THE ECONOMIC COSTS OF INTRAPARTUM CARE IN TOWER HAMLETS: A COMPARISON BETWEEN THE COST OF BIRTH IN A FREESTANDING MIDWIFERY UNIT AND HOSPITAL FOR WOMEN AT LOW RISK OF OBSTETRIC COMPLICATIONS

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Abstract

Objective

To compare the economic costs of intrapartum maternity care in an inner city area for 'low risk' women opting to give birth in a freestanding midwifery unit compared with those who chose birth in hospital.

Design

Micro-costing of health service resources used in the intrapartum care of mothers and their babies during the period between admission and discharge, data extracted from clinical notes

Setting

The Barkantine Birth Centre, a freestanding midwifery unit and the Royal London Hospital's consultant-led obstetric unit, both run by the former Barts and the London NHS Trust in Tower Hamlets, a deprived inner city borough in east London, England, 2007-2010.

Participants

Maternity records of 333 women who were resident in Tower Hamlets and who satisfied the Trust's eligibility criteria for using the Birth Centre. Of these, 167 women started their intrapartum care at the Birth Centre and 166 started care at the Royal London Hospital.

Measurements and findings

Women who planned their birth at the Birth Centre experienced continuous intrapartum midwifery care, higher rates of spontaneous vaginal delivery, greater use of a birth pool, lower rates of epidural use, higher rates of established breastfeeding and a longer post-natal stay, compared with those who planned for care in the hospital. The total average cost per mother-baby dyad for care where mothers started their intrapartum care at the Birth Centre was £1296.23, approximately £850 per patient less than the average cost per mother and baby who received all their care at the Royal London Hospital. These costs reflect intrapartum throughput using bottom up costing per patient, from admission to discharge, including transfer, but excluding occupancy rates and the related running costs of the units.

Key conclusions and implications for practice

The study showed that intrapartum throughput in the Birth Centre could be considered cost-minimising when compared to hospital. Modelling the financial viability of midwifery units at a local level is important

because it can inform the appropriate provision of these services. This finding from this study contribute a local perspective and thus further weight to the evidence from the Birthplace Programme in support of freestanding midwifery unit care for women without obstetric complications.

Keywords

Midwifery care, freestanding midwifery unit, birth centre, cost, health economics

Introduction

In the United Kingdom, policies about providing midwife-led care in non-hospital settings have a long history.[1,2] Reviews in the 1980s and 1990s found no evidence for the policy that all women should give birth in a District General Hospital.[3,4] Current policy, set out in Maternity Matters in 2007,[5] offered women in England the choice of birth at home, in a midwifery unit on or off a hospital site or supported by a maternity team in hospital. It also promised improved access to care for disadvantaged women. Although this and the National Service Framework for Children, Young People and Maternity[6] both pledged to offer choice, both earlier[3,4] and more recent reviews[7] had found that the evidence available to inform choice was limited and came from small local studies. In response to this, long overdue need for large scale research, the Birthplace in England Research Programme, was commissioned to provide some of the evidence needed. It included a prospective study to compare the outcome of care in midwifery units, at home and in consultant obstetric units[8] and to do a cost-effectiveness analysis.[9]

The research described here was designed and executed independently from the national Birthplace programme to assess a local innovation. In doing, it also complemented and collaborated with Birthplace. At a time when numbers of births in Tower Hamlets, a borough in a mainly deprived area of east London, were projected to increase by a third by 2021,[10] the Barkantine Primary Care Centre was redeveloped to serve the health and social care needs of the relatively deprived population. It opened on December 10th 2007 and the Barkantine Birth Centre, situated on the top floor of this multipurpose building, opened for births on January 7th 2008.[11] It is a freestanding midwifery unit, designed to provide care for women with

straightforward, healthy pregnancies.[8,12] It was the first new midwifery unit to be opened in an inner city area of England. Women who start their intrapartum care at the Birth Centre but develop obstetric complications are transferred by ambulance to the consultant-led obstetric unit in the Royal London Hospital, 2.6 miles away.

At the planning stage of the Birth Centre, a steering group made up of service users and professional staff developed a business plan, which was accepted by Barts and the London NHS Trust. A multidisciplinary Birth Centre Evaluation Group, with members drawn from the Barkantine Birth Centre Steering Group, the Birth Centre Network, City University London Department of Midwifery, Tower Hamlets Primary Care Trust and Barts and the London NHS Trust was formed to plan and design the research. Health economists based at the National Perinatal Epidemiology Unit and working on the Birthplace Programme were invited to join the team.

The overall aim of the project was to assess the impact of opening a freestanding midwifery unit in a multi-ethnic inner city area. It did so by comparing the care offered to women at low risk of obstetric complications resident in Tower Hamlets before and after the opening of the Birth Centre and by comparing midwifery unit care with hospital care. To do this, the project team undertook research to:

1. Assess the uptake, outcome and appropriateness of midwifery unit care for women in the catchment area for the Birth Centre, using routinely collected hospital and population-based data.
2. Compare local women's preferences and experiences of maternity care, as well as the interventions and outcomes associated with their childbirth, by conducting surveys before and after the opening of the new Birth Centre.
3. Conduct a comparative study of the economic costs of providing intrapartum care in the Birth Centre and the hospital.

The results of the surveys, published elsewhere showed that women who started intrapartum care at the Birth Centre were more likely.to report positive experiences of care and had lower levels of intervention.[13,14] This article describes the economic study, which was conducted separately but linked to the national Birthplace programme of research. Data collection from clinical notes in the Birthplace research programme replicated the methods employed here, so that the study design could be utilised in the main economic analysis. The economic study presented here was predicated on the safety equivalence hypothesis that, due to the stringent eligibility criteria at the Birth Centre, the women beginning their labour care there would not experience worse outcomes for the mother and baby. This employed an economic hypothesis of 'weak dominance', hypothesising that the Birth Centre was as safe but less costly than the nearest hospital[15].The study was conducted from a health system perspective and consequently only direct costs to the NHS were included. The time horizon identified women at the start of their care in labour and was completed when intrapartum and related in-patient postnatal care for mother and baby ended. Analyses were by 'intention to treat', so the final costs incurred were attributed to the setting where the woman planned to give birth at the start of care in labour and included costs incurred if she transferred care.

Methods

Study population

The selection of the sample was linked to that of participants in Phase 2 of the survey of women's views, undertaken after the Birth Centre was open. In the survey, women resident in the borough of Tower Hamlets who were identified to be at low risk of obstetric complications and satisfied the Trust's criteria to use the Birth Centre were approached in late pregnancy and invited to participate.[13] Those who were planning to birth in either the Royal London Hospital or the Barkantine Birth Centre and agreed to participate were interviewed by telephone in late pregnancy and again after birth by bilingual interviewers who asked about their overall experiences and about specific aspects of care. Their responses were analysed using an intention to treat approach.[13]

The economic component was designed to use anonymised information extracted from the case notes of the women who had agreed to participate in the survey. The data were compiled by midwives employed by the Barts and the London Trust who had access to the clinical notes. Data were captured retrospectively from clinical notes after both the mother and baby had been discharged from postnatal care and inserted into a purpose-designed SPSS database. Information about the father's occupation was collected from clinical notes, and this was then coded into the National Statistics Socio-economic Classification (NS-Sec) by the researchers.[16]

Despite extensive efforts to locate case notes in the Medical Records Department and elsewhere in the hospital, they were missing for 53 of the 166 women who planned to birth at the hospital. Data were therefore extracted from the more limited set of items in the Trust's 'obstetric summaries', which contain clinical data extracted from case notes. Data were extracted from 113 sets of notes and 53 obstetric summaries for women who had satisfied the criteria to birth at the Birth Centre but had all their intrapartum care at the Royal London Hospital between January 2008 and March 2009. If their admission did not result in the establishment of labour and the birth of a baby in the same episode of care, then data from their notes were not included in the study. On this basis, data were excluded for two women, leaving 164 women who had all their care at the hospital.

To increase the numbers of records of care given to women who had planned to give birth at the Birth Centre, notes were obtained for an additional 50 women who had come to birth there and therefore satisfied the Trust's criteria, but had not been recruited into the survey. Anonymised data were extracted from a total of 167 sets of notes for women resident in Tower Hamlets who received intrapartum care at the Birth Centre between August 2008 and March 2009, of whom 117 had taken part in the survey.

Ethics approval and permission to access data

An application was made to the City and East London Ethics Committee for ethics approval in November 2006. The Committee decided that the study was a service evaluation and therefore did not need formal ethics approval. Permission was given by the Caldecott Guardians for Barts and the London Trust and Tower Hamlets Primary Care Trust to use local routine data for the research. The clinical notes were accessed on the premises of the Barts and the London Trust with the permission of the Acting Head of Midwifery.

Resource use data

Data on the health service resources used in the care of each mother and baby during the period between admission and discharge were extracted directly from clinical notes and entered into a database designed for the purposes of this study. The database was designed to capture the 'pathway of care' experienced by the woman as she progressed through the stages of labour, including transfer to the Royal London Hospital from the Birth Centre if this was necessary. It was designed to capture detailed information about the time and completion of each stage of labour. This included time spent in the antenatal admission area, including triage, the labour ward or the Birth Centre for the birth of the baby, theatre if required, and postnatal care for both mother and baby. The research midwives extracted information about the duration and intensity of any adult high dependency care and also any neonatal care, based on BAPM standard criteria for level of care, which were neonatal intensive care, high dependency care and special care.[17]

They profiled the complications experienced by mothers and babies, and noted the type and quantities of treatments, surgery, diagnostic imaging tests, scans and medications administered and ambulance transfers undertaken for both mothers and babies, if undertaken separately. Prior to interview the midwives were sent a lengthy cost sheet which listed every item identified in an action, event or procedure during intrapartum care. Midwives documented the intrapartum procedures such as augmentation, mode of delivery or perineal repair relevant to their setting.

Unit costs

Detailed 'bottom up' unit cost data were collected. Unit cost proformas were drafted on a procedure by procedure basis through the 'pathway of maternity care', and every item with a cost component was documented. Primary data were obtained for all the costs. Interviews were held with the Acting Head of Midwifery and the Birth Centre Manager to collect data on staffing, protocols and administration in the two units. Contact was then made with relevant departments at the Royal London Hospital where management decisions are made for both units. Interviews were held at the Royal London Hospital's Pharmacy Department to obtain the costs of medication. Finance managers were contacted to ask for the costs of equipment, stock and the overall running costs of the unit. Ambulance services were interviewed for information about the costs of transfer between the Birth Centre and the hospital. Equipment costs were discounted over five years, at a 3.5 per cent discount rate.

If required, secondary unit costs were applied to resource items to value the total resource use for each birth (mother and baby). All unit costs employed followed well established guidelines on costing health and social care services as part of an economic evaluation.[18-20] The calculation of these costs was underpinned by the concept of opportunity cost, which can be defined as the value of the next best alternative for using these resources.[18-20]

If the hospital departments could not supply the researchers with specific cost information, this was then taken from available published sources. These included the English Department of Health reference costs and the Unit Costs of Health and Social Care as provided by the Personal Social Services Research Unit.' [21,22] Drug costs not available from primary data were obtained from the British National Formulary. [23] All costs were expressed in pounds sterling.

The same Agenda for Change salary bands, bands 6 and 7, were used to cost midwifery time in each setting, although varying proportions of committed time per episode were apportioned depending on the responsibilities and activities of the midwives in the setting. In the Royal London Hospital, midwifery care was estimated 'per ward' or setting (such as antenatal assessment, labour ward or theatre), and allocated

according to the stage and duration of labour, and the procedures required. Care at the Birth Centre and the hospital reflects differences between the groups in their resource use. At the Birth Centre, the women were admitted to a birthing room and usually stayed in the room until discharge. Midwifery care, estimated to be continuous from admission to the end of the third stage of labour, was costed separately. Following discussions with senior midwives, it was apportioned at 80 per cent per hour of contact.

For other procedures, secondary unit costs were obtained from the Unit Costs of Health and Social Care Compendium.[21] Midwifery staff time is considered to be the main cost driver generalisable across all settings for birth, and was allocated directly to the duration (hours) of the labour episode per woman. This duration variable was calculated directly from the information collected in research interviews with the relevant midwives. Medical staffing costs were calculated in a similar way to midwifery staffing, using the costs allocated to direct person contact. Medical staffing (consultant obstetrician, paediatrician, neonatologist, anaesthetist, obstetric registrar and foundation year doctor, including senior house officers) costs were allocated per patient contact hour and were calculated in this study within labour related events or procedures. Medical staff time was included in events such as the augmentation of labour, administration of an epidural, a general anaesthetic or perineal repair.

Data analysis

The characteristics of the women opting to have their baby at the Birth Centre and the hospital were compared using the Pearson's chi-squared test. Where expected numbers in cells were below five, related categories were combined for testing. The resource use values were combined with unit costs to generate estimates of maternity care of both mother and baby from admission to discharge in both units, inclusive of transfer between the units. Mean imputation was used for estimating the missing data in the analysis, though this was minimal in Tables 2-4. Comparisons were made between women admitted to their planned place of birth at the Birth Centre and the hospital. These were expressed as mean differences in resource use and costs with 95 per cent confidence intervals (CIs) where applicable. Although the cost data were skewed, the arithmetic mean was chosen as it is the most informative measure for cost data. Analyses other than the

arithmetic mean (such as transformed data or medians) can be associated with misleading conclusions by policy makers.[24,25] The resource use values were combined with unit costs to generate estimates of costs during intrapartum care. As the data for costs were skewed, in addition to Student t tests of cost differences, non-parametric bootstrap estimation was used to derive 95 per cent CIs for mean cost differences between the comparison groups. Each of these confidence intervals was calculated using 1000 bias-corrected bootstrap replications.[26] All analyses were performed using the Statistical Package for the Social Sciences (SPSS) (version 17.0; SPSS Inc, Chicago, I11) and Microsoft Excel 2007 (Microsoft Corporation, Washington 98052-6399 U.S.A) and OpenEpi Version 3 software.

Results

Study population

The socio-demographic characteristics of the women giving birth in the two settings are compared in Table 1. Apart from ethnicity, these socio-demographic data were not recorded in the obstetric summaries. Similar proportions of mothers were married or living with a partner, but the two groups differed significantly in all the other respects shown in Table 1. Only 20.0 per cent of women who booked for the Birth Centre were of South Asian ethnicity compared with 80.4 who booked for the hospital, where the majority of women were Bangladeshi. Over half the women who booked for the Birth Centre were of White ethnicity compared with 12.6 per cent at the hospital. Among women booked at the Birth Centre 92.8 per cent spoke English, compared with 46.7 per cent at hospital, although English was not necessarily the first language of those who spoke it.[13] Only 3.1 per cent of the women who booked at the Birth Centre required an interpreter, compared with 41.3 per cent at the hospital. There were considerable differences between the distributions of fathers' NS-Sec. Among those who booked at the Birth Centre, 36.0 per cent were in managerial and professional occupations compared with 10.0 per cent at the hospital, where 16.0 per cent were unemployed and 43.0 per cent in semi-routine and routine occupations.

Resource use

Mean values for intrapartum procedures are shown in Table 2, which presents them in terms of procedures undertaken by stage of labour. As Table 2 shows, there were some differences between the two birth settings.

During the first stage of labour, women who booked to deliver in the Birth Centre were more likely to experience fetal heart monitoring without a cardiotocogram. For the management of pain relief, more women used a TENS machine at the Birth Centre and significantly more used a birth pool. Only three women booked for the hospital used a TENS machine and only one used a birth pool. Epidural use was lower among women who booked for labour care at the Birth Centre, where epidurals are not available. Women are therefore required to transfer to the hospital if they wish to have one or need one for an emergency caesarean section or other procedure. Approximately 30 per cent of women who started labour care at the Birth Centre were transferred to the hospital. There were no transfers of women in this sample from the Royal London Hospital to any other unit, though there were two transfers in the survey data reported separately.

The mean numbers of spontaneous vaginal deliveries were higher amongst women who started labour care at the Birth Centre, though the mean differences for assisted birth were similar, as Table 2 shows. Mean numbers of lower segment caesarean sections were slightly but significantly lower among women who started intrapartum care at the Birth Centre.

No differences were detected between the mean numbers of women requiring a manual removal of the placenta or perineal suturing.

On average, women who booked for care at the Birth Centre spent more time in postnatal care. One woman who started care at the Birth Centre spent a day in high dependency care following the birth of her baby and one woman who started care in the hospital spent a day in intensive care. The mean differences in numbers of days spent in neonatal care were not significant.

Economic costs

The unit costs for each resource input, shown in Table 3, were compiled to estimate the costs of maternity care from admission to discharge. Detailed unit cost data collection was undertaken to estimate the cost of care in each setting from a 'bottom up' perspective. The unit costs shown in Table 3 are therefore estimates of both the midwifery staff and equipment components used in each procedure, specific to each intended place of birth.

Resource use values were then combined with the differences in the costs between women starting labour care at the Birth Centre and the hospital, as shown in Table 4, and they reflect differences between the groups in resource use. At the Birth Centre, the women would generally be admitted to a birthing room and would not necessarily move from there until discharge. Midwifery care, estimated to be continuous from admission to the end of third stage labour was thus costed separately from other procedures and this is reflected in Table 4. This shows that the average cost of midwifery care per woman was £99.00(SD 114.20). In contrast, women presenting at the hospital in early labour would be admitted to an admission or triage area, and the average cost per woman of this episode of their care was £743.50 (SD1207.40). According to our research, both obstetric and midwifery staff might attend the women at admission, and assessments such as vaginal examinations or monitoring with a cardiotocogram might also occur and are included in this cost. The high standard deviation reflects the substantial period of time that some but not all women spent in this area. Staff costs for midwives and clinicians who have direct contact with women during their episode of labour were separately attributed to each individual woman's duration of labour care. All cost data that could contribute to a 'total cost per woman per intrapartum care episode' were collected.

The average cost per woman who used a birthing pool at the Birth Centre was £101.00, compared to almost no cost at all at the Royal London Hospital, as fewer women used a birthing pool in hospital. This reflected the differences in options available to the women in the different settings. The cost of epidural uptake was

greater among women who started labour care in the hospital, reflecting higher uptake in this group of women.

The unit cost of a transfer from the Birth Centre to the hospital was estimated as £255.16, with an additional £230 if the baby was transferred separately. The total cost, when averaged across all of the study participants was £93.50 per transfer. Emergency ambulance staff and one midwife were estimated to have accompanied the woman if transfer was in-utero, with the transfer estimated to last one and a half hours in total. A new admission time was estimated for each transferred woman admitted to the hospital (mean cost £66.80, Table 4). This was calculated by the cost differential between the length of the transfer and the start of care in the subsequent designated place of care (admission area, labour ward, theatre) at the hospital. Data were collected on whether a consultant assessed the woman on arrival and this was included in the cost estimate. The average length of time a woman had to wait for assessment on admission following transfer was one hour and eighteen minutes.

The Royal London Hospital had a higher mean cost of caesarean sections, as more women who commenced labour care in this setting had this procedure. Although the difference was significant, it was small, £210.20 compared to £81.1, p=0.01), reflecting the low rate of caesarean section in the study population. The cost attributed to staff care was higher for the second stage of labour at the Royal London Hospital, with a mean cost of £16 compared to £9 ($p \leq 0.001$). The costs are likely to have been inflated by the presence of extra clinical staff attending assisted deliveries.

The mean cost of postnatal care for women who planned birth at the Birth Centre was higher, (£964.00 compared to £577.50 $p \leq 0.001$) reflecting the longer duration of postnatal stay there. The Birth Centre has a lower total average cost overall, thus varying the cost estimate does not change the relative cost differences between the two settings. There were no significant differences between the mean costs of the other postnatal levels of care for mother and baby (adult intensive care, neonatal intensive care and special baby care).

With the exclusion of a theatre-based repair of a third degree perineal trauma, and theatre care for caesarean sections, no mothers had surgery for complications. Mothers' complications postnatally included shortness of breath, which required an ECG, a perineal haemotoma and perineal infections treated with antibiotics. A few mothers were noted to be anaemic. Neonatal complications included a baby with mild renal pelvic dilatation and another with haematuria. One baby had papules in its mouth. One baby was admitted to intensive care having developed pneumonia. One baby was diagnosed with a cleft palate, but did not receive a higher level of care prior to postnatal discharge. One baby was transferred after birth from the Royal London Hospital to Great Ormond Street Hospital.

The total average cost per mother and baby dyad commencing labour care at the Birth Centre was £1296.23, approximately £850 per patient cheaper than the estimated average cost of £2200.70 per mother and baby who received all their care at the Royal London Hospital. .

Table 4 compares the bootstrap arithmetic mean costs for each component of care and their 95 per cent confidence intervals. The bootstrap arithmetic mean cost for the Birth centre was £1353.51 and £2273.35 for the hospital. The bootstrap arithmetic mean total cost difference between the two units was £919.86. These costs reflected bottom up costing per patient, from admission to discharge, including transfer, but excluding the running costs of the units.

Discussion

There are socio-economic differences between the two settings, which would place a higher resource burden on the Royal London Hospital, for example with regards to the provision of health advocates for women who do not speak English. This analysis would suggest that the two birth settings were providing care for two very different socio-economic populations within the catchment area. The socio-demographic data in this paper came from clinical notes, and are defined slightly differently from those used in interview questions in the in survey[13] but they show a similar picture. In the survey, women were directly recruited

from the area of Tower Hamlets nearest to the Birth Centre[13] but the Birth Centre sample was boosted in the survey and again in the economic study by including eligible women from other parts of the borough who had booked for Birth Centre care and they may have been of higher socio-economic status. When the Birth Centre first opened, the Bangladeshi population was reluctant to use it and the Birth Centre midwives responded by making a concerted effort to promote it to the community. It is also relevant to add that, at the time the study was undertaken, Bangladeshi women had good outcomes of pregnancy, with infant mortality rates similar to those of all women, despite their relatively deprived socio-economic status.

As mentioned above, it was intended to use routinely collected data to make comparisons of patterns of care and outcomes in both the Trust and the population of the borough before and after the opening of the Birth Centre and also enable comparisons between the survey sample and the local population. Unfortunately, the long standing Trust and community data collection systems had both been discontinued and new systems which were not fit for purpose had replaced them, thus undermining the ability to achieve this aim of the project.

The limited time horizon of the study meant that the follow up of outcomes for both mother and the baby did not extend beyond labour care or higher level in-patient postnatal or neonatal care when this was received. The size of damages paid in obstetric litigation cases, which represent a substantial cost to the NHS shows that serious adverse outcomes can result in associated life-long health and societal costs. Less serious, but more frequent, morbidities associated with labour and birth and its management affect women and babies. Follow up over weeks or longer to monitor recovery, would shed more light on the long term costs and consequences of intrapartum care.

It has been suggested that free-standing midwifery units reduce medical intervention and the need for assisted birth, and increase breastfeeding rates[27]. This study did find that the spontaneous vaginal birth rate was higher among women who booked for labour care in the Birth Centre and epidural rates were approximately ten per cent lower. If the duration of dedicated continuous midwifery care could be translated as a ‘quality of care’ indicator, this attribute might be reflected in the reduction of medicalised pain relief

and intervention attributed to planned birth at the Birth Centre. In contrast, midwifery care at the hospital was only apportioned as 'continuous care' in the second and third stages of labour, but contact time otherwise (during antenatal assessment, admission and triage and the first stage of labour) was 'intermittent' reflecting less dedicated time for midwifery support for women.

The study adopted a health services perspective, by attempting to cost care from both a 'top down' and 'bottom up' perspective in both maternity units of comparison. The data provided a reliable vehicle for collecting a broad set of resource use and health related outcome data. Women who planned their birth at the Birth Centre experienced higher rates of spontaneous vaginal birth, lower rates of epidural use, less medical intervention and higher rates of established breastfeeding. These are cost-saving and the economic analysis reported here, finds that labour care was cost-minimising for the Birth Centre when compared to hospital. No conclusions can be made about the overall running costs, the set up costs or the financial viability of the Centre as these data were not available.

The findings here are similar to those of the national Birthplace research programme, where freestanding midwifery units emerged as a cost-effective option. [9] Birthplace reported that women who planned birth in midwifery units tended to be multiparous, which was associated with a significant and substantial cost-saving effect, apparent for each additional previous pregnancy. This was primarily due to shortened labour durations and reduced medical intervention[9]. The findings of this study confirm the recommendation by NICE in its intrapartum care guideline to 'advise low risk multiparous and nulliparous women that planning to give birth at home or in a midwifery−led unit (freestanding or alongside) is particularly suitable for them because the rate of interventions is lower and the outcome for the baby is no different compared with an obstetric unit'.[28]. The potential for safety for the baby and the reduction in medical intervention for mothers could make offering women more choice an attractive option for the NHS, but the complex factors that encourage or discourage women to opt for birth in midwifery units are not yet fully understood.

The broader utilisation of maternity services is a complex issue. Occupancy rates in midwifery units tend to be lower than in other settings and unit overheads are an important cost driver for midwifery units. The financial viability of midwifery units is an important area of research as it can inform commissioning and the appropriate configuration and provision of these services. The cost calculations are susceptible to changes in occupancy rates and relative cost-effectiveness will adjust accordingly. A key cost driver is the overheads apportioned for intrapartum care. Fixed costs include estate and capital investment costs. Should changes to maternity service configuration be planned for cost-effectiveness purposes, then consideration would have to be given to the resource use and related cost implications for the maternity service as a whole, including the safety of maternity care which depends on the availability of hospital obstetric units to which women can transfer. Average costs conceal the local variations in occupancy rates in different settings. The development of a trust-based forecasting model to quantify the costs and benefits of service reconfiguration is recommended. Forecasting cost-effectiveness at a local level could include the safety, rate of transfer, occupancy rates, overheads, geographical access including urban and rural differences, the diversity of populations' needs, staffing capacity, related skills and training issues relevant to each local trust in view of fixed and variable costs, and the relative disinvestment in one form of maternity service provision in preference for another.

Contributors

Nishma Patel oversaw the collection of the data with Lucia Rocca-Ihenacho and Michelle Keeler. Liz Schroeder analysed the data. Alison Macfarlane was Principal Investigator and Carol Dossett was the administrator for the project as a whole. Liz Schroeder and Nishma Patel drafted the paper, Alison Macfarlane, Lucia Rocca-Ihenacho and Michelle Keeler took part in the revision of the paper. All authors approved the final version submitted for publication.

Conflicts of interest

We have no conflicts of interest

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Table 1 Socio-demograpic characteristics of study participants

	Birth centre		Hospital	
	Number	Percentage	Number	Percentage
Marital status				
Living with partner / married	123	87.2	90	86.5
Other marital statuses	***9***	***6.4***	***7***	***6.7***
Partner living away from home	8	5.7	7	6.7
Single / no partner	1	0.7	0	0.0
Total stated	**141**	**100.0**	**104**	**100.0**
Not stated or missing	35		67	
Comparison between living with partner and other marital statuses: chi-square= 0.014, p=0.907, 1 df				
Mother's ethnic group				
White British	72	33.5	10	5.7
All white non-British ethnic groups	***21***	***9.8***	***10***	***5.7***
White European	18	8.4	6	3.4
White other	3	1.4	4	2.3
Black	10	4.7	5	2.9
South Asian (Indian/ Pakistani/Bangladeshi	33	15.3	127	73.0
All other ethnic groups	***29***	***13.5***	***6***	***3.4***
Mixed	8	3.7	0	0.0
Chinese	4	1.9	0	0.0
Other	17	7.9	6	3.4
Total stated	**215**	100.0	**174**	100.0
Not stated or missing	2		6	
Comparison between White British, other white, Black, South Asian and other groups: chi-square=122.7, p<.0001, df=4				
Language spoken				
English	155	88.1	50	43.9
Bengali / Sylheti	3	1.7	50	43.9
Other languages	***9***	***5.1***	***7***	***6.1***
Polish	1	0.6	3	2.6
Urdu	6	3.4	1	0.9
Other	2	1.1	3	2.6
Total stated	**176**	**100.0**	**114**	**100.0**
Not stated or missing	0		57	
Comparison between English, Bengali / Sylheti and other languages combined: chi-square=86.7, p<,0001, df=2				
Interpreter needed				
Yes	5	3.1	43	41.3
No	155	96.9	61	58.7
Total stated	**160**	**100.0**	**104**	**100.0**

Not stated or missing	7		60	

Comparison between yes and no, chi-square, =61.9, p<.0001, df=1

Father's NS-Sec based on occupation,				
1, 2 and 3	***100***	***50.0***	***38***	***23.5***
1 Managerial and professional	54	27.0	10	6.2
2 Intermediate	35	17.5	22	13.6
3 Small employer	11	5.5	6	3.7
4 and 5	***38***	***19.0***	***45***	***27.8***
4 Lower supervisory and technical	19	9.5	2	1.2
5 Semi routine and routine	19	9.5	43	26.5
Unemployed and students	12	6.0	17	10.5
Unemployed	9	4.5	15	9.3
Student	3	1.5	2	1.2
Total stated	**200**	**100.0**	**162**	**100.0**
Not stated or missing	17		64	
Total women in sample	**167**		**164**	

Comparison using the three class NS-SEC with 1,2 and 3 combined, 4 and 5 combined and unemployed and students combined:

chi-square=27.2, P<.0001, df=3

Table 2: Resource use values from admission to discharge.

Resource item, unit	Birth centre		Hospital		Difference	p
	Mean	Standard deviation	Mean	Standard deviation		
Procedures occurring during 1st stage of labour						
Vaginal examination	2.21	1.8	2.91	2.1	0.70	0.003
Artificial rupture of membranes	0.13	0.3	0.30	0.4	0.17	0.001
Augmentation with Syntocinon	0.14	0.03	0.15	0.4	0.01	0.98
Fetal Heart Monitoring no CTG	0.74	0.4	0.45	0.5	-0.29	
Pain relief: birth pool	0.71	0.5	0.01	0.1	-0.70	<0.001
Pain relief: TENS machine	0.10	0.3	0.01	0.1	-0.09	<0.001
Pain relief: paracetamol	0.05	0.2	0.04	0.2	-0.01	0.6
Pain relief: co-codamol	0.23	0.4	0.04	0.2	-0.19	<0.001
Pain relief: pethidine	0.13	0.3	0.23	0.4	0.10	0.02
Pain relief: epidural	0.10	0.3	0.18	0.4	0.08	0.16
Transfer (at any point during or after labour)	0.32	0.5	0.00	0.0	-0.32	
Procedures occurring during 2nd stage of labour						
Epidural for LSCS	0.10	0.4	0.19	0.3	0.09	
General anaesthetic	0.01	0.1	0.02	0.2	0.01	
Spontaneous vaginal delivery	0.85	0.4	0.73	0.4	-0.12	0.006

Assisted delivery with ventouse	0.05	0.2	0.06	0.2	0.01	0.78
Assisted delivery with forceps	0.04	0.2	0.05	0.2	0.01	0.57
Lower segment caesarean section	0.07	0.3	0.17	0.4	0.10	0.003
Procedures occurring during 3rd stage of labour						
Perinatal Suturing	0.49	0.5	0.51	0.5	0.02	0.7
Indwelling catheter	0.17	0.4	0.21	0.4	0.04	
Wound drain	0.03	0.2	0.05	0.2	0.02	0.35
Care after Birth	**Numbers of days**					
Postnatal care	2.00	1.6	1.20	1.1	-0.80	
ICU mother	0.00	0.0	1.00	0.0	1.00	
HDU mother	0.00	0.0	0.14	0.3	0.14	
NICU	0.00	0.0	0.01	0.1	0.01	
SCBU	0.03	0.2	0.07	0.6	0.04	
Numbers of women	**167**		**164**			

Table 3 Unit costs of resource items, UK £ sterling, 2008 prices

Resource item (unit)	Unit cost or range, £[a]	Source of unit cost
Procedures occurring during 1st stage of labour		
Vaginal examination	6.70 - 7.24	Primary cost data
Artificial rupture of membranes	5.43 - 5.56	Primary cost data
Fetal heart monitoring no CTG	15.14 – 24.66	Primary cost data
Pain relief: birth pool	141.70	Primary cost data
Pain relief: tens machine	4.19 - 8.39	Primary cost data
Pain relief: epidural	378.93	Primary cost data
Transfer (at any point during or after labour)	255.16	DH Reference costs
Transfer of baby separately	230.00	DH Reference costs
Procedures occurring during 2nd stage of labour		
Epidural for LSCS	383.77	Primary cost data
Spontaneous vaginal delivery	34.60	Primary cost data
Assisted delivery with ventouse	136.52	Primary cost data
Assisted delivery with forceps	140.33	Primary cost data
Lower segment caesarean section	1231.34	Primary cost data

Procedures occurring during 3rd stage of labour		
Perinatal suturing episiotomy	14.07	Primary cost data
Indwelling catheter	3.28	Primary cost data
Wound drain	21.32	Primary cost data
Hospital admission		
Adult intensive care (per day)	1148.0	DH reference costs
Adult high dependency care (per day)	617.0 (462.0-703.0)	DH reference costs
Postnatal care (per day)	247.0	DH reference costs
Neonatal intensive care (per day)	974.0 (637.0-1002.0)	DH reference costs
Neonatal high dependency care (per day)	544.0 (462.0-703.0)	DH reference costs
Special care baby care (per day)	421.0	DH reference costs

a Ranges of unit costs are specified where unit costs varied according to location or intensity of care provided.

Table 4 Intrapartum care costs from admission to discharge.

Cost category	Birth centre		Hospital		Difference	p
	Mean	Standard deviation	Mean	Standard deviation		
Costs associated with admission	**99.1**	**114.2**	**743.5**	**1207.4**	644.4	
Midwifery care from admission	99.10	114.20	0.00	0.00	-99.10	
Patient stay in admission area (RLH)	0.00	0.00	743.50	1207.40	743.50	
Costs associated with first stage of labour	**373.10**	**343.60**	**376.30**	**314.50**	**3.20**	
Artificial rupture of membranes	0.70	1.80	0.80	2.10	0.10	<0.001
Syntocinon	1.90	0.50	0.20	0.50	-1.70	0.8
Fetal heart monitoring without CTG	73.90	76.70	71.30	85.20	-2.60	0.77
Fetal monitoring with CTG	131.30	265.90	115.40	162.70	-15.90	
Fetal blood sampling	5.40	40.60	33.80	118.70	28.40	
Pain relief water	101.00	64.30	1.00	8.10	-100.00	0.01
Pain relief TENS machine	0.40	1.30	0.10	0.10	-0.30	0.01
Pain relief paracetamol	0.0014	0.0	0.001	0.006	-0.0004	
Pain relief cocodamol	0.009	0.016	0.0017	0.008	-0.0073	
Pain relief pethidine	0.69	1.80	1.20	2.20	0.51	
Pain relief epidural	34.00	108.70	69.30	146.90	35.30	0.14
Staffing care during 1st stage of labour	8.60	20.19	27.00	22.10	18.40	
Costs associated with transfer	**114.30**	**178.20**			**-114.30**	
Transfer	93.50	147.90			-93.50	

Care provided by hospital after transfer on admission	66.80	69.60			-66.80	
Procedures occurring during 2nd stage of labour	**232.20**	**460.70**	**316.10**	**563.70**	**83.90**	
Epidural for LSCS	32.20	148.40	42.10	120.30	9.90	0.5
General anaesthetic	4.50	41.30	9.20	58.60	4.70	0.4
Spontaneous vaginal delivery	29.40	12.40	25.10	15.50	-4.30	0.01
Assisted delivery with ventouse	6.50	29.20	7.50	31.20	1.00	0.77
Assisted delivery with forcep	5.00	26.10	5.90	28.50	0.90	0.75
Lower section caesarean section	81.10	306.30	210.20	464.70	129.10	0.01
Staffing care during 2nd stage of labour	8.60	20.19	15.90	58.30	7.30	<0.001
Procedures occurring during 3rd stage of labour	**73.90**	**225.20**	**62.50**	**146.90**	**-11.40**	
Manual removal of the placenta	12.20	88.00	4.03	51.60	-8.17	0.31
Epidural for suturing	6.80	50.50	20.70	86.60	13.90	
Perinatal Suturing	48.90	170.80	15.40	63.40	-33.50	0.01
Indwelling catheter	0.20	0.40	0.70	1.30	0.50	0.43
Wound drain	0.60	3.60	0.80	4.00	0.20	0.73
Neonatal resuscitation	3.00	13.50	4.60	16.50	1.60	0.33
Staffing care during 3rd stage of labour	4.00	7.40	3.80	18.20	-0.20	0.89
Care after birth	**456.00**	**1180.20**	**702.40**	**737.50**	**246.40**	
Postnatal care	321.30	789.20	577.50	520.80	256.20	0.00
ICU mother	0.00	0.00	7.00	0.00	7.00	0.19
HDU mother	59.10	182.10	83.60	162.00	24.50	0.31
NICU	0.00	0.00	5.90	76.10	5.90	
SCBU	75.60	678.10	28.20	247.30	-47.40	0.39
Total costs	**1348.60**	**1850.80**	**2200.70**	**1896.50**	**852.10**	
Number of women	**167**		**164**			

Table 5 Summary of aritmetic mean differences in costs with bootstrapped 95% confidence intervals

Cost category	Arithmetic mean difference	Bootstrapped 95% CI
Costs associated with admission	649.40	226.5, 1291.0
Costs associated with first stage of labour	1.30	-207.2, 217.0
Costs associated with transfer	-116.20	.-203.7, -44.7
Procedures occurring during second stage of labour	83.90	-228.7, 400.4
Procedures occurring during third stage of labour	-14.50	-142.8, 94.6
Care after birth	249.60	-490.4, 794.0
Total costs	**850.30**	**-265.9, 2032.9**