representative of current UK practice.

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