# Birth Centre Care in the Netherlands: added value?!

Klapwijk-Hermus, M.A.A.

Chapter 06

# Cost-effectiveness of a planned birth in a birth centre compared with alternative planned places of birth

## Results of the Dutch Birth Centre Study

Marit Hitzert
Marieke A.A. Hermus
Inge C. Boesveld
Arie Franx
Karin M. van der Pal-de Bruin
Eric A.P. Steegers
M. Elske van den Akker-van Marle

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## Abstract

**Objectives** To estimate the cost-effectiveness of a planned birth in a birth centre compared with alternative planned places of birth for low-risk women. In addition, a distinction has been made between different types of locations and integration profiles of birth centres.

**Design** Economic evaluation based on a prospective cohort study.

**Setting** 21 Dutch birth centres, 46 hospital locations where midwife-led birth was possible and 110 midwifery practices where home birth was possible.

**Participants** 3455 low-risk women under the care of a community midwife at the start of labour in the Netherlands within the study period 1 July 2013 - 31 December 2013.

**Main outcome measures** Costs and health outcomes of birth for different planned places of birth. Health care costs were measured from start of labour until 7 days after birth. The health outcomes were assessed by the Optimality Index-NL2015 (OI) and a composite adverse outcome score.

**Results** The total adjusted mean costs for births planned in a birth centre, in a hospital and at home under the care of a community midwife were €3.327, €3.330 and €2.998, respectively. There was no difference between the score on the OI for women who planned to give birth in a birth centre and that of women who planned to give birth in a hospital. Women who planned to give birth at home had better outcomes on the OI (higher score on the OI).

**Conclusions** We found no differences in costs and health outcomes for low-risk women under the care of a community midwife with a planned birth in a birth centre and in a hospital. For nulliparous and multiparous low-risk women, planned birth at home was the most cost-effective option compared with planned birth in a birth centre.

## Introduction

The Dutch maternity care system is based on risk attribution: independent community midwives providing care for low-risk pregnant women (primary care) and obstetricians providing in-hospital care for high-risk women (secondary care). The risk attribution with reasons for consultation and referral are set out in a multidisciplinary guideline: the List of Obstetric Indications (1). Low-risk pregnant women can choose where they want to give birth: at home, in a hospital or in a birth centre. The community midwife assists them during natal care, pregnancy and the postpartum period. Most midwives work in group practices in the community and they are autonomous as regards their actions and decisions (2). If a pregnant woman's risk status changes during her pregnancy or labour or she requests pharmacological pain relief, she will be referred from primary care to secondary care.

Over the past decade fewer women planned to give birth at home. In 2004, around 48% of all low-risk births in the Netherlands were planned at home; in 2014 this number fell to 24% (3). As most low-risk women in the Netherlands are now planning to give birth outside their home, it is necessary to offer these women a good alternative. Birth centres are a relatively new phenomenon in the Netherlands and most of them have been established in the last decade. Birth centres are regarded as settings where women with low-risk pregnancies can give birth in a homelike environment, supervised by a community midwife. When complications arise or pharmacological pain relief is requested, referral to an obstetrician/paediatrician is needed (4-6). During birth the community midwife is assisted by a maternity care assistant. This assistant provides care and support for the mother and her baby for up to eight days after birth, in a birth centre or at home.

The costs and health outcomes of the different birth settings in the Netherlands (i.e., hospital and home) for low-risk women have been widely discussed in recent years (7-11), especially since the national perinatal mortality rate was shown to be one of the highest in Europe (12). The results of the studies were linked directly to the operational set-up of the Dutch maternity care system, with its clear segmentation of primary (community midwife-led) and secondary care (obstetrician-led) and lack of collaboration. It is, however, assumed that birth centres provide a better quality of care when compared to the existing system of primary and secondary care. One reason for this may be that colocation of birth centres and obstetric units is an enabler for better collaboration (13). At present, there is no evidence for this assumption.

A Dutch study found that the total costs associated with pregnancy, childbirth and postpartum care are comparable for home birth and hospital birth under the care of a community midwife (14). Evidence relating to costs and health outcomes of all Dutch

low-risk birth settings, including birth centres, is still lacking. The costs and health outcomes of birth-centre care have been studied internationally. In England, planned birth at home is the most cost-effective option compared with planned birth in an alongside or freestanding midwifery unit and an obstetric unit (15). The results of other studies on costs and health outcomes of midwifery-attended births in England, the United States of America and Australia were comparable to the British study (16-21).

However, the outcomes of these studies cannot easily be generalised to the Netherlands, since the Dutch system is different, with a relatively high rate of home births and a low rate of medical interventions compared to other high-income countries (7). We therefore studied the costs and health outcomes of Dutch birth centre care as part of the Dutch Birth Centre Study, a national project evaluating the outcomes of Dutch birth centres on aspects such as client and professional experiences, effectiveness and costs (4). The aim of this study is to estimate the cost-effectiveness of planned birth in a birth centre compared with alternative planned places of birth for low-risk women who start labour under the care of a community midwife. In addition, a distinction has been made between different types of locations and integration profiles of birth centres.

## Methods

The cohort study included 3455 term low-risk women under the care of a community midwife at the start of labour. The characteristics of these women, the exclusion criteria and the analyses on the health outcomes have been reported in detail elsewhere (22).A minimum of three midwifery practices located near a birth centre (n=23) were randomly recruited to collect data. A condition for participation was that the birth centre had been operating for over six months before the study period, leading to the exclusion of two birth centres. Midwifery practices in regions where there was the possibility of a midwifery-led hospital birth were recruited to collect data relating to planned midwife-led hospital births. Planned birth at home was an option for women in all participating midwifery practices. The women were recruited from 110 midwifery practices (127 were approached) within the study period 1 July 2013 - 31 December 2013. Twenty-one birth centres and 46 hospital locations where midwife-led birth was possible participated in this study (22).

The cohort study compared perinatal and maternal outcomes, according to the intention-to-treat method, by planned place of birth: in a birth centre, in a hospital or at home. The intention-to-treat method is used to prevent distortion in outcomes resulting from selective drop-out in the groups to be investigated. In maternity care research the place of birth is a variable where selective drop-out occurs as a result of referrals

to secondary care during childbirth. By analysing the outcomes based on the planned place of birth, the groups remain comparable (23). Separate analyses were performed for different types of birth centres, based on location and based on integration profile. Three types of birth centre locations can be distinguished: 1) freestanding from a hospital, 2) alongside an obstetric unit and 3) on-site at an obstetric unit (24).

We also distinguished three integration profiles: monodisciplinary-oriented birth centres (MOBC), multidisciplinary-oriented birth centres (MUBC) and a mixed group of birth centres (MIBC). Integrated care is increasingly encouraged in maternity care systems (25). The essence of integrated care is a continuum of care for service users, crossing the boundaries of public health, primary, secondary, and tertiary care (25-27). The focus of MOBCs is to act as a facility for giving birth rather than to improve collaboration between care providers or to realise integration of care, and MOBCs are mainly owned by primary care organisations. MUBCs can be regarded as facilities for giving birth with a focus on integrated birth care. They have governance structures consisting of both primary and secondary care organisations. The disciplines involved have formulated a joint vision on birth care. The community midwife is still the person who takes care of low-risk pregnant women. MIBCs are a mixed group. They differ more from each other in their organisation than centres in the other groups. Compared with MUBCs these centres had higher scores on clinical integration (the coordination of person-focused care in a single process across time, place and discipline) and lower scores on the other dimensions (professional, organisational, system, functional and normative integration) (28).

The primary clinical outcomes were measured by the Optimality Index-NL2015 (OI) (29) and a composite adverse outcome score (CAO) was used as a secondary outcome measure (30). The OI is a tool used to measure 'maximum outcome with minimal intervention', based on the principle of optimality. It contains both process and outcome items and background characteristics are taken into account. The tool is used to compare the extent to which different low-risk groups, with few adverse outcomes, achieve an optimal situation. An optimal situation is a situation that every woman would wish for: a spontaneous, uncomplicated birth after a full-term pregnancy, without interventions, resulting in a healthy mother and baby (31-33). The tool was revised for use in Dutch obstetric research (29). It contains 31 process and outcome items with evidence-based criteria relating to optimality (e.g., duration of first and second stage, instrumental (vaginal) birth, loss of blood during birth, referral during labour or within 2 hours postpartum and birth weight). Each item meeting the criteria for optimality was scored as '1'. Those considered non-optimal were scored as '0'. In this way a sum score of all 31 items per woman was calculated (31-33). In addition, the composite adverse outcome score (CAO), a combined measure of six distinct adverse outcomes (maternal mortality within 42 days of birth, (sub) total rupture, blood loss of more than one litre,

perinatal mortality within 7 days of birth, Apgar score below 7 at 5 minutes after birth, admission to the neonatal intensive care unit within 48 hours of birth), was used. This measure is based on the occurrence of at least one of these six adverse outcomes and is thereby a dichotomous variable with the value 0 or 1 (29).

### Type of economic evaluation, study perspective, and time horizon

The economic evaluation took the form of a cost-effectiveness analysis in which we estimated the costs and health outcomes for a planned birth in a birth centre, in a hospital or at home. The economic evaluation was performed from a health care perspective. The time horizon of the economic evaluation was from the start of labour until seven days after birth (end of maternity care period). Because of this short time frame no discounting took place. Costs were in 2015 euro; cost prices from earlier years were converted to 2015 euro using the consumer price index (34).

### Measurement of resource use

Volume of health care resource use was collected prospectively by the attending community midwives using a case record form which was designed to complement the data from the Netherlands Perinatal Registry (3). The case record form included additional process indicators and volumes such as the time of the first physical contact between the client and the community midwife after a call at the start of labour, the planned place of birth at the start of labour, time of arrival at the birth centre or hospital, referral to the hospital, use of pain relief, use of transport during referral and maternity care assistance. Information on health outcomes and the use of other medications then pain relief was extracted from the Netherlands Perinatal Registry.

### Unit cost estimation

All birth centres (n=23) were asked to send their financial details, including overheads, materials and staff costs, and 16 birth centres sent useable information. These total costs were divided by the total number of births and the total number of postpartum days to calculate unit costs (35). Dutch reference prices were used for consultation costs, blood transfusion and ambulance transport (36, 37). These reference prices include personnel costs, material costs, costs of medical equipment and supporting departments, accommodation, and overhead costs. For additional costs of interventions after referral and interventions in the third stage (delivery of the placenta) unit costs estimates were obtained from the Dutch Healthcare Authority (NZA) (38). These costs are based on the unit cost of an intervention in a representative selection of Dutch hospitals, weighted by the number of this particular intervention performed in the different hospitals. Unit costs of a birth at a hospital and maternity care assistance were also obtained from the

NZA (39). Twenty community midwives were asked about the duration of home-visits between the start of labour and birth and the duration of consultations during and after birth by a gynaecologist and paediatrician. Their mean estimates (respectively 50, 15 and 12 minutes) were converted into cost prices of consultation using gross salaries. The duration of postpartum consultations by a community midwife and the gross salaries of community midwives were provided by the Royal Dutch Organisation of Midwives (KNOV) (40, 41), and Dutch reference prices were used for the gross salaries of gynaecologists and paediatricians. Admission costs were based on a Dutch obstetric study (42). Medication costs were obtained from the website of the National Health Care Institute,which calculates costs for the Dutch situation based on doses and amounts of drugs (43). The cost of medication - which included not only the drugs but also the materials and/or equipment needed for their administration - was based on other studies (44-46). The values obtained as described above were used for the base case analysis (the model with the values that are assumed most likely). Additionally, sensitivity analyses were undertaken on variables with a great diversity in cost prices across the sources, including: epidural, general anaesthesia, birth at hospital with referral, additional costs after referral (spontaneous birth, vacuum extraction, forceps extraction and caesarean section), repair of perineal tear in operating theatre and manual placenta removal. By repeating our analysis with different cost estimates for variables with a great diversity in cost prices among sources, the implications of uncertainty in costs were explored. These sensitivity analyses included an analysis in which the maximum cost found in literature was used and a bottom-up calculation (assigning a value to each of the resources used during an intervention and summing these values) based on resource use estimates of five hospitals (two teaching hospitals and three general hospitals), see Table 1.

## Analytical methods

Total costs per birth were calculated after multiplying resource use per woman and unit costs.

A decision rule was used for missing values that were needed to calculate the outcome scores (OI and CAO): not registered was considered as not happened (since some items did not need to be filled in). Multiple imputation (20 datasets) was used to correct for other missing data. Missing values that were imputed for the cost analysis were: ambulance use (missing 0.2%), place of admission of the child (missing 1.7%), duration of admission of the child (missing 11.0%), duration of post-partum stay at the birth centre (missing 3.7%) and maternity care assistance during birth (missing 5.0%). The variables of the OI, age, parity and maternal background were used as predictors. An iterative Markov chain Monte Carlo method was used in which, for each iteration and for each variable, the fully conditional specification method is in keeping with a univariate

**Table 1** • Unit cost (2015, €) in base case analysis, and sensitivity analysis using maximum cost prices and cost prices resulting from bottom up calculation

| | | Unit | Base case analysis | Sensivity analysis | |
|---|---|---|---|---|---|
| | | | | Maximum cost in literature | Bottom up calculation |
| Consultation and medication during first and second stage | Home-visit by a midwife | visit | 49 [47] | | |
| | Gynaecological consultation | visit | 20 [37] | | |
| | Oxytocin | dose | 0.60 [43] | | |
| | Epidural | procedure | 185 [44] | 526 [38] | 252 |
| | Remifentanil | procedure | 86 [46] | | |
| | Morphine | procedure | 0.60 [43] | | |
| | Pethidine | procedure | 0.62 [43] | | |
| | Nalbuphine | procedure | 3.25 [43] | | |
| | Nitrous Oxide | procedure | 422 [45] | | |
| | General anaesthesia | procedure | 391 [39] | 713 [39] | 713 |
| | Cardiotocography | procedure | 151 [38] | | |
| Birth (staffing, overhead and referral) and intervention during second stage | Birth at birth centre | procedure | 980 | | |
| | Birth at birth centre with referral | procedure | 725 | | |
| | Birth at home | procedure | 604 [47] | | |
| | Birth at home with referral | procedure | 598 [47] | | |
| | Birth at hospital | procedure | 1136 [39] | | |
| | Birth at hospital with referral | procedure | 1130 [39] | 1130 [39] | 916 |
| | Additional costs after referral | | | | |
| | sponteanous birth | procedure | 677 [38] | 1223 [42] | 209 |
| | vacuum extraction | procedure | 637 [38] | 1445 [48] | 418 |
| | forceps extraction | procedure | 637 [38] | 1445 [48] | 516 |
| | caesarean section | procedure | 868 [38] | 2157 [48] | 1403 |
| Intervention and consultation during third stage | Blood transfusion | procedure | 446 [37] | 578 | 578 |
| | Oxytocin | dose | 0.60 [43] | | |
| | Repair perineal tear | procedure | 15 [43] | | |
| | Repair perineal tear in operating theatre | procedure | 678 [38] | 1057 | 957 |
| | Manual removal of placenta | procedure | 746 [38] | 746 [38] | 1059 |
| | Paediatric consultation | visit | 16 [37] | | |
| | Gynaecological consultation | visit | 20 [37] | | |

**Table 1 • Continued** Unit cost (2015, €) in base case analysis, and sensitivity analysis using maximum cost prices and cost prices resulting from bottom up calculation

| | | Unit | Base case analysis | Sensivity analysis | |
|---|---|---|---|---|---|
| | | | | Maximum cost in literature | Bottom up calculation |
| Admission and transport | Admission mother and child | | | | |
| | hospital stay - ward | day | 398 [42] | | |
| | hospital stay - medium care | day | 605 [42] | | |
| | NICU-stay | day | 1679 [42] | | |
| | Ambulance transport - urgent | procedure | 559 [37] | | |
| | Ambulance transport - non urgent | procedure | 270 [37] | | |
| Postnatal care | Postpartum consultation by a midwife | visit | 33 [47] | | |
| | Birth centre stay | day | 372 | | |
| | Maternity care assistance | hour | 45 [39] | | |
| | Maternity care assistance | once | 84 [39] | | |

model using the other variables as predictors; this then imputes missing values for the relevant variable. Rubin's rules were used for combining the 20 imputed datasets (49).

We estimated differences in costs using the one-way analysis of variance (ANOVA). Although the cost data were skewed, the arithmetic mean is the informative measure for cost data in cost-effective analysis. Analyses other than the arithmetic mean can produce misleading conclusions. Therefore, ANOVA is appropriate for costs where untransformed data are concerned (50, 51). Multiple regression was used to estimate the differences in total cost and to adjust for potential confounders including parity (nulliparous/multiparous), mean maternal age, maternal background (Dutch/non-Dutch), urbanisation and socio-economic status (SES). Urbanisation (<500 addresses per $km^2$/500-1500 addresses per $km^2$/≥1500 addresses per $km^2$) and SES (high/medium/low) were based on the characteristics of the four-digit postal code area in which the participants live (level of income, educational level, labour market situation) (52).

Non-parametric bootstrapping was used, involving 1,000 replications, to calculate uncertainty around all cost and health outcomes estimates. The net benefit regression framework was used to construct the cost-effectiveness acceptability curve (CEAC) comparing a planned birth in a hospital or at home to a planned birth in a birth centre (53). Net benefit regression uses net benefit, defined as $nb = \lambda \bullet effect - cost$ for each individual patient as dependent variable, where $\lambda$ is the maximum willingness to pay for a point improvement on the OI. Using the regression equation $nb = \alpha + \beta\, BC + \gamma\, X + \varepsilon$

with BC the indicator variable for a planned birth in a birth centre, e.g. BC= 1 if the planned birth was in a birth centre and BC = 0 if the planned place of birth was in a hospital or at home respectively, and X the potentially confounding variable (parity, maternal age, maternal background, urbanisation and socioeconomic status) results in estimation of $\beta$ and its p-value, with the latter being used to construct the CEAC. The CEAC for comparing the different types of birth centres was based on bootstrapping the adjusted costs and health outcomes and plotting the proportion of births with the highest net benefit for the different types of birth centres (with respect to location and integration profile) for a range of values relating to the willingness to pay for a point improvement on the OI.

Since it is known that parity highly influences the progress and outcomes of childbirth (54), all analyses were repeated by parity subgroup (nulliparous vs. multiparous women). Analyses were performed using SPSS version 21 (SPSS, Chicago, IL) and Microsoft Excel (Microsoft, Seattle, WA) 2010 software.

## Results

### Health outcomes

The characteristics of the participating women and the analyses of the health outcomes are reported in detail elsewhere (22). Overall, no differences on the OI were found in the cohort study between a planned birth in a birth centre (nulliparous OI=25.8 and multiparous OI=28.1) and a planned birth in a hospital (nulliparous OI=26.0 and multiparous OI=28.0). Women who planned to give birth at home had better outcomes (higher score on the OI) on the OI (nulliparous OI=26.3 and multiparous OI=28.8) compared with a planned birth in a birth centre; the effect size is small for nulliparous and medium for multiparous. Within the three types of birth centres based on location only the OI score of nulliparous women with a planned birth in a freestanding birth centre (27.4) was better ($p<0.001$) compared with a planned birth in an alongside birth centre (OI=25.7). No statistical differences in the OI were found for the three different integration profiles, either for nulliparous (MOBC OI=25.7, MIBC OI=25.7 and MUBC OI=26.0) or for multiparous women (MOBC OI=27.9, MIBC OI=28.0 and MUBC OI=28.5).

Overall, an adverse perinatal outcome was rare. No differences were found in the total number of women with one or more adverse outcomes (CAO) between planned births in a birth centre, in a hospital or at home (22).

### Unadjusted costs in categories

The total unadjusted mean costs per low-risk woman for births planned in a birth centre

(€3.361) are almost the same as those in a hospital (€3.354) and significantly (p<0.001) higher than those at home (€2.942). The significant difference in total costs between a planned birth in a birth centre and a planned birth at home is mainly due to: 1) the fact that more women with a planned birth in a birth centre received an epidural and a cardiotocography, 2) the higher overhead costs of the birth centre itself and 3) more mothers and children with a planned birth in a birth centre being admitted to a clinical ward. With regard to the different types of birth centres (based on location and integration profile) there were no differences in unadjusted mean costs, see Table 2.

## Adjusted total costs

The general linear model on costs showed that, after adjustment for confounders, the costs of a planned birth in a birth centre (€3.327) remained the same as in a hospital (€3.330) and were significantly ($p$<0.001) higher than a planned birth at home (€2.998). With regard to the different types of birth centres (based on location and integration profile) the adjusted mean costs did not vary significantly either.

Restriction of the analyses to nulliparous women showed overall higher mean costs per woman. The costs of a planned birth in a birth centre (€3.653) and at home (€3.397) differed significantly ($p$<0.001). With regard to the different types of birth centres (based on location and integration profile) there were no differences in adjusted mean costs.

Restriction of the analyses to multiparous women showed overall lower mean costs per woman and significantly ($p$<0.001) lower costs for women with a planned place of birth at home (€2.639), compared with a birth planned in a birth centre (€3.018). The adjusted mean costs of a planned birth in a freestanding birth centre (€3.278) were significantly ($p$<0.05) higher than in an alongside birth centre (€3.003). The adjusted mean costs of a planned birth in a birth centre in MIBC (€2.839) were significantly ($p$<0.01) lower than MUBC (€3.098), see Table 3.

## Mean costs and health outcomes (OI)

Uncertainty around costs and health outcomes (OI) obtained by bootstrapping are plotted in Figure 1a (total group) and Figure 1b (nulliparous and multiparous women).

## Mean costs and health outcomes (CAO)

The total adjusted composite adverse outcome score (CAO) and the adjusted total mean costs per woman were similar for women with a planned birth in a birth centre and in a hospital. The CAO was also similar for women with a planned birth in a birth centre and at home, but a planned birth at home resulted in lower costs, see Figure 2a. With regard to the parity subgroups, multiparous women had more favourable health outcomes and lower adjusted total mean costs than nulliparous women, see Figure 2b.

**Table 2** • Unadjusted mean (SD) costs (2015, €) in categories per woman according to planned place of birth

| Planned place of birth | Consultation and medication during first and second stage[a] | Birth and intervention during second stage[b] | Intervention and consultation during third stage[c] | Admission and transport[d] | Postnatal care[e] | Total |
|---|---|---|---|---|---|---|
| Birth centre (n=1668) REF | 155 (140) | 1074 (321) | 55 (179) | 254 (858) | 1823 (311) | 3361 (1015) |
| Hospital^ (n=701) | 148 (134) | 1015 (327)*** | 39 (145)* | 288 (1013) | 1863 (269)** | 3354 (1143) |
| Home (n=1086) | 105 (106)*** | 696 (286)*** | 43 (157) | 201 (845)* | 1898 (215)*** | 2942 (892)*** |
| Birth centre - location | | | | | | |
| Freestanding (n=65) | 98 (109)*** | 1280 (260)*** | 32 (116) | 193 (558) | 1884 (288) | 3487 (641) |
| Alongside (n=1202) REF | 163 (143) | 1061 (307) | 51 (172) | 260 (860) | 1827 (304) | 3362 (976) |
| On-site (n=401) | 141 (132)** | 1078 (358) | 71 (205) | 245 (947) | 1804 (331) | 3338 (1164) |
| Birth centre - integration profile | | | | | | |
| MOBC[1] (n=923) | 163 (136)* | 1112 (290) | 48 (162) | 231 (770) | 1841 (289) | 3394 (867) |
| MIBC[2] (n=349) | 147 (138) | 961 (332)*** | 70 (220) | 327 (1046) | 1763 (348)** | 3268 (1225) |
| MUBC[3] (n=396) REF | 144 (149) | 1085 (356) | 57 (176) | 244 (929) | 1835 (318) | 3366 (1118) |

^ community midwife led
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[1] Monodisciplinary-oriented, [2] Mixed group of birth centres, [3] Multidisciplinary-oriented
[a] Consultation and medication includes: home-visit by a midwife, gynaecological consultation, pain relief and cardiotocography during first and second stage
[b] Birth and intervention includes: community midwife, maternity care assistance, overhead costs and additional costs after referral during second stage
[c] Intervention and consultation includes: blood transfusion, oxytocin, repair perineal tear, manual removal of placenta, consultation by paediatrician/gynaecologist during third stage
[d] Admission and transport includes: admission mother and/or child to hospital and ambulance transport
[e] Postnatal care includes: consultation by a midwife, birth centre stay, maternity care assistance

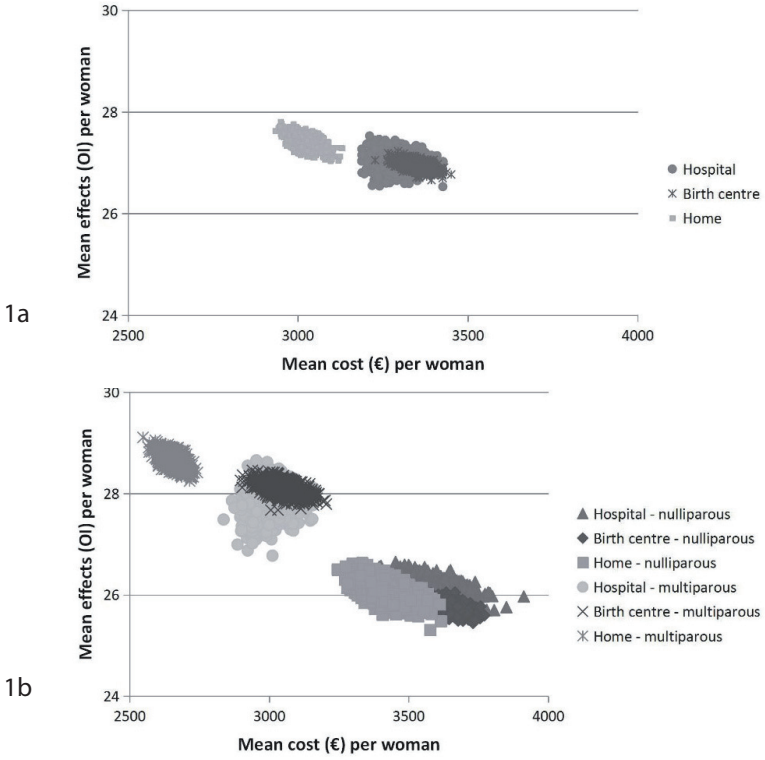



**Figure 1a and b** • Mean cost (2015, €) and health outcomes (optimality index) of planned birth at a birth centre, hospital and at home under the supervision of a community midwife

**Table 3** • (Adjusted) Mean (SD) of total costs (2015, €) per woman according to planned place of birth

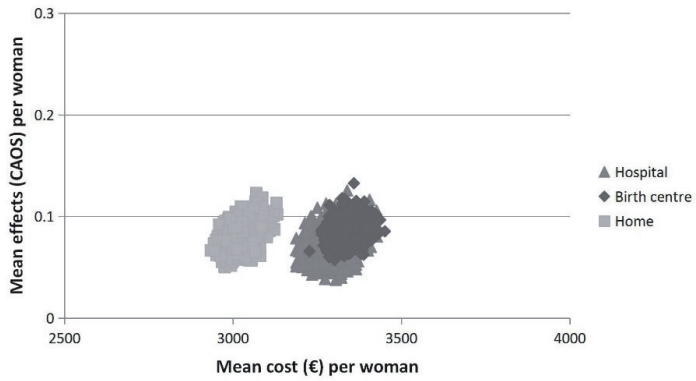
| | Total costs | | | Total costs | | |
|---|---|---|---|---|---|---|
| | n | Mean (SD) | B (95% CI) | n | Mean (SD) | B (95% CI) |
| **ALL LOW RISK WOMEN** | **Unadjusted** | | | **Adjusted#** | | |
| Birth centre | 1668 | 3361 (1015) | ref | 1610 | 3327 (6194) | ref |
| Hospital^ | 701 | 3354 (1143) | -7.4 (-99.4 - 84.6) | 659 | 3330 (1158) | 3.9 (-84.5 - 92.3) |
| Home | 1086 | 2942 (892) | -418.8 (-501.0 - -336.7)*** | 1067 | 2998 (1414) | -328.6 (-413.6 - -243.7) *** |
| Birth centre - location | | | | | | |
| Freestanding | 65 | 3487 (641) | 124.6 (-139.3 - 388.5) | 65 | 3469 (1026) | 162.7 (-86.8 - 412.2) |
| Alongside | 1202 | 3362 (976) | ref | 1158 | 3306 (5215) | ref |
| On-site | 401 | 3338 (1164) | -23.6 (-142.7 - 95.6) | 387 | 3364 (1142) | 57.6 (-56.1 - 171.4) |
| Birth centre - integration profile | | | | | | |
| MOBC[1] | 923 | 3394 (867) | 28.5 (-94.4 - 151.3) | 889 | 3342 (1783) | -14.8 (-132.0 - 102.5) |
| MIBC[2] | 349 | 3268 (1225) | -97.6 (-250.9 - 55.8) | 338 | 3250 (1377) | -107.3 (-254.2 - 39.6) |
| MUBC[3] | 396 | 3366 (1118) | ref | 383 | 3357 (3094) | ref |
| **NULLIPAROUS** | **Unadjusted** | | | **Adjusted##** | | |
| Birth centre | 939 | 3655 (1114) | ref | 913 | 3653 (7276) | ref |
| Hospital^ | 348 | 3644 (1356) | -11.5 (-160.3 - 137.3) | 328 | 3607 (1397) | -45.8 (-196.9 - 105.4) |
| Home | 399 | 3390 (1084) | -265.7 (-415.6 - -115.9)*** | 392 | 3397 (1584) | -255.6 (-412.7 - -98.5)*** |
| Birth centre - location | | | | | | |
| Freestanding | 33 | 3691 (673) | 56.1 (-361.7 - 474.0) | 33 | 3680 (1262) | 51.2 (-379.8 - 482.2) |
| Alongside | 699 | 3635 (1061) | ref | 680 | 3629 (6317) | ref |
| On-site | 207 | 3720 (1319) | 84.7 (-97.0 - 266.5) | 200 | 3730 (1378) | 100.8 (-90.2 - 291.9) |

**Table 3 • Continued** (Adjusted) Mean (SD) of total costs (2015, €) per woman according to planned place of birth

| | | Total costs | | | Total costs | |
|---|---|---|---|---|---|---|
| | n | Mean (SD) | B (95% CI) | n | Mean (SD) | B (95% CI) |
| Birth centre - integration profile | | | | | | |
| MOBC[1] | 522 | 3666 (954) | 19.9 (-162.9 - 202.7) | 507 | 3657 (2199) | 10.8 (-180.6 - 202.2) |
| MIBC[2] | 198 | 3636 (1243) | -10.4 (-238.0 - 217.1) | 193 | 3649 (1694) | 3.4 (-235.8 - 242.6) |
| MUBC[3] | 219 | 3647 (1319) | ref | 213 | 3646 (3664) | ref |
| **MULTIPAROUS** | | **Unadjusted** | | | **Adjusted##** | |
| Birth centre | 729 | 2982 (709) | ref | 697 | 3018 (3977) | ref |
| Hospital^ | 353 | 3068 (788) | 85.6 (-6.3 - 177.5) | 331 | 3074 (860) | 56.2 (-36.4 - 148.9) |
| Home | 687 | 2683 (623) | -299.7 (-374.0 - -225.4)*** | 675 | 2638 (1040) | -379.5 (-457.9 - -301.1)*** |
| Birth centre - location | | | | | | |
| Freestanding | 32 | 3276 (526) | 293.0 (37.8 - 548.3)* | 32 | 3278 (726) | 275.8 (24.2 - 527.5) |
| Alongside | 503 | 2983 (681) | ref | 478 | 3003 (3323) | ref |
| On-site | 194 | 2932 (792) | -51.0 (-171.0 - 69.0) | 187 | 3012 (838) | 9.3 (-110.8 - 129.4) |
| Birth centre - integration profile | | | | | | |
| MOBC[1] | 401 | 3040 (565) | 21.6 (-107.8 - 151.0) | 382 | 3049 (1302) | -48.5 (-179.1 - 82.0) |
| MIBC[2] | 151 | 2786 (1017) | -232.6 (-388.4 - -76.8)** | 145 | 2839 (955) | -259.2 (-414.7 - -103.7) ** |
| MUBC[3] | 177 | 3019 (654) | ref | 170 | 3098 (2082) | ref |

^ community midwife led
# adjusted for parity, maternal age, maternal background, urbanisation and social economic status
## adjusted for maternal age, maternal background, urbanisation and social economic status
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[1] Monodisciplinary-oriented, [2] Mixed group of birth centres, [3] Multidisciplinary-oriented

2a




2b

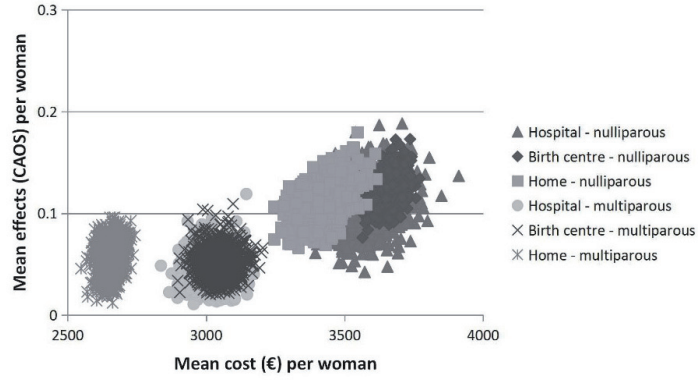



**Figure 2a and b** • Mean cost (2015, €) and health outcomes (composite adverse outcome score) of planned birth in a birth centre, hospital and at home under the supervision of a community midwife

## Cost-effectiveness acceptability curves

Figure 3 shows the probability that a planned birth in a hospital or at home is cost-effective, compared with a planned birth in a birth centre, for different willingness-to-pay values (€ 0 - € 2.000) for an improvement of one point on the OI. Regardless of the level of willingness to pay, a planned birth at home was likely to be cost-effective compared with a planned birth in a birth centre. A planned birth at home had more favourable health outcomes (higher score on the OI) and lower costs compared with a planned birth in a birth centre. The probability that a birth planned in a hospital is cost-effective increased with a higher willingness to pay, compared with a planned birth in a birth centre. A planned birth in a hospital had more favourable health outcomes (higher score on the OI) but also higher costs compared with a planned birth in a birth centre.

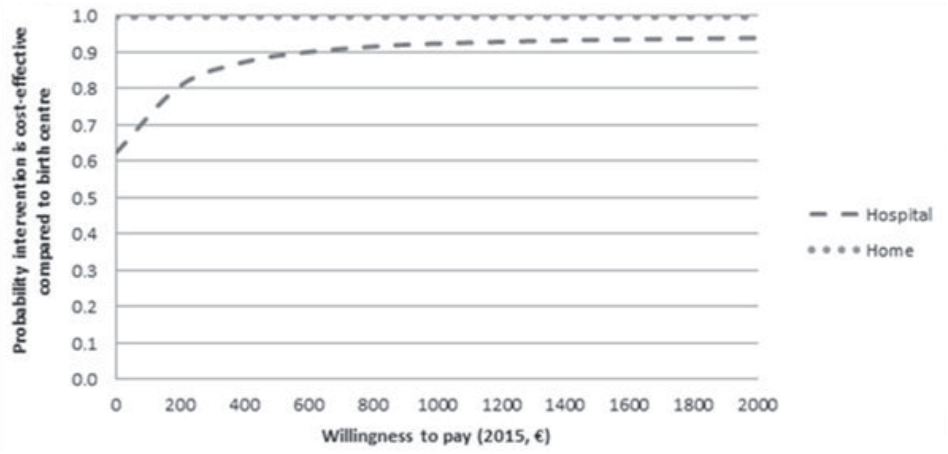



**Figure 3** • Cost-effectiveness acceptability curves, graphing the probability to be cost-effective for planned birth at the hospital and at home compared with the birth centre, for different values of the willingness to pay for an additional point on the Optimality Index

## Cost-effectiveness acceptability curves- type of birth centre based on location

Figure 4 shows the probability that a planned birth in a particular type of birth centre based on location is cost-effective, compared with a planned birth in the two other location types, for different willingness-to-pay values (€ 0 - € 1.000). If the willingness to pay for an extra point on the OI (health benefits) is € 0, the probability that a planned birth in an alongside birth centre is cost-effective is highest. The higher the willingness to pay, the higher the probability that a planned birth in a freestanding birth centre is cost-effective, compared with the two other types (alongside and on-site). A planned birth in a freestanding birth centre had more favourable health outcomes (higher score on the OI), but higher costs, compared with the two other types.

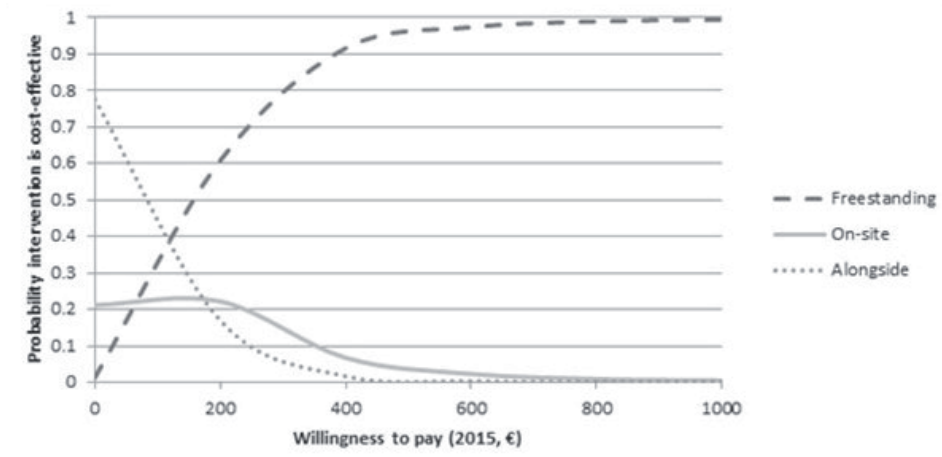



**Figure 4 •** Cost-effectiveness acceptability curves, graphing the probability to be cost-effective for planned birth in a freestanding, alongside and on-site birth centre, for different values of the willingness to pay for an additional point on the optimality index

## Cost-effectiveness acceptability curves - integration profile of birth centre

Figure 5 shows the probability that a planned birth in a particular type of birth centre based on integration profiles is cost-effective, compared with a planned birth in the two other types, for different willingness-to pay-values (€ 0 - € 1,000). If the willingness to pay for an extra point on the OI (health benefits) is € 0, the probability that a planned birth in a MIBC is cost-effective is highest. The higher the willingness to pay, the higher the probability that a planned birth in an MUBC is cost-effective, compared with the two other types (MOBC and MIBC). A planned birth in an MUBC has more favourable health outcomes (higher score on the OI), but higher costs, compared with the two other types.

## Adjusted total mean costs with varying costs prices

Finally, sensitivity analyses produced similar results as the original generalised linear model on costs: no cost differences between planned birth in a birth centre and in a hospital; planned birth at home had significantly ($p$<0.001) lower costs than planned birth in a birth centre; and no cost differences between the different types (based on location and integration profiles) of birth centres, see Table 4.

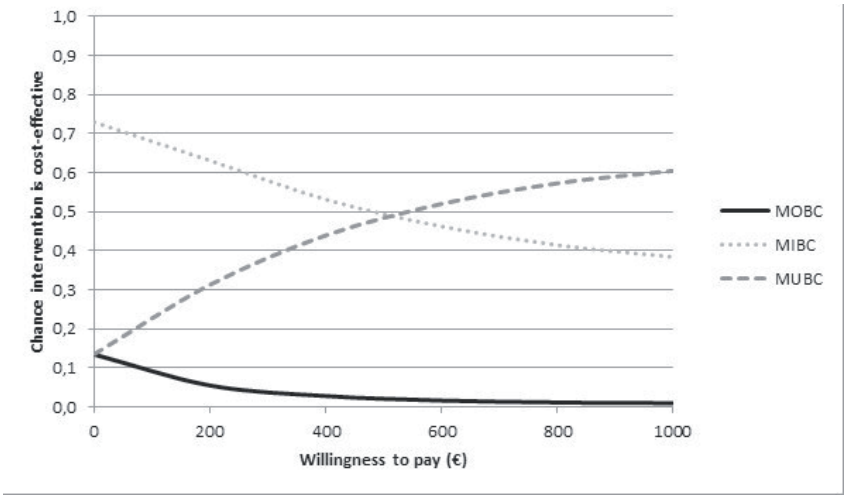



**Figure 5** • Cost-effectiveness acceptability curves, graphing the probability to be cost-effective for planned birth in a MOBC, MIBC and MUBC, for different values of the willingness to pay for an additional point on the optimality index

**Table 4** • Adjusted mean (SD) of total cost (2015, €) per woman according to planned place of birth in sensitivity analyses using maximum cost prices and cost prices resulting from a bottom up calculation with five hospitals.

| | Maximum cost | | Bottom-up calculation | |
|---|---|---|---|---|
| | Adjusted# | | Adjusted# | |
| ALL LOW RISK WOMEN | Mean (SD) | B (95% CI) | Mean (SD) | B (95% CI) |
| Birth centre (n=1610) | 3696 (7601) | ref | 3206 (6103) | ref |
| Hospital^ (n=659) | 3643 (1456) | -53.5 (-164.7 - 57.7) | 3182 (1157) | -24.3 (-112.6 - 64.1) |
| Home (n=1067) | 3271 (1742) | -425.4 (-530.0 - -320.8)*** | 2919 (1413) | -287.1 (-372.0 - -202.2)*** |
| Birth centre - location | | | | |
| Freestanding (n=65) | 3638 (1281) | -50.5 (-362.0 - 261.0) | 3397 (1025) | 219.4 (-29.9 - 468.7) |
| Alongside (n=1158) | 3689 (6490) | ref | 3178 (5211) | ref |
| On-site (n=387) | 3729 (1433) | 39.9 (-102.9 - 182.7) | 3260 (1141) | 82.4 (-31.3 - 196.1) |
| Birth Centre - integration profile | | | | |
| MOBC[1] (n=889) | 3730 (2246) | 36.0 (-111.7 - 183.7) | 3201 (1783) | -54.9 (-172.1 - 62.4) |
| MIBC[2] (n=338) | 3604 (1712) | -89.9 (-272.4 - 92.7) | 3165 (1376) | -90.3 (-237.1 - 56.5) |
| MUBC[3] (n=383) | 3694 (3866) | ref | 3256 (3093) | ref |

^ community midwife led
# adjusted for parity, maternal age, maternal background, urbanisation and social economic status
*** $p < 0.001$
[1] Monodisciplinary-oriented, [2] Mixed group of birth centres, [3] Multidisciplinary-oriented

# Discussion

## Summary of main findings

No differences were found in costs for birth if planned either in a birth centre or in a hospital. The costs of a planned birth at home are significantly lower compared with a planned birth in a birth centre. The total adjusted mean costs for births planned in a birth centre, in a hospital and at home were €3.327, €3.330 and €2.998 respectively. There was no difference in the score on the OI for women who planned to give birth in a birth centre compared with women who planned to give birth in a hospital. Women who planned to give birth at home had better outcomes on the OI (higher score on the OI). No differences were found for the CAO by planned place of birth. For nulliparous and multiparous low-risk women, a planned birth at home was the most cost-effective option compared with a planned birth in a birth centre.

No differences were found in the total adjusted mean costs for planned births for the different types of birth centres (based on location and integration profiles). The respective total adjusted mean costs for a birth planned in a freestanding, alongside and on-site birth centre were €3.469, €3.306 and €3.364. The respective total adjusted mean costs for births planned in a birth centre were €3.342, €3.250 and €3.357, when divided by the integration profile a) monodisciplinary-oriented, b) mixed group of birth centres and c) multidisciplinary-oriented). Within the three types of birth centres based on location the OI score for nulliparous women with a planned birth in a freestanding birth centre was significantly higher compared with a planned birth in an alongside birth centre. No big differences on the OI were found for the three different integration profiles. The CAO of nulliparous women with a planned birth in an MIMC was significantly more unfavourable than a planned birth in an MUBC.

## Strengths and weaknesses

This study is an initial attempt to expand the net benefit regression framework from two to three treatments. In the literature on cost-effectiveness analyses, only two treatments have to date been compared using the net benefit regression approach. This study has a high participation rate as regards midwifery practices (110 of the 127 approached) and birth centres (21 out of 23), which reduces the chance of bias. Sensitivity analyses, using different prices, produced similar results and conclusions to those of the original generalised linear model on costs, in other words: the impact of systematic errors (bias) was low.

The limited time horizon of the study meant that the registration of outcomes for mother and child did not extend beyond one week postpartum. Perinatal events (such as a low Apgar score) can result in associated longer-term costs, which are not covered

in this study. As serious perinatal events were rare in this low-risk group, this would not have changed the results (22). As usual in economic evaluations we had to deal with missing data. However, the magnitude of missing data was limited and multiple imputation (20 datasets) was used to impute the missing data.

A problem of all (Dutch) studies comparing places of birth is that women in these places are all different. Although this is taken into account in the statistical analyses by adjusting for SES, maternal background, parity, age and urbanisation, it is not possible to adjust completely. For example, women who planned to give birth in a birth centre or hospital may have a different view on childbirth and are perhaps more anxious than women who planned to give birth at home (55-58). In addition, there may be differences between the groups as regards lifestyle, such as smoking, and obstetric history, including the number of miscarriages. Therefore, the minor differences found in this study may be the result of differences between the women rather than between the settings.

## Interpretation of the results

This study is part of the Dutch Birth Centre study (30). The motive for this national study was the strong increase in the number of birth centres in the Netherlands over the last few decades and the unknown effect on outcomes such as costs, medical outcomes and client experiences.

We found comparable costs for a planned birth supervised by a community midwife in a birth centre and in a hospital and significantly lower costs for a planned birth at home. Another Dutch study found that the total costs associated with pregnancy, childbirth, and postpartum care are comparable for home birth and hospital birth. That study found lower costs during childbirth and postpartum care for maternity care assistance, admission and travelling costs for the home birth group compared with the hospital group (14). Our study showed lower costs for maternity care assistance for the birth centre group compared with the hospital and home birth group. In line with that study the admission and transport costs were lower for the home birth group. The other study was based on actual births and not, as in our study, on planned place of birth (intention to treat) and did not include the birth centre setting. We did not include pregnancy costs since this is not part of birth centre care in the Netherlands. Our results are in line with a study in England where a planned birth at home is cost-effective compared with a planned birth in alongside or freestanding midwifery units and obstetric units. However, we did not find increased adverse perinatal outcomes for nulliparous women planning to give birth at home (15).

One of the aims of this study is to provide objective, reliable and valid information to support decision-making and policy-making in healthcare. As most low-risk women

in the Netherlands are now planning to give birth outside their home, it is necessary to offer these women a good alternative. Birth centres offer a more homelike environment and are based on the philosophy of physiological birth. To know whether birth centres are a good alternative, policy makers, health insurers and managers want information on the cost-effectiveness of birth centres versus alternative places of birth. We conclude that for nulliparous and multiparous low-risk women a planned birth at home was the most cost-effective option compared with a planned birth in a birth centre. Planned births in birth centres have similar health outcomes and costs as hospital births for low-risk women.

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