Safe Midwife Staffing for Maternity Settings

Evidence Review 3 – Economic evidence review

Jasdeep Hayre
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**Economic evidence review**

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1.1.1 Overview

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

A scope was developed which defines what the guideline will and will not consider. It also outlines the 7 review questions that will be addressed to inform the development of the guideline.

This report is one of a series of evidence reviews that cover the review questions outlined in the scope. This report systematically reviews the economic evidence for all the questions outlined in the scope.

1.1.2 Acknowledgements and disclaimer

We thank Sandall J, Murrells T, Dodwell M, Gibson R, Bewley S, Coxon K et al. (2014) for early use of the report “The efficient use of the maternity workforce and the implications for safety & quality in maternity care. Health Service and Delivery Research 2014”

The Sandall et al project was funded by the Health Service and Delivery Research Programme (10/1011/94) and will be published in full in the Health Service and Delivery Research journal. Further information available at:
http://www.nets.nihr.ac.uk/projects/hsdr/10101194

This evidence review was quality assured by Sarah Richards – Technical Analyst (economics) at NICE.
1.2 Introduction

Determining midwife staffing requirements can be challenging. This is because the number and skill mix of midwives required to provide care to women and neonates is influenced by a multitude of factors. These can include: the number of women and neonates requiring care, the type of care needed, and the amount of time taken to provide the required care; the knowledge and experience of the midwife as well as many other factors. The challenge facing providers of midwifery care is ensuring that the right staff, with the right skill mix is available in the right place and at the right time.

There are different options of organising and planning midwife staffing levels or skill mix. Therefore, choosing an option will result in an ‘opportunity cost’ of a change to the number and skill mix of midwives required to provide care in maternity settings. This ‘opportunity cost’ is the cost and effects of any alternative foregone, that is, the benefits and costs that could have been achieved by choosing a different option.

This review aims to identify primary economic studies which examine different options in terms of their expected net benefits (health and non-health) and their expected costs – their ‘cost-effectiveness’. This review does not examine non-comparative costs of an option, or the cost-impact of interventions; as outlined in the NICE’s ‘Principles for the development of NICE guidance’ – Social Value Judgements.

1.3 Review questions

The aim of this report is to systematically review the economic evidence addressing the following review questions:

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

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

3. What environmental factors affect safe midwife staffing requirements? These include:
   a. Local geography and demography
   b. Birth settings and unit size and physical layout

4. What staffing factors affect safe midwife staffing requirements at a local level? These include:
   a. Midwifery skill mix
   b. Availability of and care provided by other healthcare staff (e.g. maternity support workers, obstetricians, anaesthetists, paediatricians and specialist midwives)
   c. Division of tasks between midwives and maternity support workers
   d. Requirements to provide additional services (e.g. high dependency care, public health roles, vaccinations)
5. What local level management factors affect safe midwife staffing requirements? These include:
   a. Maternity team management and administration approaches (e.g. shift patterns)
   b. Models of midwifery care (e.g. caselodging/named midwife/social enterprises)
   c. Staff and student supervision and the supernumerary arrangements

6. What organisational factors influence safe midwife staffing at a local level? These include:
   a. Management structures and approaches
   b. Organisational culture
   c. Organisational policies and procedures, including staff training

7. What approaches for identifying midwife staffing requirements and skill mix at a local level, including tool kits, are effective and how frequently should they be used?
   a. What evidence is available on the reliability and/or validity of any identified toolkits?

1.4 Methods

1.4.1 Overview

This systematic review was conducted in accordance with the draft ‘Developing NICE guidelines - the manual’ (Consultation in 2014).

The main process of the systematic review for the economic evidence is:

- Databases searched using a search strategy (Appendix A)
- Identifying potentially relevant primary economic studies by reviewing titles and abstract using the pre-specified inclusion and exclusion criteria outlined in the protocol (Appendix B). Retrieving full text papers for all references assessed to be potentially relevant.
- Appraising full text papers against the pre-specified inclusion and exclusion criteria outlined in the protocol (Appendix C)
- Critical appraisal of economic evidence table using appropriate checklist as specified in ‘Developing NICE guidelines - the manual’.
- Extracting study methods and results into evidence tables (Appendix D).
- Summarise the evidence into Economic evidence profiles and generate evidence statements.

1.4.2 Search strategy

A search strategy and review protocol were developed to identify primary economic studies comparing the use of a particular approach to another approach, or maximise outcomes in relation to resources related to the number of midwife staffing and skill mix (see Appendix A and B). Databases searched include Medline, Medline in-process, Health Management Information Consortium, Cumulative Index to Nursing and Allied Health using an economic filter. Separate searches were carried out on the NHS Economic Evaluations Database, Econlit, Health Economic Evaluations Database, Tufts Cost Effectiveness Analysis Registry.

A date restriction was imposed on all the systematic reviews that were conducted for the midwife staffing guideline, including this review, as it was deemed inappropriate to include all
evidence. This is because midwifery practices have advanced over the years, making older studies of limited relevance to midwifery practice today. A cut-off date of 1998 was chosen following advice from a topic expert, and studies published before this date or which used data from before this date were excluded. Studies published after June 2014 was not considered in this review.

For more information on the search strategy, see Appendix A.

The systematic search identified 621 references. An additional 16 references were identified through screening the searches for other review questions included in the related evidence reviews.

1.4.3 Inclusion and exclusion criteria

The inclusion and exclusion criteria are specified in the protocol, see Appendix B. The protocol mirrors the inclusion and exclusion criteria used for the other evidence reviews produced for this guideline.

All common types of economic study design were considered. The ‘Developing NICE guidelines - the manual’ outlines a preference for cost-utility analysis. This systematic review considered a wider range of types of analysis and included cost utility analysis, cost consequences analysis, cost effectiveness analysis, cost benefit analysis, cost minimisation analysis and any cost-comparative analysis which were specific to midwife staffing numbers or skill-mix. Any intervention which considered midwife staffing levels or skill mix was included.

English language studies are included, all non-English language were excluded due to a lack of capacity to translate into English. All midwife staffing in non-maternity settings or obstetric settings were excluded as these were outside of the scope of the guideline. All studies from non-OECD countries were excluded due to limited applicability to the UK NHS.

All 637 titles and abstracts identified from the search strategy were independently assessed by two reviewers. All abstracts considered to potentially meet the inclusion and exclusion criteria by either reviewer were obtained in full.

90 full-texts of studies were assessed by one reviewer using the pre-defined inclusion and exclusion criteria in Appendix B. A second reviewer assessed full-texts when the first reviewer could not make a clear decision on inclusion. One study (Allen and Thronton, 2013) was identified that met the criteria for inclusion in this evidence review. One additional unpublished study (at time of the search) (Sandall et al, 2014) was identified and assessed as relevant to the evidence review.

A total of 89 references were excluded. Most studies (n=40) were not economic evaluations and did not contained economic or cost outcomes. Many studies (n=37) contained economic outcomes in the study but the study was not specific to midwife staffing numbers or skill mix, or did not have midwife staffing numbers (non-segregated), ratio or hours as outcomes. Three references were for systematic reviews which included economic studies or outcomes. The reviews were excluded; however, reference details of the included primary studies were cross-checked with the database search to identify any further primary studies. The midwifery caseload (i.e. number of mothers or babies) was unknown in 3 economic studies and so were excluded. An economic study (n=1) was excluded because it investigated service delivery changes of maternity services as a whole and did not investigate staffing numbers or skill mix separately. Some studies (n=2) contained economic outcomes in the study but were excluded because it investigated non-OECD maternity services. A small number of studies (n=3) could not be obtained through British Library or Internet sources and thus excluded due to non-retrieval. A full list of excluded studies and reasons for exclusion is provided in appendix D.
Figure one presents a summary of the search and selection process flow.

Figure 1: Review flow chart

1.4.4 Critical appraisal and quality assessment

The two included studies were critically appraised using the appropriate checklist for the study type as outlined in the draft ‘Developing NICE guidelines - the manual’. On completion of the checklist, two overall ratings are given for the economic study ‘applicability’ and ‘limitations’. The ‘applicability’ criteria give an overall rating of the economic studies applicability to the NICE reference case (the perspective taken in this review is ‘health outcomes in NHS settings’). A study can be given one of three possible ratings:

- Directly applicable – the study meets all applicability criteria, or fails to meet 1 or more applicability criteria but this is unlikely to change the conclusions about cost effectiveness.
• Partially applicable – the study fails to meet 1 or more of the applicability criteria, and this would change the conclusions about cost effectiveness.

• Not applicable – the study fails to meet 1 or more of the applicability criteria, and this is likely to change the conclusions about cost effectiveness. Such studies would usually be excluded from further consideration and there is no need to continue with the rest of the checklist.

The ‘limitations’ criteria outlines the methodological quality of the study. A study can be given one of three possible ratings:

• The Minor limitations – the study meets all quality criteria, or fails to meet 1 or more quality criteria but this is unlikely to change the conclusions about cost effectiveness.

• Potentially serious limitations – the study fails to meet 1 or more quality criteria, and this could change the conclusions about cost effectiveness.

• Very serious limitations – the study fails to meet 1 or more quality criteria, and this is highly likely to change the conclusions about cost effectiveness. Such studies should usually be excluded from further consideration.

1.4.5 Economic evidence profile

The two included studies are summarised in an economic evidence profile. The profile summarises the key finding from many studies into one table. It includes information on the incremental benefits (both health and non-health) and incremental costs of an option compared to another option, and the cost-effectiveness estimate (incremental cost-effectiveness ratio, or net benefit) of an option compared to another. It also gives an overview of the applicability and limitations of each economic study (with reasons). The economic evidence profile will describe any information on the certainty (or uncertainty) of the results.

1.4.6 Evidence statements

Evidence statements are brief summary statements which outline key findings from the economic evidence review. The evidence statement includes the number of studies identified, the overall quality of the economic evidence (the applicability and limitations of the study) and the direction and certainty of the results.
1.5 Results

Two studies were included in the evidence review:

1.5.1 Allen and Thornton (2013)

This study used a simulation model based on 6,000 deliveries per annum from a single English hospital maternity unit. The model compared calculation using birth rate plus (BR+) to simulated scenarios. The main outcome used in the study was the occurrence of overload: the number of women or the BR+ Workload Index exceeds the scheduled midwife availability to deliver one to one care. Further background information on this study is presented in the Evidence Review 2 ‘Decision support approaches and toolkits for identifying midwife staffing requirements’.

The study was rated as ‘partially applicable’ as it used scenario modelling which may not be an appropriate realistic comparator. In addition, it did not follow any of the possible NICE reference cases outlined in the draft ‘Developing NICE guidelines - the manual’. The study was considered to have ‘very serious limitations’ for multiple reasons. The study did not describe the simulation model in detail, the cost perspective, resource estimates, unit cost estimates and sources were not stated. The study also used evidence for one ward in England and may not be generalisable to other wards. The analysis was not a fully incremental analysis and no sensitivity analysis was undertaken to investigate uncertainty.

The results of the study limitations suggested a 25% reduction in midwifery overload (the number of women exceed the scheduled workload) could be achieved with a 4% increase in budget and a lower 15% reduction in midwifery overload (the number of women exceed the scheduled workload) could be achieved by reducing staffing on Saturday night and all of Sunday and reapplied at peak weekday times with no increase in cost.

The economic profile is presented below, and the evidence table is available in Appendix D.

1.5.2 Sandall et al (2014)

The study was a large correlation study on 143 NHS trusts in England on 665,969 births using Health Episode Statistic (HES) data from 2010/11. Two approaches were used to examine economic consequences, a costing analysis (using Reference Cost and Electronic Staff Records 2010, and economic modelling analysis (a production function analysis). The study examined changes to inputs such full time equivalent (FTE) of midwives, Support Staff, Doctors and Consultants and examined outputs in terms of total annual deliveries per trust, and total cost-weighted annual deliveries (weighted by relative cost, to take into account differences in cost between vaginal and caesarean deliveries)

The study was rated as ‘partially applicable’ because it did not follow any of the possible NICE reference cases outlined in the draft ‘Developing NICE guidelines - the manual’. In addition, the analyses were at trust and not ward level. The study was considered to have potentially serious limitations because it was unclear if all relevant long term costs and consequences were considered (i.e. long term implications of mother and baby safety concerns). The analysis was not a fully incremental analysis. The time spent between roles in obstetric versus gynaecology could not be separated, and there was no consideration of bank and agency staff. Multicolinearity (a strong correlation between explanatory variables used in the model) between many variables was identified. Endogeneity (the error term and the explanatory variables are correlated) was also a potential concern. The combination of
both multicolinearity and endogeneity could result in potentially biased results, or incorrectly accepting or rejecting a null hypothesis.

The costing analysis showed higher midwife staffing levels were associated with higher costs of each delivery taking account of trust size, risk, parity, age and IMD\(^a\). However, only 17% of the variability in delivery costs could be accounted for by the model specification.

The production function analysis showed that an additional midwife would increase the number of deliveries possible in a trust between 18 and 94 deliveries in a year. The study also showed that midwives and other doctors are complements (should be used together) and midwives are consultants are complements. However, it was unclear if midwives and support staff might be complements or substitutes (can replace each other).

The economic profile is presented below, and the evidence table is available in Appendix D.

\(^a\) Index of Multiple Deprivation (IMD)
### 1.5.3 Economic profiles

<table>
<thead>
<tr>
<th>Study</th>
<th>Limitations</th>
<th>Applicability</th>
<th>Other comments</th>
<th>Incremental Costs</th>
<th>Effects Costs</th>
<th>Cost-effectiveness</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen and Thornton 2013</td>
<td>Very serious limitations&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Partially applicable&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Occurrence of workload (the number of women or the BR+ Workload Index exceeds the scheduled midwife availability)</td>
<td>Scenario 1: 4% increase in budget</td>
<td>Scenario 1: 25% reduction in occurrence of overload</td>
<td>NA&lt;sup&gt;c&lt;/sup&gt;</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Compared Birth Rate plus (BR+) to Simulated data</td>
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<td>Scenario 2: 0% increase in budget</td>
<td>Scenario 2: 15% reduction in occurrence of overload</td>
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<td></td>
<td>Scenario 1: Additional resource</td>
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<td></td>
<td>Scenario 2: Reduced staffing on Saturday night and all of Sunday and re-applied at peak load during weekdays.</td>
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</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Limitations</th>
<th>Applicability</th>
<th>Other comments</th>
<th>Cost-effectiveness</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandall et al 2014</td>
<td>Potentially serious limitations&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Partially applicable&lt;sup&gt;e&lt;/sup&gt;</td>
<td>142 NHS trust, Health Episode Statistics (HES) data from 2011/11</td>
<td>Costing analysis: Higher midwife staffing levels associated with higher costs of each delivery (relationship not strong)</td>
<td>Costing analysis: Relationship strengthened when antenatal expenditure included as an explanatory variable</td>
</tr>
<tr>
<td>Costing Analysis</td>
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<tr>
<td>Econometric analysis</td>
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</table>

<sup>a</sup> Simulation model structure was not clearly defined. There was an unclear cost perspective: resource use, unit costs and sources of unit costs were not specified. Use of one ward in the UK may not be generalisable other wards. No fully incremental analysis undertaken. No sensitivity analyses undertaken to investigate uncertainty.

<sup>b</sup> Investigated birth rate plus compared to a computer simulation model: unclear if comparator is realistic or appropriate. Does not reflect any NICE reference case.

<sup>c</sup> Cannot be calculated

<sup>d</sup> No NICE reference case was followed; a QALY approach was not taken. Trust level perspective taken and not ward level.

<sup>e</sup> Unclear if all relevant long terms costs and consequences were considered (i.e. long term implications of mother and baby safety concerns). Not a fully incremental analysis. No account of time spent between roles in obstetric versus gynaecology, no consideration of bank and agency staff. Multicollinearity between variables. Potential endogeneity between variables and error term.
## Study Limitations Applicability Other comments Cost-effectiveness Uncertainty

<table>
<thead>
<tr>
<th>Study</th>
<th>Limitations</th>
<th>Applicability</th>
<th>Other comments</th>
<th>Cost-effectiveness</th>
<th>Uncertainty</th>
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<tbody>
<tr>
<td>(production function)</td>
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<td>Comparing the following:</td>
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<td>Midwives (FTE)</td>
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<td>Support Staff (FTE)</td>
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<td>Doctors (FTE)</td>
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<td>Consultants (FTE)</td>
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<tr>
<td>NHS Workforce statistics 2010/11</td>
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<td>17% of variation between trust' delivery costs are accounted for in model, rising to 23% when antenatal expenditure is included.</td>
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<tr>
<td>CQC Maternity Survey of Maternity Provider Trusts 2007 and 2010</td>
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<td>ONS Birth Registrations 2000/01 – 2010/11</td>
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<td>BirthChoiceUK database</td>
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<td>Reference cost data – NHS reference costs 2010/11</td>
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<td>Population</td>
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<td>Total of 665,969 delivery babies</td>
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<td>Econometric analysis</td>
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<td>Econometric analysis</td>
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<td>Marginal productivity (change in output that results in the change of 1 unit of input. Keeping all other inputs constant)</td>
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<td></td>
<td>Adjusted $R^2$ (total deliveries) = 0.885</td>
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<td>Total deliveries (standard errors):</td>
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<td></td>
<td>Adjusted $R^2$ (cost weighted deliveries) = 0.878</td>
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<tr>
<td>1 additional midwife is associated with +17.93 deliveries</td>
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<td></td>
<td>Model suffers from multicollinearity – investigated by Variance Inflation Factor (VIF) which was high for multiple variables.</td>
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<tr>
<td>1 additional support staff is associated with +10.47 deliveries</td>
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<td>1 additional consultant is associated with 32.31 deliveries</td>
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<td>1 additional other doctor is associated with 42.81 deliveries</td>
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<td>Cost weighted deliveries(^a)</td>
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<tr>
<td>1 additional midwife is associated with +93.85 deliveries</td>
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<tr>
<td>1 additional support staff is associated with +50.15 deliveries</td>
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<td>1 additional consultant is associated with +58.72 deliveries</td>
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<td>1 additional other doctor is associated with +51.01 deliveries</td>
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<td>Hicks elasticity of substitution: ((degree to which two inputs can be substituted for one another))</td>
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<tr>
<td>Total deliveries:</td>
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<tr>
<td>If the number of support staff increased by 1% change in the number of midwives needed would be -0.03% (substitutes)</td>
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<tr>
<td>If the number of consultants increased y by 1%, change in the number of midwives needed would be 0.30% (complements)</td>
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</tbody>
</table>

\(^a\) Weighted by relative cost, to take into account differences in cost between vaginal and caesarean deliveries
<table>
<thead>
<tr>
<th>Study</th>
<th>Limitations</th>
<th>Applicability</th>
<th>Other comments</th>
<th>Cost-effectiveness</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>If the numbers of other doctors required rose by 1%, change in the number of midwives needed would be 0.70% (complements)</td>
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<td></td>
<td>Cost-weighted deliveries:</td>
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<td></td>
<td>If the number of support staff increased by 1%, change in the number of midwives needed would be 0.05% (complements)</td>
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<td>If number of consultants increased by 1%, change in the number of midwives needed would be 0.14% (complements)</td>
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<td></td>
<td></td>
<td>If numbers of other doctors increased by 1%, change in the number of midwives needed would be 0.97% (complements)</td>
<td></td>
</tr>
</tbody>
</table>
1.5.4 Evidence statements

One partially applicable study (Allen and Thornton, 2013) with very serious limitations suggested a 25% reduction in midwifery overload (the number of women exceed the scheduled workload) could be achieved with a 4% increase in budget. A 15% reduction in midwifery overload could be achieved by reducing staffing on Saturday night and all of Sunday and reapplied at peak weekday times with no increase in costs.

One partially applicable study with potentially serious limitations (Sandall et al, 2014) showed higher midwife staffing levels were associated with higher costs of each delivery. An additional midwife would increase the number of deliveries possible in a trust between 18 and 94 deliveries in a year. The study also showed that midwives and other doctors are complements (should be used together) and midwives are consultants are complements. However, it was unclear if midwives and support staff might be complements or substitutes (can replace each other).
2 Gaps in the evidence

This evidence review identified important evidence reviews. There is limited economic evidence examining the impact of midwife staffing levels (the number of women to each midwife) in different models of care at different stages for the care pathway. Limited high quality evidence related to outcomes and midwife staffing levels may also limit the extent to which economic evidence is available in the future.

Further research could include:

- A cost utility analysis examining the impact of different midwife staffing levels at the antenatal, intrapartum and postnatal care stages in different models of care settings (such as alongside midwifery units, or midwifery led units, home birth).

- A cost utility analysis examining the use of different support approached and toolkits (such as birth-rate plus) compared to each other and professional judgement for identifying midwife staffing requirements.
3 References


4 Appendices

4.1 Appendix A Search strategy

This appendix outlines the searches carried out for this review, in order to inform NICE’s safe staffing guidance for midwife staffing services. It should be read in conjunction with the protocol for this review, and with the appendices for the associated reviews.

The Medline; Medline in-process; Embase; HMIC and CINAHL searches for the economics review are sub-sets of those carried out for the associated reviews (henceforth the base searches). In each instance, only the search terms used to identify the economics sub-set have been given below. The final line of each of these search strings was combined with the final line of the respective base searches using the Boolean operator, ‘AND’.

References which were identified during each of the three midwife staffing reviews were shared with the other (midwife staffing) review groups if they were thought to be relevant to other review questions. No additional citation searching or website searching was carried out specifically for this review.

4.1.1 Database search strategies

4.1.2 Medline and Medline in-process

Platform: Ovid
Search date: As for base searches.

1 Economics/ or exp "Costs and Cost Analysis"/ or Economics, Dental/ or exp Economics, Hospital/ or exp Economics, Medical/ or Economics, Nursing/ or Economics, Pharmaceutical/ or Budgets/ or exp Models, Economic/ or Markov Chains/ or Monte Carlo Method/ or Decision Trees/

2 (Economic* or cost or costs or costly or costing or costed or price or prices or pricing or pharmacoeconomic* or pharmaco economic* or budget*).ti.

3 ((monte adj carlo) or markov or (decision adj2 (tree$ or analys$))).ti,ab.

4 Quality of Life/ or Health Status Indicators/ or Quality-Adjusted Life Years/ or Value of Life/

5 (quality of life or quality adjusted life or qaly* or qald* or qale* or qtime* or quality of wellbeing or quality of well-being or willingness to pay or standard gamble* or time trade off* or time tradeoff*).ti.

6 (disability adjusted life or daly).ti.

7 (value adj2 (money or monetary)).ti.

8 health* year* equivalent*.ti.

9 (sf36 or sf 36 or short form 36 or short form 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).ti.

10 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sf six or shortform six or short form six).ti.

11 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sf twelve or shortform twelve or short form twelve).ti.
(sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).ti.
(sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sft twenty or shortform twenty or short form twenty).ti.
(euroqol or euro qol or eq5d or eq 5d).ti.
Computer Simulation/
simulation*.ti.
(dynamic adj model*).ti.
Operations Research/
"operation* research".ti.
(efficiency adj3 maximi*).ti.
stochastic.ti.
(efficiency adj3 maximi*).ti.
stochastic.ti.
Stochastic Processes/
data envelopment.ti.
Efficiency, Organizational/
or/1-26
(((energy or oxygen) adj cost*) or (metabolic adj cost*) or ((energy or oxygen) adj expenditure*)).ti,ab.
27 not 28
4.1.3  **Embase**  
Platform: Ovid  
Search date: As for base searches.

The Embase search for the economics review was derived by combing the last line of the search string below with each of the base searches using the Boolean ‘AND’ operator.

1. Computer Simulation/
2. simulation*.ti.
3. exp mathematical model/
4. system analysis/
5. (dynamic adj model*).ti.
6. system analysis/
7. "operation* research".ti.
8. (efficiency adj3 maximi*).ti.
9. stochastic.ti.
10. (efficiency adj3 maximi*).ti.
11. stochastic.ti.
12. data envelopment.ti.
13. organizational efficiency/
14. economic evaluation/ or economics/
15. *health-economics/ or exp *economic-evaluation/ or exp *health-care-cost/ or *pharmacoeconomics/ or *Monte Carlo Method/ or *Decision Tree/
16. (Economic* or cost or costs or costly or costing or costed or price or prices or pricing or pharmacoeconomic* or pharmac economic* or budget*).ti.
17. ((monte adj carlo) or markov or (decision adj2 (tree$ or analys$))).ti.
18. (value adj2 (money or monetary)).ti.
19. *Quality of Life/ or *Quality Adjusted Life Year/ or *Quality of Life Index/ or *Short Form 36/ or *Health Status/
20. (quality of life or quality adjusted life or qaly* or qald* or qale* or qtime* or quality of wellbeing or quality of well-being or willingness to pay or standard gamble* or time trade off* or time tradeoff*).ti.
22. Health* year* equivalent*.ti.
23. (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six or sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six or sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve or sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen or sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty or euroqol or euro qol or eq5d or eq 5d).ti.
24. or/1-23

4.1.4  **Health Management Information Consortium**  
Platform: Ovid
Search date: As for base searches.

The HMIC search for the economics review was derived by combing the last line of the search string below with each of the base searches using the Boolean ‘AND’ operator.

1. exp health economics/ or exp costs/ or cost effectiveness/ or exp economic analysis/ or economic models/ or exp models/ or quality adjusted life years/ or quality of life/ or exp health indicators/ or exp operational research/ or exp efficiency/
2. (Economic* or cost or costs or costly or costing or costed or price or prices or pricing or pharmacoeconomic* or pharmaco economic* or budget*).ti.
3. ((monte adj carlo) or markov or (decision adj2 (tree$ or analys$))).ti,ab.
4. (quality of life or quality adjusted life or qaly* or qald* or qale* or qtime* or quality of wellbeing or quality of well-being or willingness to pay or standard gamble* or time trade off* or time tradeoff*).ti.
5. (disability adjusted life or daly).ti.
6. (value adj2 (money or monetary)).ti.
7. health* year* equivalent*.ti.
8. (sf36 or sf 36 or short form 36 or short form thirty six or short form thirtysix or short form thirty six or short form thirty six or short form thirtysix).ti.
9. (sf6 or sf 6 or short form 6 or short form six or sfsix or short form six).ti.
10. (sf12 or sf 12 or short form 12 or short form twelve or sftwelve or short form twelve).ti.
11. (sf16 or sf 16 or short form 16 or short form sixteen or sfsixteen or short form sixteen).ti.
12. (sf20 or sf 20 or short form 20 or short form twenty or sftwenty or short form twenty).ti.
13. (euroqol or euro qol or eq5d or eq 5d).ti.
15. (dynamic adj model*).ti.
16. "operation* research".ti.
17. (efficiency adj3 maximi*).ti.
18. stochastic.ti.
19. (efficiency adj3 maximi*).ti.
20. stochastic.ti.
21. data envelopment.ti.
22. or/1-21
23. (((energy or oxygen) adj cost*) or (metabolic adj cost*) or ((energy or oxygen) adj expenditure*)).ti,ab.
24. 22 not 23
4.1.5 Cumulative Index to Nursing and Allied Health (CINAHL)
Platform: Ovid
Search date: As for base searches.

<table>
<thead>
<tr>
<th>#</th>
<th>Query</th>
<th>Limiters/Expanders</th>
</tr>
</thead>
<tbody>
<tr>
<td>S24</td>
<td>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 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S23</td>
<td>TI (data AND envelopment)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S22</td>
<td>TI stochastic</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S21</td>
<td>TI (efficiency N3 maximi*)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S20</td>
<td>TI &quot;operation* research&quot;</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S19</td>
<td>TI (dynamic N1 model*)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S18</td>
<td>TI simulation*</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S17</td>
<td>TI (euroqol OR euro AND qol OR eq5d OR eq AND 5d)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S16</td>
<td>TI (sf20 OR sf AND 20 OR short AND form AND 20 OR shortform AND 20 OR shortform AND twenty OR sftwenty OR shortform AND twenty)</td>
<td>Search modes - Boolean/Phrase</td>
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<tr>
<td>S15</td>
<td>TI (sf16 OR sf AND 16 OR short AND form AND 16 OR shortform AND 16 OR shortform AND sixteen OR sfsixteen OR shortform AND sixteen OR short AND form AND sixteen)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S14</td>
<td>TI (sf12 OR sf AND 12 OR short AND form AND 12 OR shortform AND 12 OR shortform AND twelve OR sftwelve OR shortform AND twelve OR short AND form AND twelve)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S13</td>
<td>TI (sf6 OR sf AND 6 OR short AND form AND 6 OR shortform AND 6 OR shortform AND six OR sfsix OR shortform AND six OR short AND form AND six)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S12</td>
<td>TI (sf36 OR (sf AND 36) OR (short AND form AND 36) OR shortform AND 36 OR (sf AND thirty AND six) OR (shortform AND thirtysix) OR (shortform AND thirty AND six))</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>Search Id</td>
<td>Search Term</td>
<td>Search Mode</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>S11</td>
<td>TI (health* AND year* AND equivalent*)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S10</td>
<td>(value N2 (money OR monetary))</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S9</td>
<td>TI (disability adjusted life OR daly)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S8</td>
<td>TI ((quality of life OR quality adjusted life OR qaly* OR qald* OR qale* OR qtime* OR quality of wellbeing OR quality of well-being OR willingness to pay OR standard gamble* OR time trade off* OR time tradeoff*))</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S7</td>
<td>TI (((monte ADJ carlo) OR markov OR (decision N2 (tree* OR analys*))))</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S6</td>
<td>TI (Economic* OR cost OR costs OR costly OR costing OR costed OR price OR prices OR pricing OR pharmacoeconomic* OR (pharmaco AND economic*) OR budget*)</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S5</td>
<td>MH &quot;ORGANIZATIONAL EFFICIENCY+&quot;</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S4</td>
<td>MH &quot;QUALITY-ADJUSTED LIFE YEARS&quot;</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S3</td>
<td>MH BUDGETS</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S2</td>
<td>MH &quot;DECISION TREES&quot;</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
<tr>
<td>S1</td>
<td>MH &quot;ECONOMICS+&quot;</td>
<td>Search modes - Boolean/Phrase</td>
</tr>
</tbody>
</table>

### 4.1.6 NHS Economic Evaluations Database

Platform: Wiley  
Search date: 13/6/2014

Strategies and search dates: see Cochrane database strategies for “influences and outcomes” and “toolkits” reviews.

### 4.1.7 Econlit

Platform: Ovid  
Search date: 20/6/2014
See Medline database strategies for “influences and outcomes” and “toolkits” reviews. No additional filters applied.

Note that thesaurus terms are not recognised in Econlit on the Ovid platform.

4.1.8 Health Economic Evaluations Database (HEED)
Platform: Wiley
Search date: 20/6/2014

Title search for: maternity OR midwife OR midwifery OR midwives OR MSW OR MSWs

Note: database crashed for any more complex searches.

4.1.9 Tufts Cost Effectiveness Analysis Registry
Basic interface
Search date: 20/6/2014

Searched for the following words individually: maternity; midwife; midwifery; midwives; MSW; MSWs.

Note: limited search functionality. Zero results for Boolean searches.
### 4.2 Appendix B Review protocol

<table>
<thead>
<tr>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives</strong></td>
</tr>
<tr>
<td><strong>Language</strong></td>
</tr>
</tbody>
</table>
| **Study design** | Cost-utility analysis  
Cost-consequences analysis  
Cost-effectiveness analysis  
Cost-benefit analysis  
Cost- minimization analysis  
Any comparative cost analysis  
Econometric studies which include cost  
Costs outcomes reported in included studies from non-economic evidence review. |
| **Status** | Published papers (full papers only) |
| **Setting** | Maternity settings |
| **Perspective** | NA |
| **Intervention** | Any approach or process identified in the non-economic evidence review (midwife staffing number or skill-mix) |
| **Comparator** | No assessment  
Comparison to each other approach |
| **Evaluation** | Cost per outcome (incremental cost-effectiveness ratios) if available  
Total and Incremental Costs  
Total and Incremental Benefits (including process outcomes)  
Any cost-effectiveness data |
| **Other criteria for inclusion/exclusion of studies** | **Include:**  
English language  
Cost/productivity outcomes reported in included studies from non-economic evidence review  
**Exclude:**  
Obstetric settings  
Studies conducted before 1998  
Any evaluations in non-maternity settings  
Studies in non-OECD countries (due to limited applicability to the UK) |
| **Review strategies** | The appropriate NICE methodology checklist will be used as a guide to appraise the quality of individual studies  
Data on all included studies will be extracted into evidence tables  
Data will be placed into NICE economic evidence profiles |
4.3 Appendix C Excluded studies

Reason for exclusion: not an economic evaluation:

Reason for exclusion: Not specific to midwife staffing numbers; Cannot calculate economic outcomes specifically for midwife staffing numbers (non-segregated), ratio or hours

Reason for exclusion: Systematic review including studies excluded in protocol (included studies were checked)
Studies: (Dawson et al. 1999; Ryan et al. 2013; Sandall et al. 2013)

Reason for exclusion: Midwifery caseload unknown
Studies: (Schroeder et al. 2012; Simpson 2010)

Reason for exclusion: Service delivery – outside scope
Studies: (Draper et al. 2004)

Reason for exclusion: non OECD country
Studies: (Hutton 2004; Manasyan et al. 2011)

**Reason for exclusion: unable to source**

Studies: (Chamberlain et al. 1998; Geitona 2007; O'Brien-Pallas et al. 2001)

---

**Excluded Studies Reference List**


Ashcroft B, Elstein M, Boreham N et al. (2003) Prospective semistructured observational study to identify risk attributable to staff deployment, training, and updating opportunities for midwives


Baldo MH (2001) The antenatal care debate. [Review] [43 refs]


Bones E (2005) The true cost of the centralisation of maternity services. MIDIRS Midwifery Digest 15: 559-64.


401. Human Resources for Health 10


Leversidge A (2013) 12-hour shifts: Friend or foe? RCM Midwives: The Official Journal of the Royal College of Midwives,


Sandall J, Soltani H, Gates S et al. (2013) Midwife-led continuity models versus other models of care for childbearing women

2. Cochrane Database of Systematic Reviews


Tillett J (2009) The economy, unit staffing, and patient outcomes


Tracy SK, Hartz D, Hall B et al. (2011) A randomised controlled trial of caseload midwifery care: M@NGO (Midwives @ New Group practice Options). BMC Pregnancy & Childbirth 11: 82.


### 4.4 Appendix D Evidence tables

<table>
<thead>
<tr>
<th>Study details</th>
<th>Population and setting</th>
<th>Intervention / comparator</th>
<th>Outcomes and methods of analysis</th>
<th>Results</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authors: Allen and Thornton, Year: 2013</td>
<td>Source population: A total of 5800 births (1 year). Setting: A labour ward of a city hospital Data sources: Whether through primary research, published studies or sources, meta-analyses or decision-analytic techniques.</td>
<td>Interventions: Birth Rate Plus Comparator: Simulated data Sample sizes: Total N=5800</td>
<td>Outcomes: Occurrence of workload (the number of women or the BR+ Workload Index exceeds the scheduled midwife availability) Budget&lt;sup&gt;d&lt;/sup&gt; Time horizon: 1 year Discount rates: NA Perspective: Unclear&lt;sup&gt;e&lt;/sup&gt; Measures of uncertainty: None Modelling method: Retrospective simulation model</td>
<td>Primary results: 25% reduction in occurrence of overload achieved with 4% increase in budget. Secondary analysis: Reduced staffing on Saturday night and all of Sunday and re-applied at peak load during weekdays. 15% reduction in occurrence of overload achieve</td>
<td>Source of funding: National Institute for Health Research (NIHR) Collaboration for Leadership in Applied Health Research and Care (CLAHRC) for the South West Peninsula</td>
</tr>
</tbody>
</table>

<sup>a</sup> Simulation undertaken, type of economic evaluation is unclear; does not produce a cost-effectiveness ratio.
<sup>b</sup> Investigated birth rate plus compared to a computer simulation model: unclear if comparator is realistic or appropriate. Does not reflect any NICE reference case.
<sup>c</sup> Simulation model structure not clearly defined. Unclear cost perspective; resource use, unit costs and sources of unit costs were not specified. Use of one ward in the UK may not be generalisable to other wards. No fully incremental analysis. No sensitivity analysis undertake to investigate uncertainty
<sup>d</sup> Budget not defined in study
<sup>e</sup> Unclear cost perspective assumed to be NHS only
### Safe Midwife Staffing for Maternity Settings

<table>
<thead>
<tr>
<th>Study details</th>
<th>Population and setting</th>
<th>Intervention / comparator</th>
<th>Outcomes and methods of analysis</th>
<th>Results</th>
<th>Notes</th>
</tr>
</thead>
</table>
| **Authors:** Sandall et al | **Setting:** UK NHS Data sources: See evidence review (for more information) 142 NHS trust, Health Episode Statistics (HES) data from 2011/11 NH Workforce statistics 2010/11 CQC Maternity Survey of Maternity Provider Trusts 2007 and 2010 ONS Birth Registrations | Midwives (FTE) Support Staff (FTE) Doctors (FTE) Consultants (FTE) Relationships between above and number of births | **Outcomes:** Descriptive statistics, regression analysis coefficients, Marginal productivity, Hicks elasticity **Time horizon:** 1 year **Discount rates:** NA **Perspective:** NHS **Measures of uncertainty:** Sensitivity analyses undertaken **Modelling method** Production function analysis (Econometric analysis) | **Costing analysis** Higher midwife staffing levels associated with higher costs of each delivery (relationship not strong) **Econometric analysis** Descriptive aggregate results per trust: Mean (SD) Midwives 135 (6.45) FTE Support workers 42 (3.55) FTE Other Doctors 24 (1.46) | **Costing analysis:** Relationship strengthened when antenatal expenditure included as an explanatory variable 17% of variation between trust’ delivery costs are accounted for in model, rising to 23% when antenatal expenditure is included. **Econometric analysis** Adjusted $R^2$ (total deliveries = 0.88 or higher) | **Notes**

- No NICE reference case was followed, a QALY approach was not taken. Trust level perspective taken, and not ward level.
- Unclear if all relevant long terms costs and consequences were considered (i.e. long term implications of mother and baby safety concerns). Not a fully incremental analysis. No account of time spent between roles in obstetric versus gynaecology, no consideration of bank and agency staff. Multicollinearity between variables. Potential endogeneity between variables and error term.
- Aggregated at a trust level.
<table>
<thead>
<tr>
<th>2000/01 – 2010/11 BirthChoiceUK database Reference cost data – NHS reference costs 2010/11</th>
<th><strong>Costing analysis</strong> Takes into account of trust size, risk, parity, age and IMD&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Total of 665,969 delivery babies</td>
<td></td>
</tr>
<tr>
<td>Sample mean number of total deliveries per trust (sd)</td>
<td></td>
</tr>
<tr>
<td>Total deliveries: 4,600 (1991)</td>
<td></td>
</tr>
<tr>
<td>Cost weighted deliveries&lt;sup&gt;b&lt;/sup&gt; 5,740 (2,491)</td>
<td></td>
</tr>
<tr>
<td>Consultants 11 (0.60)</td>
<td></td>
</tr>
<tr>
<td>50.35% of patients considered High Risk using NICE criteria</td>
<td></td>
</tr>
<tr>
<td>Mean maternal age 29.47 (1.18)</td>
<td></td>
</tr>
<tr>
<td>Mean Parity 1.02 (0.30)</td>
<td></td>
</tr>
<tr>
<td>% High Risk (NICE) 50.35% (6.36%)</td>
<td></td>
</tr>
<tr>
<td><strong>Econometric analysis</strong> Controlled for case-mix of patients. Included variables on maternal age, parity, proportion of mothers considered high risk</td>
<td></td>
</tr>
<tr>
<td>Marginal productivity (change in output that results in the change of 1 unit of input. Keeping all other inputs constant)</td>
<td></td>
</tr>
<tr>
<td>Total deliveries (standard errors): 1 additional midwife is associated with +17.93 deliveries</td>
<td></td>
</tr>
<tr>
<td>1 additional support staff is associated with +10.47 deliveries</td>
<td></td>
</tr>
<tr>
<td>1 additional</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Costs converted to costs per delivery, and adjusted for geographical variations in labour and capital using Market Forces Factor (MFF)

<sup>b</sup> Weighted by relative cost, to take into account differences in cost between vaginal and caesarean deliveries based on HRG tariff

<sup>c</sup> Index of Multiple Deprivation (IMD)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>consultant is associated with 32.31 deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 additional other doctor is associated with 42.81 deliveries</td>
</tr>
<tr>
<td>Cost weighted deliveries</td>
<td></td>
<td>1 additional midwife is associated with +93.85 deliveries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 additional support staff is associated with +50.15 deliveries</td>
</tr>
<tr>
<td>Hicks elasticity of substitution: (degree to which two inputs can be substituted for one another)</td>
<td></td>
<td>1 additional consultant is associated with +58.72 deliveries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 additional doctor is associated with +51.01 deliveries</td>
</tr>
<tr>
<td>Total deliveries:</td>
<td></td>
<td>If the number of support staff increased by 1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>change in the number of midwives needed would be -0.03% (substitutes)</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If the number of consultants increased by 1%, change in the number of midwives needed would be 0.30% (complements)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If the numbers of other doctors required rose by 1%, change in the number of midwives needed would be 0.70% (complements)</td>
</tr>
<tr>
<td>Cost-weighted deliveries:</td>
<td></td>
<td>If the number of support staff increased by 1%, change in the number of midwives needed would be 0.05% (complements)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If number of consultants increased by 1%, change in the number of midwives needed would be</td>
</tr>
<tr>
<td></td>
<td>0.14% (complements)</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td>If numbers of other doctors increased by 1%, change in the number of midwives needed would be 0.97% (complements)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>