# Costing childbirth at home, in a birth centre or in a hospital for women at low risk of pregnancy complications in New South Wales, Australia

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**CERTIFICATE OF ORIGINAL AUTHORSHIP**

I, Vanessa L Scarf, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Health at the University of technology Sydney.

This thesis is wholly my own work unless otherwise referenced of acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This research is supported by the Australian Government Research Training Program.

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# Publications included in this thesis

## Statement of contributions to jointly authored works contained in the thesis

The results from this thesis have been submitted for publication in peer-reviewed journals. Below is a description of the contributions made to the papers by the co-authors. I take full responsibility for the accuracy of the findings presented in these publications and this thesis. All authors have given permission for the publications to be incorporated into this PhD.

## Thesis Format

This is a thesis by compilation and consists of seven chapters, five of which are papers; Chapters two to six. Chapters two, three and five are papers that have been published during my PhD candidature. Chapters four and six are currently under review. Publication details for each chapter are outlined below, together with a statement of contribution and percentage contribution for each author.

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# Table of Contents

Abstract

**Background**

There are three settings available to women in which to give birth in New South Wales: Home, birth centre and hospital. The cost of giving birth for women at low risk of complications in each of these settings is not known.

**Aim**

The aim of this study was to estimate the cost of giving birth for women at low risk of complications who are planning birth at home, in a birth centre or in a hospital in NSW from the perspective of the health service.

**Methods**

A cost analysis was conducted comprising four components. Firstly, two systematic reviews were conducted to examine the literature on 1) the safety of giving birth at home or in a birth centre, and 2) the cost associated with birth in these settings. Secondly, a decision tree framework was used to map the trajectories (or pathways) of women in New South Wales using linked health data. Thirdly, a micro-costing study employing time-and-motion observation along with resource use data collection via a unique data collection sheet was conducted. Finally, using the decision tree framework, a macro-costing analysis, the cost of the trajectories of the women who planned birth at home, in a birth centre or in hospital was estimated using Australian-Refined Diagnosis Related Groups (AR-DRGs).

**Findings**

Maternal and perinatal outcomes of planned place of birth were significantly better for women planning birth at home or in a BC, including higher rates of normal vaginal birth and lower rates of intervention and admission to the NICU for infants. The trajectories of women showed those who plan to give birth at home or in a BC have high rates of vaginal birth and women in all groups had low rates of intervention. When cost was explored, it was either less costly or the same to provide birth services at home or in a BC. The median micro-cost of providing care for women who plan to give birth at home, in a birth centre or in a hospital were AUD $2150.07, $2094.86 and $2097.30

respectively. Macro costs using AR-DRGs for homebirth, BC and hospital birth were $4748, $4979 and $5463 respectively.

**Conclusion**

Given the relatively lower rates of complex intervention and adverse neonatal outcomes associated with women at low risk of complications, expanding choices for women to give birth at home or in a BC would be less costly to the health system. However, what is required now is the political will and advocacy to progress the future planning of maternity service provision in New South Wales.

# Chapter 1: Introduction

There are three places of birth available to women in Australia; at home, in a birth centre and in hospital (the characteristics of these birth settings are described below). The availability of these settings for birth varies between rural and metropolitan areas. There is very little information available regarding the costs associated with providing homebirth or birth centre facilities for women in Australia. This limited understanding of the costs involved in providing options for place of birth impedes decision making by policy makers, clinicians and childbearing women. Research into the costs of these birth settings will contribute an economic perspective to inform policy makers and service providers about the relative costs of providing alternative choices of birth settings for women at low risk of complications in New South Wales.

Evidence supporting the safety of alternative birth settings in Australia is building (Homer et al. 2014; Homer et al. 2019; McLachlan et al. 2012; McLachlan et al. 2008; Tracy et al. 2013) however, there are few studies reporting the comparative costs of birth settings. Internationally, the Birthplace in England Prospective Cohort Study examined the outcomes of 64,538 women and babies according to intended place of birth at the onset of labour (Birthplace in England Collaborative et al. 2011). This study conducted a cost-effectiveness analysis and found that it was less expensive and as safe for low risk women to give birth at home or in a birth centre, especially for women having their second or subsequent baby (Schroeder et al. 2012).

The cost analyses performed in Australia to date have examined the model of care (Homer et al. 2001; Toohill et al. 2012; Tracy et al. 2013) or public versus privately provided care (Tracy & Tracy 2003). These studies do not address the comparative cost to the health system in Australia of giving birth at home or in a birth centre compared to a hospital setting for women at low risk of complications.

This thesis forms part of the Birthplace in Australia Study. The Birthplace in Australia Study is a National Health and Medical Research Council (NHMRC) funded study (grant numbers 1022422 and 1103015) focusing on maternal and neonatal outcomes by place of birth for women at low-risk of complications using linked administrative data

from every state and territory around the country (Homer et al, 2019). One aspect of the Birthplace in Australia Study is a cost analysis, the focus of this thesis.

This chapter will provide an introduction and background to this thesis, focussing on the current healthcare system and specifically, maternity care in Australia, including place of birth and choice of birth setting. In addition to providing an overview of the research described in this thesis, this chapter also introduces the concepts of economic evaluation in general, and specifically related to place of birth. The aims and objectives of this research described here form the structure of this thesis, as it is mapped to each research objective. Ultimately, this thesis provides much needed evidence of the cost of three different birth settings available to women in New South Wales and will inform service providers' decision making around the expansion of maternity care choice for women in this state.

## Background

Maternity services are the third most common specialist service in Australia and 'single spontaneous delivery' is the most common principal diagnosis among acute overnight separations (from hospital) in Australia (Australian Institute of Health and Welfare 2018a). There are over 300,000 births in Australia each year, and in 2017, the vast majority (96.7%) of Australian women planned to give birth in a hospital, either in a public (77%) or private hospital (23%). The remaining women intended a birth centre birth (2.4%) or a homebirth (0.3%) (AIHW 2019).

In 2009, the Department for Health and Ageing released the National Review of Maternity Services which contained feedback from stakeholders outlining issues relating to limited access to models of care (Commonwealth of Australia 2009). As a result, the National Maternity Services Plan (Australian Health Ministers' Advisory Council 2011) was released in 2011 with priorities for the following five years. One of these was to "increase access for Australian women and their family members to local maternity care by expanding the range of models of care" going on to state that "continuing to provide a range of maternity care options, including homebirth, is a priority" (p 31). While this was a worthy priority, it is not available to many women in Australia, with a lack of knowledge about relative costs being one potential reason. There are barriers to expanding choices of place of birth which will be further discussed in chapter 7. A lack of availability is one issue, a broader social and political

construct is another, and this contributes to the lack of availability of birth place options. Politics and the interests of various contributors to policy development influence health service reform; it is recognised that data is only one component of the evidence required to effect policy change. This study will fill a gap and provide much needed evidence to inform healthcare policy relating to choice of place of birth.

### *The Australian healthcare system*

The Australian healthcare system is a complex, multi-tiered system including public and private providers. Australian Governments, both state and federal, fund and support universal access to health care through the taxation-funded Medicare system which is delivered via a plethora of publicly and privately provided services (Australian Institute of Health and Welfare 2018b). At a federal level, Medicare subsidises consultations with general practitioners and medical specialists, pharmaceuticals, tests, and public hospitals, as well as an increasing number of other health professionals (Duckett & Willcox 2015) including endorsed midwives. Government expenditure on health care amounted to 67% of the total health funding and non-government sources, including individuals and private insurers funded the remaining 33% (Australian Institute of Health and Welfare 2018b).

State and territory governments are responsible for operating public hospitals, and receive funding through activity based funding (ABF), a mechanism by which hospitals are recompensed for the number and acuity of patients that are treated in a public hospital (IHPA 2019). Other contributions come from Medicare, non-government organisations, individuals and private health insurers (Australian Institute of Health and Welfare 2018b). This complex funding structure can result in cost-shifting between levels of government, for example, General Practitioner (GP) antenatal shared care, which may be encouraged by health services to ease the burden in metropolitan public hospital antenatal clinics. GP shared care can, however, be a way of receiving continuity of carer, particularly for women in rural settings (Doggett 2017; Hoang, Le & Ogden 2014).

The Federal and state governments are also responsible for regulating the health system, including practitioners working within it. In 2010, the National registration and Accreditation Scheme developed nationally consistent legislation and now sixteen

health professions are regulated through the Australian Health Practitioner Regulation Agency (AHPRA).

*Maternity care providers and models of care*

Maternity care in Australia is provided by midwives and doctors in a variety of models of care and settings. Recent research by Donnolley et al. (2019) classified maternity models of care with the view to standardise recording these models in health data collections (Donnolley et al. 2019). The following models of midwife-led care were identified in the Maternity Care Classification System (MaCCS): Private midwifery care, public hospital maternity care, team midwifery care, midwifery group practice caseload care, remote area maternity care (Donnolley et al. 2019). All these models of midwifery care are practised within the scope of practice of a midwife and referrals are made when the needs of the woman fall outside this scope, as determined in the Australian College of Midwives Consultation and Referral Guidelines (Australian College of Midwives 2014).

In Australia, midwives are educated in universities either in a baccalaureate degree (Bachelor of Midwifery, Bachelor of Nursing/Bachelor of Midwifery combined degree) or as a postgraduate degree (Graduate Diploma in Midwifery, Master of Midwifery) for which nursing registration is a pre-requisite. They are registered to practice by the Nursing and Midwifery Board of Australia (NMBA) and practice to the NMBA Midwife Standards for Practice.

Doctors undertake either speciality training as an obstetrician and gynaecologist, or general practitioners (GP) augment their qualifications with a diploma of obstetrics and gynaecology which enables them to engage women in GP shared care. GP shared care is available in metropolitan and rural Australia and in rural regions, GP obstetricians are often the highest qualified medical practitioner who provides maternity care in that region. The remaining models of care as defined in the MaCCS relate to either medical models or shared models of care: Private obstetrician (specialist) care, General practitioner obstetrician care, shared care, public hospital high-risk maternity care and private obstetrician and privately practising midwife joint care (Donnolley et al. 2019).

In Australia, birth setting is closely linked with model of care, as homebirth and birth in a birth centre are almost exclusively provided through midwife-led models of care (a small number of private obstetricians care for women who choose to give birth at a birth centre). There are also midwife-led models of care in hospital settings through antenatal clinics, run both in the hospital and in the community in some areas.

Midwife-led models of care are often recommended for women at low risk of complications and have been shown to confer many benefits for women and their babies (Sandall et al. 2016). Sandall et al. (2016) conducted a review of 15 trials (17,674 women) which investigated the outcomes of women who were randomly allocated to midwife-led continuity models and other models of maternity care. The primary outcomes included in the review were regional analgesia, mode of birth, intact perineum, pre-term birth, fetal loss and cost. Results of the meta-analyses showed that women engaged in midwife-led continuity of care models had a higher spontaneous vaginal birth rate and reduction in epidural analgesia, reduction in the rate of instrumental birth and increased feelings of satisfaction (Sandall et al. 2016). The results of the analysis of costs reported in some of the included studies suggested a cost saving for intrapartum care for midwife-led continuity of care compared to medical-led care.

### *Birth settings in Australia*

The setting for this study is NSW, the most populous state in Australia. NSW contributes over one third of Australian births per annum (in 2017, 95,825 babies were born in NSW and 309,142 babies were born across Australia). There are 61 maternity hospitals with birth rates over 200 per year in NSW. This number comprises 46 public hospitals and 15 private hospitals (Centre for Epidemiology and Evidence 2017). Within these services, there are five freestanding birth centres and five alongside birth centres, however these birth centre settings are sparsely located and not available to all eligible women in NSW.

### *Hospital Birth Suites*

Hospital birthing services are referred to as ‘birth suites’, ‘labour wards’, ‘delivery suites’ or ‘birth units’, and for the purposes of this thesis, when ‘hospital’ is referred to, it is intended to mean a birth suite in a hospital setting. Hospital birthing services

are staffed by midwives and doctors and are available to women with and without pregnancy complications, in both the public and private sector.

*Birth Centres*

A birth centre offers maternity care to women at low risk of complications, throughout the pregnancy, labour and birth and into the post-natal period, sometimes for up to six weeks. The birth centre setting is a more "home-like" environment, with a strong emphasis on natural, normal birth (Laws et al. 2009; Tracy et al. 2007). This is a midwifery-led model of care, sometimes in a team structure (team midwifery care) or individually allocated as is seen in a Midwifery Group Practice or "caseload" model. Birth centres are mostly co-located within the campus of a standard maternity facility (sometimes called alongside midwifery units) or are free-standing midwifery units, that is, located apart from a hospital that provides obstetric and neonatal services and can be some distance from such services. All birth centres are publicly funded in NSW.

*Homebirth*

Homebirth refers to the choice of a woman to give birth at home under the care of a midwife, either publicly funded or privately practising. There are currently fourteen publicly funded homebirth services available in Australia, four of which are in NSW (National Publicly-funded Homebirth Consortium 2018). These programs operate out of selected public hospitals and the midwives are employees of the health system. The other homebirth option for women is to engage a privately practising midwife, who is registered as a midwife with the Australian Health Practitioner Regulating Agency (AHPRA), and operate within a private business model.

The majority of Australian women, however, do not have access to these birth settings. Publicly-funded homebirth models have been established around the country but still cater for very small numbers of women, in fact less than 2000 women over a six year period in one study from 2013 (Catling-Paull, Coddington, Foureur, Homer, et al. 2013).

*Safety of different places of birth*

The impact of birth setting is an issue debated around the world with the debate centring on maximising the safety of women and their newborn babies. In low and middle-income countries, the best evidence indicates better outcomes for women and infants where skilled birth attendants are present (Alkema et al. 2015; Koblinsky et al.

2006; Prata et al. 2011), most likely in a health care facility. For women in high-income countries where skilled birth attendants are available across birth settings, safety is less of an issue and women are increasingly seeking greater choice in childbirth, including options other than institutional health facilities where technology and intervention prevail.

The Birthplace in England study examined the outcomes of more than 64,000 women with a singleton pregnancy at term specifically comparing place of birth between 2008 and 2010 (Birthplace in England Collaborative et al. 2011). A composite primary outcome of perinatal mortality and intrapartum-related neonatal morbidities was used to compare outcomes using planned place of birth at the onset of labour (at home, freestanding midwifery units, alongside midwifery units and obstetric units). The findings showed no significant differences in the adjusted odds of the primary outcome for any of the non-obstetric unit settings compared with obstetric units, however there were differences according to parity. Transfer rates and the odds of the primary outcome were higher for nulliparous women having homebirths however for multiparous women, transfer rates were lower and there were no significant differences in outcomes between the settings.

The safety of place of birth has been investigated in several countries in recent years, largely through observational studies (Davis et al. 2011; De Jonge et al. 2009; Janssen et al. 2009) and an un-blinded, pragmatic randomised trial (Begley et al. 2011). All these studies reported outcomes of no significant difference between the alternative birth settings and the hospital setting, as well as significantly higher risk of intervention for women in the hospital groups (Begley et al. 2011; Davis et al. 2011; De Jonge et al. 2009; Janssen et al. 2009). Chapter 2, a systematic review and meta-analysis of maternal and perinatal outcomes by planned place of birth (Scarf et al. 2018), presents and synthesises evidence of the safety of these different birth settings.

An investigation of the outcomes for women who gave birth in different settings in NSW was undertaken as part of the Birthplace in Australia Study (Homer et al. 2014). Women who gave birth at home or in a birth centre were more likely to have a normal labour and birth, compared with women in the standard labour ward group. There was no statistically significant difference in stillbirth and neonatal death rates among the

three settings. There were similar findings in the Birthplace in Australia Study on a national level (Homer et al. 2019).

Fundamental to the safety debate is the issue of proximity to emergency care when required. Intrapartum transfer from home or a birth centre is argued to be an unacceptable risk to the woman and baby and is perceived as a barrier to providing these choices of place of birth. Evidence presented in this thesis will describe the safety of birth at home and in a birth centre (Chapter 2) and the frequency of transfer from these settings (Chapter 4) for women at low risk of complications.

*Why is it important to provide a choice of birth setting to women in Australia?*

The decision of where to give birth for a woman is considered "through a woman's personal lens of values and experiences, including her previous healthcare experience" (Nieuwenhuijze & Low 2013) p277). This philosophy is often challenged by the notions of risk and risk minimisation. The public discourse in Australia regarding the 'safest' or 'most sensible' place to give birth revolves around hospital, and for many women, this is the only option either because of the limited availability of home or birth centre birth services or because of a systemic fear to provide alternatives.

For many women, there is limited choice of place of birth, and often women's ability to make this decision is influenced by scientific evidence delivered in such a way as to coerce or frighten them into choosing a 'safer' option (ie. hospital) (Nieuwenhuijze & Low 2013). Evidence on the absolute and relative risks associated with childbirth abound, however, this can influence the decision-making on an individual level due to superimposing the possibility of low-prevalence adverse outcomes onto all pregnancies (Bisits 2016; Coxon, Sandall & Fulop 2014). This contributes to the increase in interventions, as anxiety around birth increases (Dahlen 2016). There is no doubt that childbirth has become extremely safe, particularly in Australia, and the literature review and meta-analysis in chapter two illustrates this point. Some of the success can be attributed to greater skill in recognising and treating complications, however as Bisits (2016) concludes in his commentary, "maternity carers need to be wary of flooding women with risk information and work to build confidence in women and their partners."(p13)

As previously mentioned, the Australian Government sought public submissions to inform a review of maternity services in Australia in 2009 (Commonwealth of Australia 2009). Many women made submissions advocating for greater choice of both place of birth and care provider including continuity of carer and more accessible options for birth at home or in a birth centre (Dahlen, Jackson, et al. 2011; Dahlen, Schmied, et al. 2011). It is clear from these submissions that women are demanding greater choice and that the 'one-size-fits-all' approach to maternity services was not acceptable (McIntyre, Francis & Chapman 2011). It is difficult to explore the expansion of these options when there has not been a comprehensive economic evaluation into birth at home or in a birth centre.

It must be acknowledged that not all women are interested in exploring home or birth centre birth options. A recent review by Coxon et al. (Coxon et al. 2017) explored the influences on women around their choice of place of birth, their preferences and how they made decisions relating to this in the United Kingdom, which has a long history of offering choice of birth place. They found that the decision to have a hospital birth was very straightforward, however, even in a system where alternative options are reasonably widely available, women reported resistance to their preference for a birth at home or in a freestanding birth centre from clinicians and family members.

The following section describes the concept of economic evaluation of health services in general then specifically focuses on maternity care evaluations.

*Economic evaluations and health care services*

When designing a health service or introducing a new service model, many competing interests are at play. Resources are scarce and demands are increasing as available interventions and treatments place more pressure on limited health budgets. Allocation of resources to one health service involves an opportunity cost. Finite health budgets and scarce resources means that their allocation in one area will inevitably result in a sacrifice elsewhere (Edlin et al. 2015). An economic evaluation can inform decision makers on the efficient use of resources when there are two or more alternative courses of action (treatments/interventions). (Drummond et al. 2005; McPake, Normand & Smith 2013).

Economic evaluation considers the costs and consequences of alternative uses of resources (Drummond et al. 2005). Economic evaluations can be broadly categorised into four types: a cost minimisation analysis measures the difference in cost between two or more alternatives that have the same consequences; a cost-effectiveness analysis compares the costs and consequences of health programs and is expressed in terms of a ratio of incremental cost per unit of health outcome (where outcomes are measured in natural units, for example, live births, lives saved or life years saved); a cost-benefit analysis assigns a monetary value to the measure of effect and thus provides an estimate of the net incremental benefit in monetary terms of the intervention; and a cost utility analysis, which is a specialised form of cost-effectiveness analysis in which the measure of health outcome captures both incremental survival and quality of life (lives saved or quality adjusted life years-QALYs) (Drummond et al. 2005). Economic evaluation requires consideration of both the incremental costs and incremental outcomes. A key component of any economic evaluation is the estimation of comparative costs, or a cost analysis.

*Economic evaluations of maternity care*

The literature review outlining economic analyses of place of birth (see Chapter 3) revealed the variation in methods of measuring costs associated with pregnancy and birth service provision. Maternity care is complex and can involve many care providers in a variety of settings. Getting the "right person in the right place at the right time" presents challenges, as safety and human resources are balanced with satisfaction an increase in choice for childbearing women (Sandall et al. 2011).

*Economic evaluations of models of care in Australia*

Midwife -led models of care are a natural fit for women experiencing a healthy pregnancy; indeed, these models of care have been recognised as essential in the care of all pregnant women, including those at high risk of pregnancy complications, in collaboration with medical practitioners when appropriate (Homer et al. 2017; Rayment-Jones, Murrells & Sandall 2015; Sandall et al. 2016).

Studies from Australia evaluating the cost of models of midwifery care have demonstrated lower costs for women in midwifery led models compared with standard hospital care for women in all risk categories. In a randomised trial in 1995, Rowley et al. used Australian Refined Diagnosis Related Groups (AR-DRGs) and found

that costs were lower by 4.5% for women receiving care from a midwifery team model (Rowley et al. 1995). Another study involving women at low risk of complications and a midwifery led model of care found the mean cost per woman was significantly less that the control group (Homer et al. 2001).

More recently, The M@ngo Study evaluated the cost associated with midwifery group practices which had caseloads of high and low risk women and also found a cost saving of AU$566.74 for women managed in the midwifery group practice (MGP) model of care (Tracy et al. 2013). Similarly, when comparing a 'standard primipara' (a term used to describe a woman pregnant with her first baby, between the ages of 20 and 34, free of obstetric and medical complications and carrying a singleton pregnancy in the cephalic presentation) across three models of care – MGP, standard hospital care and private obstetric care – costs were AU$1300 - $1500 lower for women in the MGP group than women cared for by a private obstetrician or in the standard hospital care group. (Tracy et al. 2014). This was largely attributable to a spontaneous onset of labour and fewer interventions during the birth for the women in the MGP group. Toohill et al. (2012) also found that MGP was a statistically significantly less costly service compared to standard care, with outcomes similar to previously mentioned studies including fewer obstetric interventions and fewer neonatal admissions to the special care nursery (Toohill et al. 2012).

Australian Indigenous women are a particularly vulnerable group, and the Northern Territory has the highest proportion of the population identifying as Indigenous at 26% (ABS, 2016). A study by Gao, et al. (Gao et al. 2014) compared the cost of midwifery group practice and the usual-care model (local health centres, usually in remote locations, delivered by midwives, Aboriginal Health Workers (AHW), District medical Officers (DMO) and 'fly-in fly-out' specialist obstetricians). Women from remote areas in Australia are usually required to relocate to a metropolitan centre close to their due date which disrupts families and separates women from their support networks at a time of great need. Notwithstanding the increase in cost for antenatal and postnatal care, infant readmission and travel, there were significant savings in birthing costs and fewer catastrophic outcome for infants born vaginally which saved on special care nursery costs resulting in a cost saving of AU$703 per mother-infant episode.

*International economic evaluations of models of care*

International studies into the costs of differing models of care have yielded varying results. Young et al (1997) conducted an economic evaluation comparing the cost of midwife-managed care and shared care which is maternity care delivered by midwives, GPs and obstetricians. Midwife-managed care was more costly in the postnatal period however antenatal and intrapartum care were similar. Women reported higher levels of satisfaction in the midwife-managed group, prompting the question of what aspects of care are important when considering service planning. (Young, Lees & Twaddle 1997). A systematic review from the United Kingdom found that if midwifery led services were expanded to 50 percent of all eligible women, there would be an aggregate cost saving of over one million Pounds Sterling. (Ryan et al. 2013).

Given the most frequent acute separation from hospital is childbirth (Australian Institute of Health and Welfare 2018a), there is surprisingly little evidence related to the resource requirements and allocation of resources for women entering the health care system to give birth. An interesting study on the cost of cumulative intervention for women at low risk of complications was conducted in Australia in 2003 (Tracy & Tracy 2003) . This study constructed a cost model of four groups of interventions which measured an 'average cost unit per woman' related to the labour only. Unsurprisingly, as each intervention was added, the cost increased, with the sharpest rise associated with epidural block (up to 33% for low-risk nulliparous women) (Tracy & Tracy 2003). This information is most relevant when managers and health service planners are considering introducing midwifery models of care which are known to reduce intervention rates (Sandall et al. 2016) and thus be a cost saving to the service.

Similar results were found in a review by Fahy et al. (2013) who also criticised the disparate methodologies and outcomes included in the studies as most economic analyses of childbirth, or the interventions which ensue, do not include antenatal, birth and postnatal care costs and outcomes (Fahy et al. 2013). There is also little research into the long-term health service costs of operative and other interventions in childbirth.

The safety of alternative birth settings in Australia is growing in evidence; however there is little evidence of the comparative costs to the health system associated with giving birth outside a hospital. Anecdotally, it is widely assumed that one of the bigger

barriers to introducing state-funded alternatives to giving birth in a hospital setting is a perception that it will be more costly to staff, maintain, and run.

## Research Question

The research question to be addressed in this thesis is: What are the comparative costs associated with giving birth at home, in a birth centre or in a hospital for women at low risk of complications?

## Aims

The aim of this study was to provide evidence on the comparative costs of providing maternity care for women at low risk of complications in the three available birth settings in New South Wales: home, birth centre or hospital.

## Objectives

There were four objectives. These were:

1. To undertake systematic reviews of: 1. the maternal and perinatal outcomes of giving birth at home, in a birth centre or in a hospital, and 2. the comparative cost of giving birth at home, in a birth centre or in a hospital for women at low risk of complications.

2. To identify the birthing trajectories possible for the three planned places of birth in NSW over a 13 year period and calculate the probability of each of these trajectories.

3. To identify and cost the staff time and resources required to provide care in a public hospital, birth centre or at home (micro-costing, bottom-up).

4. To identify the costs of giving birth in the three planned places of birth in NSW over a 13 year period (2000-2012) by applying AR-DRGs to the birth trajectories identified in objective two (top-down).

This study did not include the collection of comparative effectiveness data and is therefore is a cost analysis. The systematic review of maternal and perinatal outcomes by planned place of birth which was undertaken as part of my PhD provides some evidence of the safety and efficacy outcomes related to birth at home, in a birth centre and in a hospital setting.

## Researcher statement

As a midwife of over two decades, and a past consumer of maternity services (midwife-led in all pregnancies) I am familiar with both the world-class quality of public maternity care in Australia and the limitations of changing the status quo in regard to the expansion of models of care which lie outside the current biomedical paradigm. I am also a fierce advocate of a woman's right to choose her place of birth and maternity care provider. However, I see a gap between this right to choose and a woman's knowledge of what is available which fundamentally affects her decision making. With this in mind, I was cognisant of my own desire for change whilst analysing and interpreting the data collected during this research process. The methods by which I collected the data were informed by industry professionals (practising midwives and other health service personnel) and rigorous cleaning and filtering of the linked data was conducted by a professional data analyst. I am optimistic that increasing the evidence, as presented in this thesis, will have a tangible impact on future change in policy and practice, and on women's health and wellbeing. My PhD research, therefore, aims to provide robust evidence on the comparative cost of providing alternative settings for maternity care to women at low risk of complications from the perspective of the health care provider, the NSW Ministry of Health.

## Structure of the thesis

The thesis, a PhD by compilation, comprises five first-author publications, presented in Chapters two to six. There is some repetition between the included publications, as they contain a degree of background at the beginning of each paper, which is similar, to allow the individual manuscripts to stand alone and to provide context.

This PhD has utilised several methodologies to achieve the above objectives. Each chapter contains a methods section appropriate to the objective of each paper and as such, there is no dedicated methods chapter. Table 1 summarises the structure of the thesis in relation to the objectives and a brief description of the chapters is below.

Chapter one has introduced the aim and objectives of this study. It also introduces the context of birth at home, in a birth centre or in a hospital in Australia and internationally, including the safety and cost in relation to these settings. Economic analysis of maternity care is briefly described.

Chapter two describes the first part of objective one of the study and provides context of the 'safety debate' relating to birth at home, in a birth centre or in a hospital as it examines the literature on maternal and perinatal outcomes for women at low risk of complications by planned place of birth. This is a published paper.

> Scarf, V.L., Rossiter, C., Vedam, S., Dahlen, H.G., Ellwood, D., Forster, D., Foureur, M.J., McLachlan, H., Oats, J., Sibbritt, D., Thornton, C. & Homer, C. 2018, 'Maternal and perinatal outcomes by planned place of birth among women with low-risk pregnancies in high-income countries: A systematic review and meta-analysis', *Midwifery*, vol. 62, pp. 240-55.

Chapter three comprises the second part of objective one of this study and is a published paper examining economic evaluations of place of birth.

> Scarf, V., Catling, C., Viney, R. & Homer, C. 2016, 'Costing Alternative Birth Settings for Women at Low Risk of Complications: A Systematic Review', *PloS one*, vol. 11, no. 2, p. e0149463.

Chapter four addresses the second objective and contains the findings of using linked data to map the trajectories of women at low risk of complications who plan to give birth at home, in a birth centre or in a hospital in a decision tree framework. This

framework illustrates separately the trajectories of nulliparous and multiparous women between 2000 and 2012. This paper is under review.

> Scarf, V., Viney, R., Yu, S., Foureur, M., Rossiter, C., Dahlen, H., Thornton, C., Cheah, S., Homer, C. S. E., 2019. Mapping the trajectories for women and their babies from births planned at home, in a birth centre or in a hospital in New South Wales, Australia, between 2000 and 2012. *BMC Pregnancy and Childbirth* (under review).

Chapter five describes the third objective and contains findings of the micro-costing study. This paper is published in Women and Birth.

> Scarf, V.L., Yu, S., Viney, R., Lavis, L., Dahlen, H., Foureur, M., Homer, C. 2019, The cost of vaginal birth at home, in a birth centre or in a hospital setting in New South Wales: A micro-costing study. *Women and Birth* (https://doi.org/10.1016/j.wombi.2019.06.003)

Chapter six describes objective four where DRGs were applied to a decision tree of all women in NSW (at low risk of complications). This paper is under review.

> Scarf, V., Yu, S., Cheah, S., Dahlen, H., Sibbritt, D., Thornton, C., Tracy, S., Homer, C. 2019 Modelling the cost of place of birth: A pathway analysis. *PharmacoEconomics* (under review).

Chapter seven discusses the key findings of the chapters in an international and local context. Referring to the evidence found in my program of research, I propose suggestions to facilitate the expansion of options of birth setting for women in NSW.

**Table 1: Thesis structure and publications linked to research objectives**

| Chapter | Title | Objective |
|---|---|---|
| 1 | Introduction | |
| 2 | Maternal and perinatal outcomes by planned place of birth among women with low-risk pregnancies in high-income countries: A systematic review and meta-analysis. | 1 |
| 3 | Costing Alternative Birth Settings for Women at Low Risk of Complications: A Systematic Review | 1 |
| 4 | Mapping the trajectories for women and their babies from births planned at home, in a birth centre or in a hospital in New South Wales, Australia, between 2000 and 2012 | 2 |
| 5 | The cost of vaginal birth at home, in a birth centre or in a hospital setting in New South Wales: A micro-costing study | 3 |
| 6 | Modelling the cost of place of birth: A pathway analysis | 4 |
| 7 | Discussion and conclusions | |

## Summary

Interest in providing alternative settings for birth in New South Wales is growing, as outlined in the National Maternity Services Plan released in 2011. There is a perception that the relative cost of implementing and providing birth services at home or in a birth centre is higher, however there is little evidence to support this assertion. This lack of cost data means that widespread implementation of home birth or birth centre options is impeded.

This PhD thesis explores the cost of providing options for birth at home or in a birth centre to women at low risk of complications. This chapter has provided background and context to the structure of the maternity care system in New South Wales as well as an introduction to the economic analysis of place of birth. The concepts described here are extended in the following chapters, beginning with Chapter 2 which contains a published systematic review of maternal and perinatal outcomes for women who plan to give birth at home, in a birth centre or in a hospital.

# Chapter 2: Maternal and perinatal outcomes by planned place of birth among women with low-risk pregnancies in high-income countries: A systematic review and meta-analysis.

## Context

Place of birth is a contentious topic in both high and low income countries. For women in low-income countries, pregnancy, birth and sexual and reproductive healthcare can determine their future wellbeing, not the least of which is survival of the birth for the mother and baby. Inadequate or untimely pregnancy care, spacing of pregnancies and lack of safe, clean birthing facilities with skilled birth attendants contribute to the poor maternal and perinatal outcomes seen in low-income settings. Conversely, unnecessary intervention including caesarean section, induction of labour and routine continuous electronic fetal monitoring are seen in high-income countries, with little effect on maternal and perinatal mortality. The highly medicalised nature of pregnancy and birth care in these settings has been associated with birth in a hospital. Birth centres and homebirth, where available, can be options for women with a pregnancy at low risk of complication who are seeking a more physiological approach to birth and herein lies the contention: Is it safe to give birth outside a hospital obstetric unit?

Chapter two addresses the question of the safety of birth planned to be at home, in a birth centre and in a hospital setting for women at low risk of complication. This published paper relates to the first part of Objective One: Maternal and perinatal outcomes for women at low risk of complications who plan to give birth in these three settings.

## Publication details

This paper was published in *Midwifery* in 2018 and has been in the "most downloaded" category of the journal webpage since its publication in April 2018.

Scarf VL, Rossiter C, Vedam S, Dahlen HG, Ellwood D, Forster D, Foureur M, McLachlan H, Oats J, Sibbritt D, Thornton C, Homer C. 2018. Maternal and perinatal outcomes by planned place of birth among women with low-risk pregnancies in high-income countries: A systematic review and meta-analysis. *Midwifery*, vol. 62, pp. 240-55.

## Abstract

**Background**

The comparative safety of different birth settings is widely debated. Comparing research across high-income countries is complex, given differences in maternity service provision, data discrepancies, and varying research techniques and quality. Studies of births planned at home or in birth centres have reported both better and poorer outcomes than planned hospital births. Previous systematic reviews have focused on outcomes from either birth centres or home births, with inconsistent attention to quality appraisal. Few have attempted to synthesise findings.

**Objective**

To compare maternal and perinatal outcomes from different places of birth via a systematic review of high-quality research, and meta-analysis of appropriate data (Prospero registration CRD42016042291).

**Design**

Reviewers searched CINAHL, Embase, Maternity and Infant Care, Medline and PsycINFO databases to identify studies comparing selected outcomes by place of birth among women with low-risk pregnancies in high-income countries. They critically appraised identified studies using an instrument specific to birth place research and then combined outcome data via meta-analysis, using RevMan software.

**Findings**

Twenty-eight articles met inclusion criteria, yielding comparative data on perinatal mortality, mode of birth, maternal morbidity and/or NICU admissions. Meta-analysis indicated that women planning hospital births had statistically significantly lower odds of normal vaginal birth than in other planned settings. Women experienced severe perineal trauma or haemorrhage at a lower rate in planned home births than in obstetric units. There were no statistically significant differences in infant mortality by planned place of birth, although most studies had limited statistical power to detect differences for rare outcomes. Differences in location, context, quality and design of identified studies render results subject to variation.

**Conclusions and implications for practice**

High-quality evidence about low-risk pregnancies indicates that place of birth had no statistically significant impact on infant mortality. The lower odds of maternal morbidity and obstetric intervention support the expansion of birth centre and home birth options for women with low-risk pregnancies.

**Keywords**

Home childbirth, birthing centres, obstetric delivery, pregnancy outcome, infant mortality, postpartum haemorrhage

# Introduction

The universal importance of maternal and newborn well-being is unquestioned. However, the impact of place of birth on safety and well-being is widely debated globally. Debate is fuelled by divergent conclusions from research on planned place of birth (de Vries et al. 2013) and is further complicated by national and regional variation in provision of maternity care across birth places.

Women are increasingly seeking greater choice in birth place, including options other than hospitals that offer fewer interventions and greater autonomy (Vedam et al. 2018). Yet, researchers vary in their conclusions about outcomes from different places of birth. Consequently, there is keen interest in reliable research evidence comparing maternal and perinatal outcomes by place of birth, especially amongst clinicians, policy-makers, and childbearing women and their families. There is particular attention devoted to home as a safe place of birth. Study findings must take account not only of whether the mother and infant *survive* but also how well mother and infant *thrive* in different birthplaces. Diverse study designs and methods, and contradictory research findings create difficulty in synthesising outcomes to inform clinical decisions. Accordingly, government policy and professional guidelines in different countries vary in their support for birth centres and home births. Variation reflects differing beliefs about autonomy, safety, risk and childbirth, together with differing interpretations of the body of existing research (Roome & Welsh 2015).

## Variation in birth setting

In many high-income countries, most women give birth in hospital. Access to alternative birth places varies within and between countries, although usually limited. In the Netherlands approximately 20% of births take place at home; elsewhere the proportion of planned home births in high-income countries ranges between 0.3% in Australia (Hilder et al. 2014) and 3.3% in New Zealand (Shaw et al. 2016). Similarly, the rate of births in midwife-led birth centres (a term encompassing various models) varies from approximately 0.5% in the United States (MacDorman & Declercq 2016) to over 10% in New Zealand and the Netherlands (Shaw et al. 2016) and 11% in England (National Audit Office 2013). Variation in birthplace options is affected by the status, scope and role of the midwife in different jurisdictions, licensing and insurance issues,

the extent of integration between maternity care options, funding issues and other sociocultural factors (Benoit et al. 2005; De Vries et al. 2002; Vedam et al. 2018).

## The debate on safety

Several recent studies in high-income regions compared outcomes from births planned in hospitals and at home. They found no significant difference in risk of adverse perinatal outcomes for planned home births among women with low-risk pregnancies (de Jonge et al. 2015; de Jonge et al. 2009; Hutton et al. 2016; Janssen et al. 2009) and among low-risk parous women (Birthplace in England Collaborative 2011; Homer et al. 2014). Similarly, studies found no significant differences in adverse outcomes between births planned in labour wards and in birth centres (Birthplace in England Collaborative 2011; Gottvall et al. 2005; Homer et al. 2014; Laws, Tracy & Sullivan 2010). Further, many studies identified lower rates of intervention and/or maternal morbidity in births planned in birth centres and at home, compared with hospital births.

However, other investigators reported higher rates of adverse perinatal outcomes in planned home births than in planned hospital births (Grunebaum et al. 2014; Pang et al. 2002; Snowden et al. 2015; Wax, Lucas, et al. 2010). Some of these findings were reported in countries where skilled birth attendants are not universally integrated across birth settings into regional health systems (e.g. Chang & MacOnes 2011; Kennare et al. 2010; Snowden et al. 2015). Other results were from population-based studies that combined pregnancies with different levels of risk or used unreliable data sources for the reported outcome (e.g. Cheng et al. 2013; Evers et al. 2010; Grunebaum et al. 2013; Kennare et al. 2010; Pang et al. 2002; Wax, Pinette, et al. 2010). Others combined data from births with skilled and unskilled birth attendants (e.g. Chang & MacOnes 2011; Malloy 2010). A large English study reported a small but statistically significant increase in adverse results on a composite primary perinatal outcome (including both mortality and morbidity) among nulliparous women planning home births compared with those planning a hospital birth (Birthplace in England Collaborative Group 2011).

Variation in the design and quality of research on place of birth inhibits the development of universally acceptable recommendations for provision of services

across settings (Gyte et al. 2009; Michal et al. 2011; Nove, Berrington & Matthews 2012b; Vedam 2003; Vedam, Schummers & Fulton 2013).

## Methodological challenges in research about place of birth

Researchers have delineated and discussed the unique features of studies into place of birth (Declercq 2013; Leslie & Romano 2007; Nove, Berrington & Matthews 2012b; Olsen & Clausen 2012; Vedam 2003; Zielinski, Ackerson & Kane Low 2015). These features include appropriately identifying intended (as distinct from actual) birth place, ensuring equivalence of risk status, controlling for confounding and mediating factors, dealing with adverse events that would have occurred regardless of setting (especially related to congenital abnormalities), and accounting for different providers in countries with different models of maternity provision.

When comparing outcomes across places of birth, consistent, standardised inclusion criteria across cohorts, reliable sampling methods, and relevant outcome measures are all imperative. For example, some research on place of birth is compromised by amalgamating data from unplanned home births (without skilled birth attendants) and from planned births at home within integrated maternity systems (Gyte et al. 2010; Kirby & Frost 2011; Michal et al. 2011). All these factors, as well as the limits to randomisation, complicate appraisals of research quality and risk of bias (Nove, Berrington & Matthews 2012b; Vedam, Rossiter, et al. 2017).

Further, adequate sample sizes are essential to allow for comparisons between settings, especially when exploring rare outcomes such as mortality and severe morbidity. Relatively small numbers of women choose to give birth in birth centres or at home in most high-income countries. Typically, datasets with sufficient power can only be generated by large population-based studies conducted over several years, notwithstanding the limitations of using registry-based data (de Jonge et al. 2017), or through meta-analysis, where possible. Some studies have utilised a ‘composite outcome’ to group data on uncommon adverse outcomes to improve statistical power (Birthplace in England Collaborative Group et al. 2011). Finally, the diverse context of maternity provision in different countries generates inconsistencies in data availability, inclusion criteria and key definitions, further complicating research in this field.

## Synthesising research findings

There have been few Cochrane reviews of place of birth outcomes. Olsen and Clausen attempted a systematic review comparing planned home versus hospital birth (2012) and were able to identify only one small study (n=11) that met inclusion criteria. Noting difficulties with recruiting women who will consent to randomisation, their discussion highlighted the importance of well-designed population-based observational studies. Another Cochrane review (Hodnett, Downe & Walsh 2012) incorporated 10 trials comparing 'alternative settings for birth' with conventional hospital labour wards, of which five examined alongside midwifery units. This review found no impact on adverse outcomes for mothers or infants across included settings, but women allocated to alternative settings had higher rates of spontaneous vaginal births and breastfeeding at six to eight weeks, and lower rates of obstetric intervention than women giving birth in hospital units (Hodnett, Downe & Walsh 2012).

Other research syntheses about outcomes by place of birth have involved largely narrative analysis. Some compared data from hospital births with home births (Elder, Alio & Fisher 2016; Fullerton, Navarro & Young 2007; Leslie & Romano 2007; McIntyre 2012; Stotland & Declercq 2002; Zielinski, Ackerson & Kane Low 2015); others compared births in hospitals with birth centres (Alliman & Phillippi 2016; Dixon et al. 2012; McIntyre 2012; Muthu & Fischbacher 2004; Stewart et al. 2005; Stotland & Declercq 2002; Walsh & Downe 2004).

The varying quality of research has been a recurring theme in reviews (Campbell & MacFarlane 1986; Elder, Alio & Fisher 2016; McIntyre 2012; Olsen 1997; Vedam, Schummers & Fulton 2013). Some authors have specifically concluded that the limited quality or comparability of studies precludes undertaking meta-analysis (Blix et al. 2014; Stewart et al. 2005; Walsh & Downe 2004). Some systematic reviews indicate methods used to assess potential bias in selected studies (Alliman & Phillippi 2016; Blix et al. 2014; Stewart et al. 2005; Walsh & Downe 2004), although other reviews do not indicate how quality was determined. One systematic review and meta-analysis comparing planned home births and hospital births (Wax, Lucas, et al. 2010) reported that study quality was evaluated using a published instrument (Zaza et al. 2000) but did not report on the quality assessment of included studies. This meta-analysis has

been widely criticised for methodological flaws (Gyte et al. 2010; Kirby & Frost 2011; Michal et al. 2011).

We did not identify any systematic review or meta-analysis that examined outcomes from studies across three places of birth (home, birth centre, hospital), using a validated rating tool to appraise the quality of included studies.

## Objectives

This systematic review addressed the question: are perinatal and maternal outcomes significantly different from births planned at home, in birth centres or hospitals, for women with low-risk pregnancies? We reviewed original research from high-income countries (World Bank 2016) using a birthplace-specific quality appraisal instrument (Vedam, Rossiter, et al. 2017), and undertook meta-analysis of outcome data where possible.

## Methods

The review examined the effect of *birth place* as distinct from model of maternity care, although often closely linked. The definition of place of birth varied between studies, depending on data availability, regional differences in provision and study design. We registered our protocol with Prospero international register of systematic reviews (http://www.crd.york.ac.uk/PROSPERO/) in July 2016 (CRD42016042291). This paper follows the PRISMA guidelines for reporting systematic reviews and meta-analyses (Moher, Liberati, Tetzlaff, Altman, et al. 2009).

### Eligibility criteria

The systematic review included articles:

- published in peer-reviewed journals between 2000 and 2016;
- comparing outcomes from two or more places of birth;
- written in English.

We included articles which provided evidence on one or more of nine outcomes addressing important dimensions of perinatal mortality and morbidity, mode of birth and maternal morbidity (regardless of other outcomes examined):

1. intrapartum stillbirth
2. early neonatal mortality 0-7 days
3. admission to neonatal intensive care unit (NICU)
4. normal vaginal birth
5. instrumental birth
6. caesarean section
7. intact perineum after vaginal birth
8. severe perineal trauma (3rd or 4th degree tear) after vaginal birth
9. postpartum haemorrhage (PPH) ≥1000mL.

Table 1 indicates inclusion criteria following a framework comprising population, intervention, comparison, outcomes and study design (PICOS) (Moher, Liberati, Tetzlaff & Altman 2009), giving examples of excluded study types.

***Table 1. Inclusion and exclusion criteria for articles in systematic review***

| **Inclusion criteria** | **Exclusion examples** |
|---|---|
| **Participants** | |
| Healthy women with low-risk pregnancies, assessed by the researchers using clear consistent criteria | • Non-human participants<br>• Women with known antenatal risk factors e.g. twins, non-vertex presentation, previous caesarean section, pre-term labour, elective caesarean section, gestational diabetes, hypertension<br>• Risk self-rated by study participants<br>• Risk factors not comparable in all study cohorts |
| Women giving birth in a high-income country | • Women in low- or medium-income countries<br>• Women in two or more high-income countries, where outcomes may be affected by variation between jurisdictions rather than place of birth |
| **Intervention** | |
| Intended place of birth, determined at or close to the onset of labour | • Model of care or provider type rather than birth place<br>• Actual place of birth, regardless of intention |

| | |
|---|---|
| | • Intended birth place determined at booking, not close to onset of labour<br>• Cohorts including births without skilled attendants<br>• Cohorts including unplanned home births<br>• Studies where intended place of birth is a comparator rather than the independent variable<br>• Comparison of specific antenatal, intrapartum or postnatal interventions or management approaches |
| **Comparison** | |
| Comparison of two or more intended birth settings – home birth, birth in hospital obstetric unit or birth centre (including, where relevant, free-standing and alongside midwifery units) | • Studies of outcomes in one birth setting i.e. just home births or birth centres, without comparison cohort<br>• Studies of modified rooms within hospital obstetric unit<br>• (Meta-analysis excluded studies comparing birth centres with home births as the meta-analysis which uses hospital births as referent.) |
| **Outcomes** | |
| Maternal or neonatal outcomes related to labour and birth, specifically:<br>• Perinatal mortality – intrapartum stillbirth and early neonatal mortality (0-7 days postpartum)<br>• Admission to NICU<br>• Mode of birth – normal vaginal birth, instrumental birth, caesarean section<br>• Perineal status – intact perineum, $3^{rd}/4^{th}$ degree perineal trauma<br>• Postpartum haemorrhage $\geq$1000mL<br>Many studies also investigated other outcomes not addressed here, as indicated in Table S1. | • Articles presenting study protocols rather than outcomes<br>• Studies with place of birth as outcome<br>• Articles which do not include data on at least one of these outcomes<br>• Psycho-social outcomes only<br>• Cost-related or other economic outcomes<br>• Studies which only report satisfaction or other qualitative results |
| **Study design** | |
| Original research comparing outcomes from two or more birth place cohorts, prospectively or retrospectively determined | • Studies which don't compare outcomes from two or more places of birth<br>• Opinion pieces, reports, case-studies, commentaries etc. |

| | |
|---|---|
| | • Systematic reviews and/or meta-analyses (individual studies may be included)<br>• Studies not reported in peer-reviewed journals published between 2000 and 2016 |

## Information sources

We searched five databases during May 2016: CINAHL, Embase, Maternity and Infant Care, Medline and PsycINFO. We further scrutinised reference lists manually to identify other potential articles, and set up alerts from the databases used to receive notification of relevant articles published after the main data extraction. We updated the search in January 2017, to fully cover the period 2000-2016.

## Search strategy

The review used a combination of search terms (Box 1) encompassing different concepts. The 'birth place terms' in column A were all combined with the Boolean term OR, as were all 'outcome terms' in column B. The resulting searches A and B were then combined with AND.

***Box 1: Review search terms***

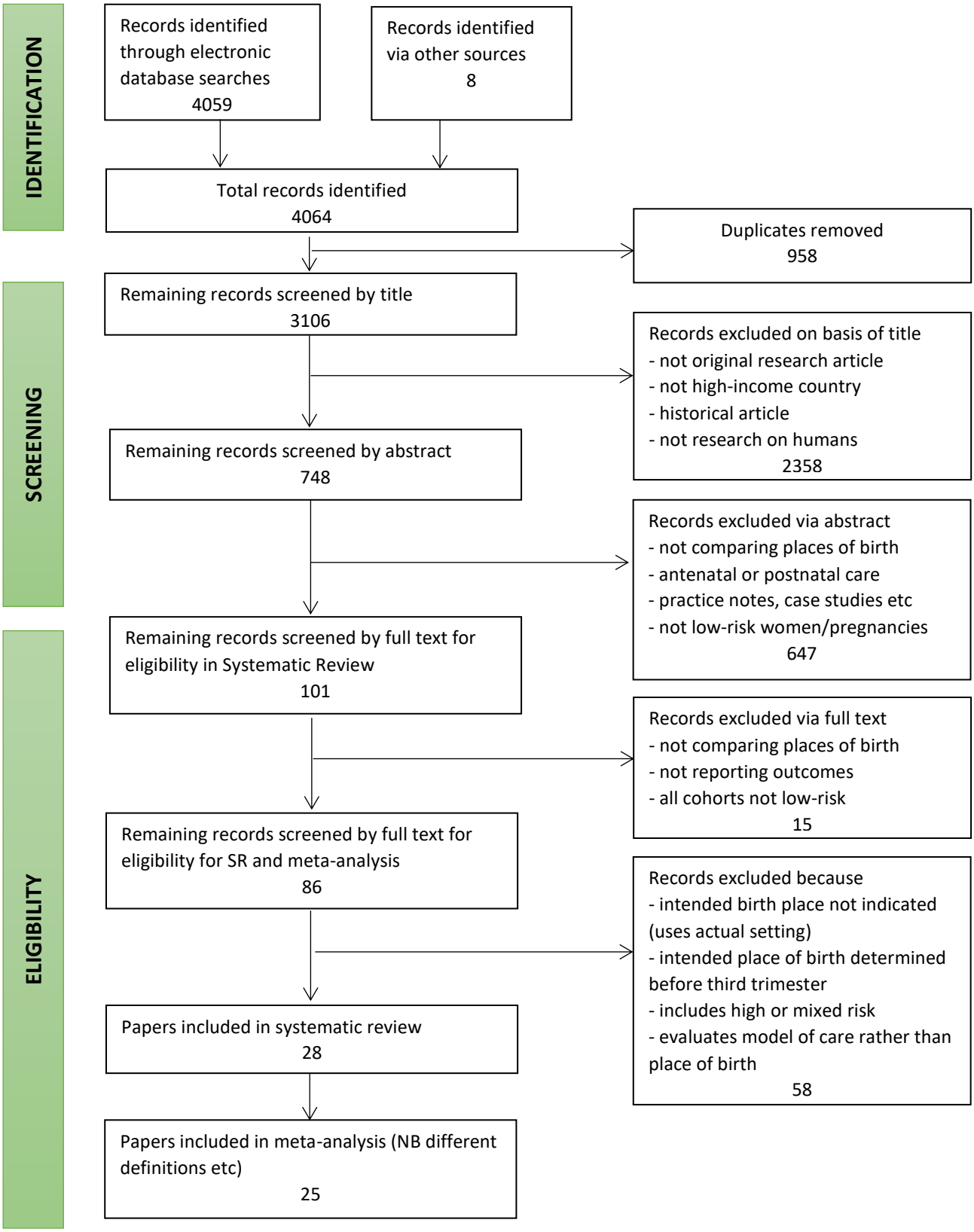
| **A** | **B** |
|---|---|
| ***General birth place terms*** | ***Outcome-related terms*** |
| Birth place OR birthplace | Outcomes + CV2[##] |
| Place of birth | Safety + CV2 |
| Birth setting | Risk + CV2 |
| Birth site OR site of birth | Mortality + CV2 |
| Out-of-hospital + CV1[#] | Morbidity + CV2 |
| Model of care[1] + CV1 | Death + CV2 |
| Midwife-led | Loss + CV2 |
| Midwifery-led | Stillbirth |
| | Death in childbirth |
| | Complications + CV1 |
| ***Specific birth place terms[2]*** | Birth injuries |
| Home birth OR Homebirth | Perineal trauma |
| Home childbirth OR child birth | Perineal tear |
| Childbirth at home | Episiotomy |
| Alternative birth cent* | Postpartum h(a)emorrhage |
| Birthing cent* | Transfer + CV1 |
| Birth cent* OR birthcent* | Neonatal intensive care |

| | |
|---|---|
| Domiciliary birth | Special care nursery |
| Alongside unit | Psycho-social outcomes + CV1 |
| Freestanding unit | Trauma + CV1 |
| Alternative birth setting | Stress + CV1 |
| | PTSD + CV1 |
| | Postpartum mood |
| | Postnatal depression |
| | Fear of childbirth |
| | Apgar |
| | Breast feeding |
| | Transfer + CV1 |
| | Neonatal intensive care |
| | Special care nursery |
| [#] *CV1 = Childbirth Variable 1*<br>Child birth OR Childbirth OR Maternity OR Midwife OR Obstetric | |
| [##] *CV2 = Childbirth Variable 2*<br>Perinatal OR Neonatal OR Maternal OR Newborn OR Pregnancy OR Obstetric OR F(o)etal OR Infant | |

## Study selection

Two researchers searched electronic databases and screened the results for eligibility. We removed duplicates, screened titles to remove those clearly out of scope and then reviewed abstracts to assess eligibility. Both then read the remaining 86 articles to further determine eligibility, and resolved any disagreement about inclusion by discussion. In ensuring that selected studies contained relatively comparable risk levels, we excluded those including women with even one previous caesarean section (CS) (Hutton et al. 2016; Janssen et al. 2009). Supplementary Table S1 (Appendix A) indicates reasons for excluding 58 articles from the systematic review following this close reading. Figure 1 illustrates the study selection process.

**Figure 1: Flow diagram of systematic review process**



## Study appraisal (risk of bias)

We assessed study quality using the Birth Place Research Quality (ResQu) Index (see Appendix A), a newly developed critical appraisal system. This instrument was developed specifically to appraise studies that compare different birth settings, and takes account of the unique characteristics of place of birth research. Development and content validation by an international panel of experts are described elsewhere (Vedam, Rossiter, et al. 2017). The instrument provides a quantitative summary score based on 27 criteria to rate the quality of research evidence at study level: high (scores of 75% and above), moderate (65-74%) and low (less than 65%).

Two researchers read the remaining 28 articles and rated them using the ResQu Index, discussing any diverging scores until reaching consensus. During meta-analysis, sensitivity analyses eliminated studies that scored less than 75% to explore the impact of research quality on identified outcomes.

## Data items

***Box 2: Definition of data terms***

***Birth Place (= Birth Setting = Place of Birth)***

*Birth centre*: a separate area designated to provide midwife-led primary-level care in a home-like setting with no routine involvement of medical staff. Birth centres may be located as part of a hospital (Alongside Midwifery Unit – AMU) or a Freestanding Midwifery Unit (FMU). Access to specialist obstetric, anaesthetic or paediatric consultation requires transfer to a hospital obstetric unit. Birth centres may be publicly or privately funded.

*Planned home birth*: where a woman intends to give birth outside a formal health facility, usually in her home, and plans to receive care from one or more qualified birth attendants (midwife or doctor recognised in their country as competent to provide care). Home birth may be funded publicly or privately.

*Hospital birth*: births planned to take place in a hospital obstetric unit (OU) which is staffed by qualified midwives, nurses and doctors. Hospitals provide access to anaesthetic, surgical and neonatal facilities and may be public or privately-funded.

**********

*High-income country*: as defined by the World Bank for the 2016 fiscal year (World Bank 2016).

*Intended place of birth*: recorded as close as possible to the onset of care in labour and preserving integrity of cohorts by taking account of intrapartum or postpartum transfers from home or birth centre to hospital. We approximate intention-to-treat by including the outcomes of the place of birth determined at (or close to) the start of labour.

*Low-risk pregnancy*: definitions may vary by country or by study. However, it is critical that studies specify the criteria utilised, the source of their definition and apply the same criteria to different birth place cohorts to maximise comparability. Ideally studies use recognised guidelines for determining low obstetric risk (e.g. NICE guidelines). In addition to specifying term, vertex, singleton pregnancies, studies should also indicate clearly what other maternal factors are eliminated from the dataset, e.g. hypertension, pre-existing medical conditions. For simplicity, this paper refers to 'low-risk pregnancies' and acknowledges variation in definitions in selected studies.

*Mode of birth*: Normal vaginal birth, instrumental birth (forceps or vacuum extraction) or non-elective caesarean section. Elective caesarean sections are correctly excluded from samples of women with low-risk pregnancies.

*NICU admission*: admission of newborn after birth to a neonatal intensive care unit

*Normal vaginal birth* is defined variously by study authors. The meta-analysis groups results for births other than caesarean sections or instrumental birth. However, we also conducted sensitivity analyses based on a more rigorous definition i.e. births other than caesarean sections or instrumental birth, specifically stating there was no induction of labour, epidural or spinal analgesia or episiotomy; vertex presentation.

*Outcomes:* measurable results for mother and/or infant with an emphasis on items related to safety as commonly defined by clinical studies. We focused on outcomes resulting from care in labour and birth, rather than the processes of that care, and did not include data on interventions such as induction, analgesia, anaesthesia, and episiotomy. Similarly we do not review data about Apgar scores because of the subjective nature of this measure and the variety of thresholds reported in the literature.

Our analysis principally focuses on nine outcomes: perinatal mortality (intrapartum stillbirth and early neonatal mortality 0-7 days), NICU admission, mode of birth (normal vaginal birth, instrumental birth, caesarean section), perineal status (intact perineum and severe perineal trauma) and post-partum haemorrhage ≥1000mL. Many studies investigated additional outcomes (see Table S3).

*Perinatal mortality*: data on intrapartum death of a fetus known to be alive at the onset of labour (stillbirth) and early neonatal death (0-7 days). Sensitivity analyses group data from studies specifically excluding deaths resulting from known congenital abnormalities.

*Perineal status:* This review reports results on either intact perineum (no lacerations and no episiotomy) or severe perineal trauma (third or fourth degree lacerations).

*Postpartum haemorrhage* (PPH): blood loss of greater than 1000mL.

*Research quality:* refers to a study's score on the ResQu Index (Vedam et al. 2017)

1. High quality evidence –75% or above
2. Moderate – 65-74%
3. Low – below 65%

*Spontaneous vaginal birth*: see *Normal vaginal birth*.

## Data collection process

Two researchers independently extracted the raw data for the nine outcomes from the 28 articles, ensuring consistency with our definitions (Box 2). These were recorded on a specifically-developed extraction form (Supplementary Table S2, Appendix A). We endeavoured to locate additional data for this systematic review, including seeking supplementary tables. At times, the extracted data differed from the published rates; for instance, for studies examining perineal outcomes, we ensured that the denominator included only vaginal births. We resolved any discrepancies by careful discussion of the studies' methodology and results.

## Summary measures

Selected studies presented outcome data in different ways, most commonly (adjusted) odds ratios (OR) but also relative risk or as percentages. Supplementary Table S3 (Appendix A) presents further detail on the statistical techniques and findings from the selected studies on outcomes relevant to this review.

## Synthesis of results (meta-analysis)

Data on the nine outcomes (where available) were entered into the RevMan software (The Nordic Cochrane Centre 2014) to calculate estimated ORs for each outcome, with a 95% confidence interval (CI). This used the random effects statistical model given the varying study designs and heterogeneity in findings. Few individual studies included in the meta-analyses had sample sizes of sufficient power to detect meaningful differences in rare outcomes such as perinatal mortality (de Jonge et al. 2015; van der Kooy et al. 2011).

Where there were zero events reported in a study, individual odds ratios are not calculable, but these data are included in the pooled denominator to calculate the overall odds ratio for that outcome. Occasionally we have included studies which did not define mortality variables fully but where zero events in both cohorts (Gaudineau et al. 2013; Halfdansdottir et al. 2015; Homer et al. 2000; Overgaard et al. 2011) meant that a specific definition (e.g. neonatal death) was not required as the result would have been zero regardless of the actual definition.

Some articles reported data from the same study or utilise the same (or overlapping) datasets. For instance, several studies use data from the Netherlands Perinatal Registry for intersecting periods (de Jonge et al. 2013; van der Kooy et al. 2011; Wiegerinck et al. 2015). Similarly, two New Zealand studies used data from the same dataset for the years 2006-2007 (Davis et al. 2011; Dixon et al. 2014). We only used one source in each meta-analysis. Two selected studies were not included in any meta-analysis because they used data which overlapped other studies (Overgaard, Fenger-Grøn & Sandall 2012; van der Kooy et al. 2011). Another study did not present raw data from the lowest-risk cohorts (Pang et al. 2002). Other studies were excluded from specific meta-analyses because they used different definitions from ours on individual variables. For

instance, regarding perinatal mortality, the Birthplace in England study used a composite neonatal outcome rather than stillbirth or early neonatal death (Birthplace in England Collaborative Group 2011). Others presented data on neonatal death up to 28 days rather than seven (Davis et al. 2011; Laws, Tracy & Sullivan 2010) or combined data on intrapartum stillbirth and neonatal death (Dixon et al. 2014; van der Kooy et al. 2011). Some studies did not provide sufficient specificity on critical terms, such as 'stillbirth' (Burns et al. 2012; Dixon et al. 2014; Laws, Tracy & Sullivan 2010). A number of studies were excluded from the PPH meta-analysis because they only presented data on blood loss over 500mL (Blix et al. 2012; Gaudineau et al. 2013; Miller & Skinner 2012; Prelec, Verdenik & Poat 2014) or over 300mL (Byrne, Crowther & Moss 2000).

### Additional analyses

To address the unavoidable heterogeneity of the selected studies, we conducted sensitivity analyses, excluding studies that achieved less than 75% in the ResQu Index. The results of the sensitivity analyses are reported beside the main findings. For perinatal outcomes, we also eliminated data from studies that did not specifically exclude known congenital abnormalities and conducted further analysis by parity when data were available from studies of planned home births. (Data on planned births in birth centre were insufficient to stratify by parity.) In assessing birth centre outcomes, separate analyses compared data from FMUs and AMUs. In studies of birth centres in Australia (Homer et al. 2014; Laws, Tracy & Sullivan 2010), the meta-analysis assumed these to be AMUs. However, it is possible that data include a small number of FMU births during the periods studied; there are very few FMUs in Australia and some units closed during the study period (Monk et al. 2013).

## Results

### Study selection

Initial searching identified 4059 records across five databases and another eight manually. Figure 1 illustrates the process of screening and reviewing articles to meet inclusion criteria. In the final stage, two reviewers read the remaining 86 articles and excluded 58 (Supplementary Table 1).

## Study characteristics

Twenty-eight eligible articles from 26 studies remained, published 2000-2016. Table 2 summarises PICOS with further detail in Supplementary Table 2. Five studies originated in Australia (Byrne, Crowther & Moss 2000; Homer et al. 2000; Homer et al. 2014; Laws, Tracy & Sullivan 2010; Ryan & Roberts 2005), five in the Netherlands (Bolten et al. 2016; de Jonge et al. 2015; de Jonge et al. 2013; van der Kooy et al. 2011; Wiegerinck et al. 2015), three in the United Kingdom (Birthplace in England Collaborative Group 2011; Burns et al. 2012; Nove, Berrington & Matthews 2012a), six in Nordic countries (Bernitz et al. 2011; Blix et al. 2012; Eide, Nilsen & Rasmussen 2009; Halfdansdottir et al. 2015; Overgaard, Fenger-Gron & Sandall 2012; Overgaard et al. 2011), two in other European countries (Gaudineau et al. 2013; Prelec, Verdenik & Poat 2014), four in New Zealand (Davis et al. 2012; Davis et al. 2011; Dixon et al. 2014; Miller & Skinner 2012), two in the USA (Pang et al. 2002; Thornton et al. 2016) and one in Japan (Hiraizumi & Suzuki 2013). Research design included two randomised controlled trials (both of AMUs), 21 retrospective studies (4 with matched data), and five prospective studies. Eighteen were rated as providing high quality evidence.

Despite all meeting eligibility criteria, the articles varied considerably, in rigour and in study design and outcomes investigated. In addition to the nine outcomes under review (Table 2 and Box 2), studies examined various interventions (induction, augmentation, episiotomy, fetal monitoring, third stage management), pain management, duration of labour, birth positions, breastfeeding, transfer, maternal satisfaction and/or psychological well-being. Several investigated infants' Apgar scores. Table 2 also includes a rating of research quality (risk of bias, summarised as high, moderate or low, Box 2).

***Table 2: Summary of studies included in Systematic Review (N=28)***

| | **First author. Publication date. Country** | **Study design** | **Source of data. Year/s** | **Population – eligibility criteria** | **Intervention – Planned place of birth** | **Comparator – Planned place of birth** | **Outcome measures – relevant to current review outcomes** | **Quality rating** |
|---|---|---|---|---|---|---|---|---|
| | | | | **Abbreviations at foot of table** | | | | |
| 1 | Bernitz<br>2011.<br>Norway | RCT | Admin data<br>2004-2010 | 1111 women with low-risk pregnancies = AMU eligibility. | MW-led AMU<br>N=412 | Normal birth unit (NU)<br>N=417.<br>Special birth unit (SU)<br>N=282. | Operative birth, PPH, sphincter injuries, NICU admission | High |
| 2 | Birthplace in England Collaborative 2011.<br>England | Prospective cohort study | Data collection forms.<br>2008-2010 | 64,538 women with low-risk pregnancies as per NICE guidelines.<br>*Additional analysis of 57,127 women without complicating conditions at labour onset.* | Planned HB<br>N=16,840<br>AMU<br>N=16,710<br>FMU<br>N=11,282 | Obstetric Unit (OU)<br>N=19,706 | Composite PO = perinatal mortality + major intrapartum morbidity (defined).<br>SO: 'normal birth' (SVB without IOL; anaesthesia; or episiotomy) | High |
| 3 | Blix<br>2012.<br>Norway | Retrospective cohort study | Patient files + registry data.<br>1990-2007 | 17,941 low-risk pregnancies | Planned HB<br>N=1631 | Planned hospital birth<br>N=16,310 | PO: PPH >500mL.<br>SO: perinatal and neonatal death rates | High |
| 4 | Bolten<br>2016. | Prospective cohort study | Perinatal database + participant questions | 3495 women with low-risk pregnancies in MW care at onset of labour | Planned HB<br>N=2050. | MW-led OU birth<br>N=1445 | PO: SVB and perineal outcomes, PPH. | High |

| | First author.<br>Publication date.<br>Country | Study design | Source of data.<br>Year/s | Population –<br>eligibility criteria | Intervention –<br>Planned place of birth | Comparator – Planned place of birth | Outcome measures – relevant to current review outcomes | Quality rating |
|---|---|---|---|---|---|---|---|---|
| | | | | **Abbreviations at foot of table** | | | | |
| | Netherlands | | 2009-2011 | | | | | |
| 5 | Burns<br>2012.<br>England, Scotland, Northern Ireland | Prospective cohort study | Data collection forms.<br>2000-2008 | 8924 women "low risk" as per RCOG water immersion joint statement. | Water immersion in a birth pool in AMU<br>N=2100.<br>Combined FMU/HB (=community)<br>N=2694. | Water immersion in a birth pool in OU<br>N=4130 | Maternal: mode of birth, perineal trauma, PPH.<br>Neonatal: NICU admission, mortality | High |
| 6 | Byrne<br>2000.<br>Australia | RCT | Case notes + participant questions<br>1993-1995 | 201 women with normal uncomplicated pregnancies. | Birth centre AMU.<br>N=100 | Hospital delivery suite<br>N=101 | CS, blood loss ≥300mL, SCN admission | High |
| 7 | Davis<br>2011.<br>New Zealand | Comparative descriptive study | Perinatal database<br>2006-2007 | 16210 women with low risk pregnancies | Primary Unit (PU, like FMU)<br>N=2877 | Planned HB N=1830,<br>Secondary hospital (SU)<br>N=7380,<br>Tertiary hospital (TU) N=4123 | Mode of birth, perineal trauma (not defined), PPH ≥1000mL, NICU admission | High |
| 8 | Davis<br>2012 | Retrospective cohort study | Perinatal database 2006-2007 | 16,210 women with low risk pregnancies | Planned PU birth<br>N=2877 | Planned HB N=1830<br>SU N=7308 | PPH ≥ 1000mL | High |

| | First author.<br>Publication date.<br>Country | Study design | Source of data.<br>Year/s | Population –<br>eligibility criteria | Intervention –<br>Planned place of birth | Comparator –<br>Planned place of birth | Outcome measures – relevant to current review outcomes | Quality rating |
|---|---|---|---|---|---|---|---|---|
| **Abbreviations at foot of table** | | | | | | | | |
| | New Zealand | | | | | TU N=4123 | | |
| 9 | de Jonge, 2013.<br>Netherlands | Linked cohort study | Perinatal database + LEMMoN study data<br>2004-2006 | 146,752 women with low risk pregnancies. | Planned HB<br>N=92,333 | Planned OU birth<br>N=54,419. | PO: Severe acute maternal morbidity (defined).<br>SO: PPH $\geq$ 1000mL | High |
| 10 | de Jonge 2015.<br>Netherlands | Retrospective cohort study | Linked national registry data.<br>2000-2009 | 743,070 women with low risk pregnancies in MW-led care | Planned HB<br>N=466,112 | Planned hospital birth<br>(including AMU)<br>N=276,958 | Intrapartum and neonatal death, NICU admission | High |
| 11 | Dixon<br>2014.<br>New Zealand | Retrospective cohort (aim to replicate BPiE in NZ) | NZ College Midwives Research Data.<br>2006-2010 | 61,072 women defined as low-risk using BPiE criteria) | Planned HB<br>N=4921<br>Primary unit (PU) N=10,158 | Hospital birth in either<br>SU (N=29,027) or<br>TU (N=16,966) | Perinatal mortality, NICU admission. | Moderate |
| 12 | Eide<br>2009.<br>Norway | Prospective observational cohort study | Hospital data.<br>2001-2002 | 453 *nulliparous* women with low-risk pregnancies = MLW eligibility | MLW<br>N=252 | Conventional delivery ward (CDW)<br>N=201 | PPH, perineal trauma, mode of birth | High |

| | First author.<br>Publication date.<br>Country | Study design | Source of data.<br>Year/s | Population –<br>eligibility criteria | Intervention –<br>Planned place of birth | Comparator –<br>Planned place of birth | Outcome measures – relevant to current review outcomes | Quality rating |
|---|---|---|---|---|---|---|---|---|
| | | | | **Abbreviations at foot of table** | | | | |
| 13 | Gaudineau<br>2012.<br>France | Retrospective case-control study | Hospital data.<br>2005-2008 | 1206 women with low risk pregnancies. | Home-like BC<br>N=316 | Traditional labour ward (TLW)<br>N=890 | Mode of delivery, perineal trauma, PPH (≥500mL), adverse neonatal outcomes (including neonatal death). | Moderate |
| 14 | Halfdans-dottir<br>2015.<br>Iceland | Retrospective cohort study – matched.<br>Two methods | Hospital data + registry data.<br>2005-2009 | *Method 1*: 1228 all HB + matched hospital births<br>*Method 2:* 1112 women with no contraindications | Planned HB<br>(1) N=307<br>(2) N=278. | Matched planned hospital birth (including AMU)<br>(1) N=921<br>(2) N=834. | Operative birth, PPH, anal sphincter injury, NICU admission | High |
| 15 | Hiraizumi<br>2013.<br>Japan | Retrospective cohort study | ?Medical records.<br>2007-2011 | 508 women with low risk pregnancies | Planned HB under MW-led care<br>N=168 | Planned OU birth under MW (N=123) or under obstetrician (N=217). | Mode of birth, perineal trauma, PPH ≥ 1000mL | Moderate |
| 16 | Homer<br>2000.<br>Australia | Retrospective cohort study | Hospital data.<br>1995. | 734 women with low-risk pregnancies | Birth centre<br>N=367 | Hospital labour ward<br>N=367 | Mode of birth, perineal trauma, neonatal outcomes. | Moderate |
| 17 | Homer<br>2014.<br>Australia | Retrospective population-based cohort study (similar to BPiE) | Linked registry + hospital data.<br>2000-2008 | 258,161 women with low risk pregnancies. | Planned HB<br>N=742<br>BC | Hospital labour ward<br>N=242,936 | PO: primary neonatal outcome (see BPiE Collaboration). | High |

| | First author.<br>Publication date.<br>Country | Study design | Source of data.<br>Year/s | Population –<br>eligibility criteria | Intervention –<br>Planned place of birth | Comparator –<br>Planned place of birth | Outcome measures – relevant to current review outcomes | Quality rating |
|---|---|---|---|---|---|---|---|---|
| **Abbreviations at foot of table** | | | | | | | | |
| | | | | *Additional analysis for 235,611 women without complications at start of labour* | N=14,483 | | SO: stillbirth + NND, mode of birth, perineal trauma, 'normal labour and birth' (defined) | |
| 18 | Laws<br>2010.<br>Australia | Retrospective population-based study | Perinatal database.<br>2001-2005 | 822,955 women.<br>*Additional analysis of 498,023 women with term, low-risk pregnancies* | Planned BC birth<br>N=22,222 | Intended OU birth<br>N=800,733<br>Low-risk group: N=475,791 | Perinatal mortality, mode of birth, severe perineal trauma, SCN admission | Moderate |
| 19 | Miller<br>2012.<br>New Zealand | Retrospective matched case control study | Questionnaires to MW.<br>2006-2007 | 225 *nulliparous* women with low-risk pregnancies. | Planned HB<br>N=109 | Planned OU birth with same MW as HB group<br>N=116 | Type of birth, perineal status, PPH ≥500ml | Moderate |
| 20 | Nove<br>2012.<br>UK | Observational study | Secondary analysis of maternity data.<br>1998-2000 | 273,872 women.<br>Exclude high risk pregnancies (NICE guidelines) | Planned HB<br>N=5998 | Planned hospital birth<br>N=267,874 | PPH ≥1000ml | High |
| 21 | Overgaard<br>2011.<br>Denmark | Cohort study with matched control. | Patient records and admin data.<br>2004-2008. | 1678 women with low risk pregnancies (NICE guidelines) + healthy multips with uncomplicated obstetric history regardless of age and BMI. | Planned FMU birth.<br>N=839 | Hospital birth, women matched on 9 key factors.<br>N=839 | PO: CS.<br>SO: NICU admission, perineal status, type of birth, PPH ≥500ml, perinatal mortality | High |
| 22 | Overgaard<br>2012 | Cohort study with matched control. | Secondary analysis of data from | 1678 women as above, stratified by educational disadvantage. | Planned FMU birth.<br>N=839 | Hospital birth<br>N=839 | Composite optimal birth outcome (uncomplicated SVB with good | High |

| | First author. Publication date. Country | Study design | Source of data. Year/s | Population – eligibility criteria | Intervention – Planned place of birth | Comparator – Planned place of birth | Outcome measures – relevant to current review outcomes | Quality rating |
|---|---|---|---|---|---|---|---|---|
| | | | | **Abbreviations at foot of table** | | | | |
| | Denmark | | Overgaard et al 2011. | *[460 women without post-secondary education]* | *[Women without post-secondary education N=230]* | *[Women without post-secondary education N=230]* | maternal and fetal outcomes), SVB, CS, NICU admission, perineal status. | |
| 23 | Pang 2002. USA | Retrospective population-based cohort study | Birth registry data, linked with death records. 1989-1996 | Singleton birth 34/40+ with no recorded complications (defined) N=16,726 women. *Additional analysis used infants 2500g+ or 37/40+ N=16,253.* | HB with health professional as attendant or certifier (not 'planned HB') N=5854 + attempted HB transferred to hospital N=279. *Secondary analysis N=6052* | Hospital birth N=10,593. *Secondary analysis N=10,347* | Neonatal death, PPH (not defined) | Low |
| 24 | Prelec 2014. Slovenia | Prospective case-control study | Hospital data 2013 | 497 low-risk *nulliparous* pregnancies (NICE guidelines). | MW-managed births in MLU N=154 | OU births N=343 | PO: CS SO: SVB, PPH≥ 500mL, perineal status, NICU admission | Moderate |
| 25 | Ryan 2005. Australia | Retrospective cohort study | Hospital records. 1995-1996 | 3683 women all with BC eligibility. | Planned BC birth N=720 | Planned hospital labour ward (LW) N=2963 | Type of labour and birth, perineal status, PPH≥ 600mL, perinatal death, SCN admission | Low |
| 26 | Thornton 2016. USA | Retrospective cohort study using | Secondary analysis of data from AABC. 2006-2011 | 11,303 women attending BC for antenatal care, who chose hospital or BC birth. | FMU birth N=8776 | Hospital birth N=2527 | PO: Type of birth. SO: PPH, composite of severe newborn outcomes | High |

| | First author.<br>Publication date.<br>Country | Study design | Source of data.<br>Year/s | Population –<br>eligibility criteria | Intervention –<br>Planned place of birth | Comparator – Planned place of birth | Outcome measures – relevant to current review outcomes | Quality rating |
|---|---|---|---|---|---|---|---|---|
| **Abbreviations at foot of table** | | | | | | | | |
| | | prospective study data | | | | | | |
| 27 | Van der Kooy<br>2011.<br>Netherlands | Population-based cohort –<br>2 methods | Perinatal Registry data.<br>2000-2007 | 679,952 women with low risk pregnancies in MW care.<br>*[602,331 excluding labour <37/40 or >41/40, or earlier intrauterine death ]* | Planned HB with MW<br>1) N=402,912<br>2) N=363,568 | Planned hospital birth<br>1) N=219,105<br>2) N=190,098<br>OR unclear planned BP<br>1) N=57,935<br>2) N=48,665 | Combined intrapartum death, neonatal death up to 24/24, neonatal death from 1-7 days. | High |
| 28 | Wiegerinck, 2015.<br>Netherlands | Retrospective cohort study | Linked admin + Registry data.<br>2005-2008 | Main study 83,289 women with singleton term pregnancies no elective CS, congenital abnormality or fetal death, at all risk levels.<br>*Additional data on 52,629 women with low-risk pregnancies* | Planned HB following MW-led care<br>N=23,323 | Planned hospital birth after MW-led care (n=18,675) + obstetrician-led care of low-risk pregnancies (n=10,631)<br>Total N=29,306 | PO: Perinatal mortality<br>SO: mode of birth, perineal trauma, PPH, admission to NICU | Moderate |

***Abbreviations:***

AABC=American Association of Birth Centers; AMU=Alongside Midwifery Unit; BC=birth centre; BMI=Body Mass Index; BP=birth place; BPiE=Birthplace in England (Collaboration Group); CDW=conventional delivery ward; CLU=consultant led unit; CS=Caesarean section; FMU=Freestanding (stand-alone) Midwifery Unit; HB=home birth; HELLP = haemolysis, elevated liver enzymes, low platelet count; IOL=induction of labour; ITT=intention to treat; LW=labour ward; mL=millilitres; MLU=Midwifery Led Unit; MW=midwife; N=number in cohort; NICU=Neonatal Intensive Care Unit; NICE=National Institute for Health and Care Excellence; NND=neonatal death; NS=not significant; NU=normal unit; NZ=New Zealand; OU=hospital (obstetric unit); PO=primary outcome; PPH=postpartum

| First author. Publication date. Country | Study design | Source of data. Year/s | Population – eligibility criteria | Intervention – Planned place of birth | Comparator – Planned place of birth | Outcome measures – relevant to current review outcomes | Quality rating |
|---|---|---|---|---|---|---|---|
| **Abbreviations at foot of table** | | | | | | | |
| haemorrhage;PU=primary unit; RCOG=Royal College of Obstetricians and Gynaecologists; RCT=randomised controlled trial; SCN=special care nursery; signif=significant; SO=secondary outcome; SU=special/secondary unit; SVB=spontaneous vaginal birth; TLW=traditional labour ward; TU=tertiary unit | | | | | | | |

## Results and synthesis of selected outcomes

The results from meta-analyses of data from 25 studies across nine outcome variables are summarised in Tables 3 and 4, showing comparisons of planned hospital births with births planned at home and in birth centres. Forest plots from each meta-analysis are included in Supplementary Figures S1-S18, including separate results from AMUs and FMUs in birth centre analysis.

Tables 3 and 4 also report sensitivity analyses for selected outcomes repeating the meta-analysis using only the studies rated as high quality (i.e. ≥ 75% on the ResQu Index). The description of infant mortality reports sensitivity analyses limited to studies which specifically excluded infants with known congenital abnormalities. We also repeated the meta-analyses of perinatal data from studies of planned home births, stratifying by parity where possible.

## Infant outcomes

There was no significant difference in the odds of intrapartum stillbirth according to place of birth. This was true for meta-analyses combining data from studies of planned home birth (Table 3 and Fig S1) and births planned in birth centres (Table 3 and Fig S2). This finding did not change when low and medium quality studies were removed from the analysis (Table 3). Limiting the analysis to studies where known congenital abnormalities were specifically excluded also yielded non-significant odds ratios (home births: OR=0.98 [95% CI: 0.66-1.46]; birth centres OR=0.65 [95% CI: 0.31-1.34]). Further analysis by parity indicated that there were no significant differences in the odds of stillbirth between births planned in hospitals and at home for either nulliparous or multiparous women (Table 3 and Fig S1a).

## Table 3: Meta-analysis of Infant Outcomes

| **Infant outcomes – planned homebirth vs hospital** | **Fig** | **No. of studies** | **Planned home birth n/N** | **Planned hospital birth n/N** | **Estimated odds ratio** | **95% confidence interval** | **Sensitivity analysis – High quality studies only** | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **No. of studies** | **Est odds ratio** | **95% CI** |
| Stillbirth | S1 | 6[a] | 206/486035 | 280/542374 | 0.94 | 0.76– 1.17 | 6 | 0.94 | 0.76 – 1.17 |
| *Stillbirth – nulliparous* | *S1a* | *3* | *113/198948* | *87/144273* | *1.20* | *0.32 – 4.51* | | | |
| *Stillbirth – multiparous* | *S1a* | *3* | *87/269031* | *45/149866* | *1.04* | *0.73 – 1.50* | | | |
| Early neonatal death | S3 | 6[b] | 171/484165 | 166/534878 | 1.00 | 0.78 – 1.27 | 6 | 1.00 | 0.78 – 1.27 |
| *ENND – nulliparous* | *S3a* | *3* | *95/198845* | *69/144193* | *0.99* | *0.73 – 1.36* | | | |
| *ENND – multiparous* | *S3a* | *3* | *72/268949* | *42/149823* | *1.03* | *0.69 – 1.54* | | | |
| Admission to NICU | S5 | 4[c] | 1123/472914 | 2694/335202 | 0.71 | 0.55 – 0.92 | 3 | 0.79 | 0.63 – 0.98 |
| *NICU admission – nulliparous* | *S5a* | *2* | *656/198476* | *499/137280* | *1.11* | *0.65 – 1.89* | | | |
| *NICU admission – multiparous* | *S5a* | *2* | *337/267687* | *272/140426* | *0.74* | *0.62 – 0.87* | | | |
| **Infant outcomes - planned birth in birth centre (BC) vs hospital** | **Fig** | **No of studies** | **Planned BC birth n/N** | **Planned hospital birth n/N** | **Estimated odds ratio** | **95% confidence interval** | | | |
| Stillbirth | S2 | 7[d] | 9/44750 | 151/253294 | 0.66 | 0.32 – 1.34 | 4 | 0.65 | 0.31 – 1.34 |
| Early neonatal death | S4 | 7[e] | 10/46522 | 56/245921 | 1.10 | 0.44 – 2.72 | 4 | 1.08 | 0.42 – 2.78 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Admission to NICU | S6 | 6[f] | 387/16540 | 2073/63507 | 0.82 | 0.62 – 1.08 | 4 | 0.88 | 0.59 – 1.32 |

*Included studies:*

a. Birthplace in England Collaborative Group 2011; Blix et al. 2012; Davis et al. 2011; de Jonge et al. 2015; Halfdansdottir et al. 2015; Homer et al. 2014. Parity data not available for two studies: Davis et al. 2011; Homer et al. 2014
b. Birthplace in England Collaborative Group 2011; Blix et al. 2012; Burns et al. 2012; de Jonge et al. 2015; Halfdansdottir et al. 2015; Homer et al. 2014. Parity data not available for two studies: Burns et al. 2012; Homer et al. 2014
c. Davis et al. 2011; de Jonge et al. 2015; Dixon et al. 2014; Halfdansdottir et al. 2015. Parity data not available for Davis et al. 2011; Dixon et al. 2014
d. Birthplace in England Collaborative Group 2011; Davis et al. 2011; Gaudineau et al. 2013; Homer et al. 2000; Homer et al. 2014; Overgaard et al. 2011; Ryan & Roberts 2005). Parity data only available for two studies with nil events for either cohort (Gaudineau et al. 2013; Overgaard et al. 2011
e. Birthplace in England Collaborative Group 2011; Burns et al. 2012; Gaudineau et al. 2013; Homer et al. 2000; Homer et al. 2014; Overgaard et al. 2011; Ryan & Roberts 2005. Parity data only available for one study with nil events for either cohort Gaudineau et al. 2013
f. Bernitz et al. 2011; Davis et al. 2011; Dixon et al. 2014; Overgaard et al. 2011; Prelec, Verdenik & Poat 2014. AMU data only for Burns et al. 2012 as FMU data merged with homebirth data.

There were no significant differences in the odds for early neonatal death (0-7 days) in relation to birth place, regardless of study quality (Fig S3 and Fig S4). Studies of planned home births that specifically excluded congenital abnormalities also showed a non-significant difference (OR=0.99 [95% CI: 0.77-1.26]). Studies of birth centres that excluded infants with congenital abnormalities had a non-significant OR of 0.99 [95% CI: 0.34-2.86]. Similarly, there were no significant differences in early neonatal death by parity between births planned at home and in hospital (Table 3 and Fig S3a).

Meta-analysis of four studies of planned home births identified significantly lower odds of NICU admission than for planned hospital births, as did the three high quality studies (Davis et al. 2011; de Jonge et al. 2015; Halfdansdottir et al. 2015). Babies of multiparous women had significantly lower odds of NICU admission if they planned a home birth rather than a hospital birth, although there was no significant difference by birth place among nulliparous women on this outcome (Figs S5 and S5a). Combining data from studies of planned birth centre births showed no significant difference in odds of NICU admission regardless of study quality (Table 3 and Fig S6).

Women planning home births were nearly three times more likely to have a normal (non-instrumental) vaginal birth than women planning a hospital birth. The odds were higher when analysis was restricted to high quality studies (Table 4 and Fig S7) and to studies using a more specific definition of non-instrumental vaginal birth without induction of labour, epidural, spinal or general anaesthesia (Birthplace in England Collaborative Group et al. 2011; Burns et al. 2012; Homer et al. 2014) (OR=5.62 [95% CI: 1.30-24.24]). Women planning home births had significantly lower odds of either caesarean section or instrumental birth (approximately one third of those for women planning a hospital birth), regardless of study quality.

## Table 4: Meta-analysis of Maternal Outcomes

| Maternal outcomes – planned homebirth vs hospital | Figure | No. of studies | Planned home birth n/N | Planned hospital birth n/N | Estimated odds ratio | 95% confidence interval | Sensitivity analysis – High quality studies only | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | No. of studies | Estimated odds ratio | 95% confidence interval |
| Normal vaginal birth | S7 | 9[a] | 41473/45777 | 163523/300507 | 2.93 | 2.13 – 4.03 | 6 | 3.25 | 1.97 – 5.38 |
| Caesarean section | S9 | 9[b] | 1006/46935 | 31209/322166 | 0.35 | 0.27 – 0.46 | 6 | 0.36 | 0.24 – 0.53 |
| Instrumental birth | S11 | 9[c] | 2682/46935 | 46157/322166 | 0.37 | 0.24 – 0.58 | 6 | 0.33 | 0.21 – 0.51 |
| Intact perineum | S13 | 2[d] | 1632/3720 | 5284/12079 | 1.15 | 1.06 – 1.25 | 2 | 1.15 | 1.06 – 1.25 |
| Severe perineal trauma | S15 | 9[e] | 920/44625 | 9333/290389 | 0.57 | 0.40 – 0.81 | 6 | 0.49 | 0.30 – 0.81 |
| PPH ≥1000mL | S17 | 6[f] | 2853/102663 | 5231/336330 | 0.73 | 0.55 – 0.96 | 5 | 0.68 | 0.52 – 0.89 |

| Maternal outcomes – planned birth in birth centre vs hospital | Figure | No. of studies | Planned BC birth n/N | Planned hospital birth n/N | Estimated odds ratio | 95% confidence interval | No. of studies | Estimated odds ratio | 95% confidence interval |
|---|---|---|---|---|---|---|---|---|---|
| Normal vaginal birth | S8 | 11[g] | 53108/63443 | 322132/521925 | 1.92 | 1.59 – 2.32 | 7 | 2.05 | 1.60 – 2.63 |
| Caesarean section | S10 | 15[h] | 4061/81697 | 136964/782157 | 0.48 | 0.39 – 0.60 | 9 | 0.54 | 0.42 – 0.70 |
| Instrumental birth | S12 | 14[i] | 5731/72921 | 97916/780066 | 0.61 | 0.52 – 0.71 | 8 | 0.58 | 0.46 – 0.72 |
| Intact perineum | S14 | 6[j] | 2517/6912 | 7014/19361 | 1.20 | 0.98 – 1.47 | 3 | 1.04 | 0.82 – 1.30 |
| Severe perineal trauma | S16 | 11[k] | 1852/68328 | 14429/621185 | 1.01 | 0.96 – 1.07 | 7 | 0.93 | 0.87 – 0.99 |
| PPH ≥1000mL | S18 | 5[l] | 77/6378 | 238/17309 | 0.87 | 0.67 – 1.14 | 4 | 0.83 | 0.63 – 1.09 |

*Included studies*:

a. Birthplace in England Collaborative Group 2011; Blix et al. 2012; Bolten et al. 2016; Davis et al. 2011; Halfdansdottir et al. 2015; Hiraizumi & Suzuki 2013; Homer et al. 2014; Miller & Skinner 2012; Wiegerinck et al. 2016
b. Birthplace in England Collaborative Group 2011; Blix et al. 2012; Bolten et al. 2016; Davis et al. 2011; Halfdansdottir et al. 2015; Hiraizumi & Suzuki 2013; Homer et al. 2014; Miller & Skinner 2012; Wiegerinck et al. 2016
c. Birthplace in England Collaborative Group 2011; Blix et al. 2012; Bolten et al. 2016; Davis et al. 2011; Halfdansdottir et al. 2015; Hiraizumi & Suzuki 2013; Homer et al. 2014; Miller & Skinner 2012; Wiegerinck et al. 2016
d. Bolten et al. 2016; Davis et al. 2011
e. Birthplace in England Collaborative Group 2011; Blix et al. 2012; Bolten et al. 2016; Davis et al. 2011; Halfdansdottir et al. 2015; Hiraizumi & Suzuki 2013; Homer et al. 2014; Miller & Skinner 2012; Wiegerinck et al. 2016
f. Bolten et al. 2016; Davis et al. 2012; de Jonge et al. 2013; Halfdansdottir et al. 2015; Hiraizumi & Suzuki 2013; Nove, Berrington & Matthews 2012a
g. Bernitz et al. 2011; Birthplace in England Collaborative Group 2011; Burns et al. 2012; Davis et al. 2011; Eide, Nilsen & Rasmussen 2009; Gaudineau et al. 2013; Hiraizumi & Suzuki 2013; Homer et al. 2000; Homer et al. 2014; Laws, Tracy & Sullivan 2010; Overgaard et al. 2011
h. Bernitz et al. 2011; Birthplace in England Collaborative Group 2011; Burns et al. 2012; Byrne, Crowther & Moss 2000; Davis et al. 2011; Eide, Nilsen & Rasmussen 2009; Gaudineau et al. 2013; Hiraizumi & Suzuki 2013; Homer et al. 2000; Homer et al. 2014; Laws, Tracy & Sullivan 2010; Overgaard et al. 2011; Prelec, Verdenik & Poat 2014; Ryan & Roberts 2005; Thornton et al. 2016
i. Bernitz et al. 2011; Birthplace in England Collaborative Group 2011; Burns et al. 2012; Byrne, Crowther & Moss 2000; Davis et al. 2011; Eide, Nilsen & Rasmussen 2009; Gaudineau et al. 2013; Hiraizumi & Suzuki 2013; Homer et al. 2000; Homer et al. 2014; Laws, Tracy & Sullivan 2010; Overgaard et al. 2011; Prelec, Verdenik & Poat 2014; Ryan & Roberts 2005
j. Burns et al. 2012; Davis et al. 2011; Gaudineau et al. 2013; Homer et al. 2000; Overgaard et al. 2011; Ryan & Roberts 2005
k. Bernitz et al. 2011; Birthplace in England Collaborative Group 2011; Burns et al. 2012; Davis et al. 2011; Eide, Nilsen & Rasmussen 2009; Gaudineau et al. 2013; Hiraizumi & Suzuki 2013; Homer et al. 2014; Laws, Tracy & Sullivan 2010; Overgaard et al. 2011; Prelec, Verdenik & Poat 2014
l. Bernitz et al. 2011; Burns et al. 2012; Davis et al. 2012; Hiraizumi & Suzuki 2013; Overgaard et al. 2011

Women planning a birth centre birth had nearly twice the odds of having normal vaginal births compared with women planning hospital births – with higher odds identified amongst higher quality studies (Table 4) and planned FMU births (Fig S8). Sensitivity analysis using the stricter definition found that women planning birth centre births had significantly higher odds of normal vaginal births without other interventions (n=3, OR=2.12 [95% CI: 1.54-2.92]). The odds of instrumental birth and caesarean section were also significantly lower for women planning to give birth in birth centres, regardless of type of birth centre or quality of the study (Fig S10 and S12).

### Maternal outcomes - perineal status

Only two studies investigated the likelihood of an intact perineum amongst women planning home births, reporting significantly higher odds (Fig S13). The six studies investigating this variable in planned birth centre births found no significant difference in odds compared with planned hospital births, regardless of study quality (Table 4 and Fig S14).

The odds of severe perineal trauma were significantly lower amongst planned home births, regardless of study quality (Fig S15) and among higher-quality studies of births planned in birth centres (Table 4).

### Maternal outcomes - PPH

Severe PPH ($\geq$1000mL) was significantly less likely in planned home births than in planned hospital births (Fig S17). However, there was no significant difference in the odds identified in studies of planned birth centre births, regardless of the type of birth centre (Fig S18) or the rating of study quality (Table 4).

## Discussion

### Principal findings

This review examined whether there were significant differences between different planned birth places in critical maternal and perinatal outcomes, to help women make informed decisions about where to give birth. It is unique in including data from both birth centres and home births.

Limiting data to outcomes from low-risk pregnancies, we endeavoured to compare planned birth place cohorts across nine relevant outcomes. Combined maternal data from the selected studies indicated significantly lower odds of intervention and maternal morbidity, and significantly higher odds of normal vaginal births among planned home births compared to planned hospital births (Table 4). This is consistent with conclusions from other syntheses of research on planned home births (not all of which included comparative data) (Fullerton, Navarro & Young 2007; Leslie & Romano 2007; McIntyre 2012; Stotland & Declercq 2002; Zielinski, Ackerson & Kane Low 2015) and with Olsen's early meta-analysis (1997). Further, women planning birth centre births had nearly twice the odds of a normal vaginal birth compared to women planning a hospital birth, with correspondingly lower rates of caesarean section or instrumental births. This is consistent with findings from other reviews (Alliman & Phillippi 2016; Dixon et al. 2012; Hodnett, Downe & Walsh 2012; McIntyre 2012; Muthu & Fischbacher 2004). Our results found no significant difference in rates of severe perineal trauma or PPH between planned birth centre and hospital births.

While many authors have identified favourable maternal outcomes in planned birth centre and home births, including outcomes not addressed in this review, results regarding infant outcomes from different places of birth are more controversial. Our meta-analysis found no significant difference between the cohorts in the odds of stillbirth or early neonatal death (Table 3), albeit by combining several studies with limited statistical power to detect differences in such rare outcomes. This was consistent for studies of births planned in birth centres and at home, regardless of study quality. Moreover, the odds of perinatal mortality did not differ between births planned in hospital and at home, among both nulliparous and multiparous women. The absolute numbers of adverse events were still very small (Olsen & Clausen 2012). There were significantly lower odds of admission to NICU for babies of women planning a home birth than those of women planning hospital births.

## Limitations

Given different countries of origin, the selected studies varied considerably in context: service provision, setting, models of care and the overall integration between maternity services. Thus, generalisation of findings to high-income countries with different healthcare systems requires caution. There was diversity too in the quality of the included studies, although we attempted to reduce its impact through strict eligibility criteria and appraisal with the ResQu Index. Studies explored a wide range of outcomes; even common outcomes were sometimes defined differently, limiting the extent to which we could extract comparable data. Thus not all studies addressing a given outcomes contributed data to its relevant meta-analyses.

Limiting eligibility to publication in English language peer-reviewed journals may have resulted in some publication bias across studies, overlooking studies from some regions. Publication bias may have also resulted in the inclusion of studies that only reported significant differences between cohorts. However, given the controversial nature of this topic and the strong perspectives of different provider groups in some regions, it is likely that good quality studies on perinatal and maternal outcomes would usually be published. Further, for some outcomes such as mortality, a non-significant difference between places of birth is as noteworthy as one that is statistically significant.

We only conducted a few meta-analyses in terms of parity, focussing on adverse perinatal outcomes from planned home births. Although we recognise that parity is an important determinant of maternal and perinatal outcomes, many studies did not present data by parity. Further, by focusing specifically on birth setting, we did not explore the impact of provider type or model of care.

Most research into place of birth is observational. Our quality appraisal process, eligibility criteria and data extraction endeavoured to minimise bias between individual studies in design, analysis and reporting. However, there may have been systematic differences in confounders that could be overcome through

randomisation. The rarity of perinatal mortality in high-income countries necessitates combining studies to provide sufficiently large home birth or birth centre cohorts to show meaningful results.

Another proposed systematic review and meta-analysis (Hutton et al. 2014) is in progress. It will focus on studies of home birth outcomes that stratify by parity and those in countries where home birth is well integrated with other maternity services.

## Heterogeneity

Not surprisingly, several meta-analyses showed high heterogeneity ($I^2$) scores (Figures S1-S18), especially for mode of birth. These scores largely reflect the variation in sample size and in the outcomes of the individual studies and are consistent with the conclusions of other reviews that have highlighted the disparities between selected observational studies. The measures generated by the software may overlook other aspects of heterogeneity in studies, such as unmeasured differences in staffing or resources between birth settings or in underlying characteristics of the women in different cohorts.

## Risk status

We closely analysed the studies' definitions 'low-risk', rather than comparing them with a strict definition determined *a priori*. Most studies gave detailed criteria, including at minimum gestational age, fetal presentation, and singleton pregnancy. The descriptions of exclusion criteria varied from vaguely-defined 'pre-existing medical conditions' or 'obstetric complications', through to comprehensive lists of factors which contribute significantly to risk status. Even where they demonstrated similar levels of obstetric risk, several studies identified marked disparity in the demographic characteristics between cohorts. Most studies adjusted reported odds ratios to take account of some if not all of these demographic differences; some discussed the impact of less measurable distinctions between their cohorts (e.g. motivation, attitudes).

### Quality appraisal

This paper is unique in using the ResQu Index, an innovative instrument to appraise research specifically on place of birth (Vedam, Rossiter, et al. 2017). Although the development of the Index included expert validation and extensive pilot-testing, this is the first known application of the tool in a systematic review. Only ten included studies scored as moderate or low in quality. This does not demonstrate that the Index is undiscriminating; rather it reflects that review inclusion criteria were strict and addressed similar considerations as the ResQu Index itself (e.g. adherence to intention-to-treat analysis or exclusion of non-comparable cohorts).

Findings from the sensitivity analyses (Tables 3 and 4) indicate that the overall odds ratios rarely changed substantially by ruling out weaker studies, which typically had smaller sample sizes. In one meta-analysis of perineal trauma among planned birth centre births, data limited to higher quality studies generated a statistically significant difference from planned hospital births whereas analysis of all studies yielded a non-significant difference.

## Conclusions

By comparing and synthesising results from three distinct birth settings, this review offers valuable evidence to inform decisions about birth place. The results demonstrate that, amongst carefully selected studies of women with low-risk pregnancies in high-income countries, planned place of birth appears to have little significant impact on adverse perinatal outcomes. Moreover, women who planned to give birth in a birth centre or at home had significantly lower odds for intervention and severe morbidity in labour and birth.

These findings have important implications for healthcare costs and services. They support the expansion of birth centres and home birth options, and the systems to support them, including professional guidelines and education. The results also have ramifications for information provided to pregnant women and their families, as a means to enhance their choice and autonomy about birthplace options. They help extend existing knowledge about the risks and potential outcomes from

different places and birth, and the circumstances necessary to optimise the safety and well-being of mothers and newborns.

# Chapter 3: Costing Alternative Birth Settings for Women at Low Risk of Complications: A Systematic Review

## Context

The evidence presented in the previous chapter is of the safety of giving birth at home or in a birth centre compared to a hospital setting. The question of the economic considerations related to birth outside a hospital setting emerges.

Chapter three contains a systematic review of economic analyses of planned birth at home, in a birth centre and in a hospital setting for women at low risk of complications. In this chapter I have gathered evidence from high-income countries which supports the economic benefit of birth in the three settings. This relates to the second part of Objective One, further supporting that birth is not only safe at home or in a birth centre for healthy women, it is also economically advantageous.

## Publication details

This work was published in Plos One in February 2016:

Scarf, V, Catling, C, Viney, R & Homer, C 2016, 'Costing Alternative Birth Settings for Women at Low Risk of Complications: A Systematic Review', *PloS One*, vol. 11, no. 2, p. e0149463.

# Abstract

**Background**

There is demand from women for alternatives to giving birth in a standard hospital setting however access to these services is limited. This systematic review examines the literature relating to the economic evaluations of birth setting for women at low risk of complications.

**Methods**

Searches of the literature to identify economic evaluations of different birth settings of the following electronic databases: MEDLINE, CINAHL, EconLit, Business Source Complete and Maternity and Infant care. Relevant English language publications were chosen using keywords and MeSH terms between 1995 and 2015. Inclusion criteria included studies focussing on the comparison of birth setting. Data were extracted with respect to study design, perspective, PICO principles, and resource use and cost data.

**Results**

Eleven studies were included from Australia, Canada, the Netherlands, Norway, the USA, and the UK. Four studies compared costs between homebirth and the hospital setting and the remaining seven focussed on the cost of birth centre care and the hospital setting. Six studies used a cost-effectiveness analysis and the remaining five studies used cost analysis and cost comparison methods. Eight of the 11 studies found a cost saving in the alternative settings. Two found no difference in the cost of the alternative settings and one found an increase in birth centre care.

**Conclusions**

There are few studies that compare the cost of birth setting. The variation in the results may be attributable to the cost data collection processes, difference in health systems and differences in which costs were included. A better

understanding of the cost of birth setting is needed to inform policy makers and service providers.

# Introduction

Maternity services are the third most common specialist service in Australia and single spontaneous delivery is the most common principle diagnosis among acute overnight admissions to hospital. (Australian Institute of Health and Aging 2014) There are over 300,000 births in Australia each year (Hilder et al. 2014), with over 99% occurring in a public or private hospital setting, or in a birth centre, leaving less than 1% of women giving birth at home.

In 2009, the Department for Health and Ageing released the National Review of Maternity Services which contained feedback from stakeholders outlining issues relating to limited access to different models of care. (Commonwealth of Australia 2009) As a result, the National Maternity Services Plan (Australian Health Ministers' Advisory Council 2011) was released in 2011 with priorities for the following five years. One of these was to "increase access for Australian women and their family members to local maternity care by expanding the range of models of care" going on to state that "continuing to provide a range of maternity care options, including homebirth, is a priority" (p 31).

The majority of Australian women do not have access to alternative birth settings. Access to birth centres remains at around 5% of women and homebirth less than 1% .(Li et al. 2013 ) Publicly-funded homebirth models have been established around the country but still cater for very small numbers of women, in fact less than 2000 women over a six year period. (Catling-Paull, Coddington, Foureur & Homer 2013) In a recent analysis of population data in NSW (Homer et al. 2014) from 2000 to 2008, the vast majority of healthy low risk women (around 94%) gave birth in a hospital labour ward. Other places of birth were home (0.3%), attended by a public or private midwife; or a birth centre (5.6%), most often co-located on the campus of a public maternity service and staffed by midwives.

There is evidence that alternative models of care and settings for birth are a safe, highly acceptable option for childbearing women. Within the last decade, Australian research has shown significantly lower perinatal mortality for women cared for in birth centres compared to hospital births (Tracy et al. 2007). Significantly higher

spontaneous birth rates, lower caesarean section rates and admissions to special care nurseries have also been found in a study of two freestanding birth centres in NSW.(Monk et al. 2014) In a review of 12 publicly-funded homebirth models from 2005 to 2009 (Catling-Paull, Coddington, Foureur & Homer 2013) a normal birth rate of 90% was reported with no significant increase in perinatal mortality associated with planned homebirth.

Access to alternative birth settings internationally varies both within and between countries and this is closely linked to status and role of the midwife in that country (Benoit et al. 2005; De Vries et al. 2002) which is influenced by cultural values, social norms, legislation, education, and the consumer interest. (Benoit et al. 2005) Of the countries included in this review, maternity care in the United Kingdom is the most similar to Australia. The National Health Service (NHS) provides maternity care which is free at point of care to the vast majority of childbearing women. In 2007, the proportion of women giving birth across the settings is as follows: 8% gave birth outside a hospital based maternity unit (obstetric unit), 2.8% at home, and the remainder in a birth centre, either alongside (AMU) an obstetric unit or freestanding (FMU). (Redshaw et al. 2011) The Netherlands has an extensive primary health care service which provides out-of-hospital birth services (at home or in a short-stay hospital setting) to women at low risk of complications and has a homebirth rate of approximately 29%. (Wiegers et al. 2000) These low-risk women are under the care of a midwife or general practitioner who refer any women with medical complications to specialist obstetric care in a secondary care setting (ie hospital). (Hendrix, Evers, et al. 2009)

In Norway, midwives provide care to all childbearing women in labour in and out of hospital with referral to medical specialists for complicated cases. In-hospital birth accounts for 98.4% of women, the remaining 1.6% of women giving birth out of hospital including at home or in “freestanding birth homes”. (Blix et al. 2012) The proportion of women giving birth at home in Ireland is 0.2% and these births are attended by self-employed midwives (Irish perinatal stats report). Midwifery-led units, an out-of-hospital birth option, have more recently been implemented

however the number of births in these facilities is reported as part of the hospital birth statistics (Irish perinatal stats report) therefore it is not possible to report these statistics.

The total number of out-of-hospital births in the Unites States (US) in 2012 was 1.36%, two-thirds of which occurred at home and the remaining third in birth centres. (MacDorman MF, Mathews TJ & E. 2014) While this is a national statistic, the state by state proportions vary from 2% to 6% largely due to availability of midwives (state laws vary regarding midwifery and credentialing) and birth centres. The number of birth centres increased to 310 in 2015 (Alliman & Phillippi 2016) however 13 states do not offer birth centre facilities at all. (MacDorman MF, Mathews TJ & E. 2014) Out-of-hospital birth options in Canada also vary by province. Midwifery regulation was first introduced in 1994 in Ontario and now out of hospital birth is offered six of the 13 provinces. For example, in British Columbia, 11% of births are attended by a midwife and 20% of these are at home (Janssen, Milton & Aghajanian 2015), and in Ontario, home births comprise 1.6% of the births in the province. (Hutton, Reitsma & Kaufman 2009)

Whilst evidence of the safety of alternative birth settings in Australia and internationally is growing, information about the comparative costs and cost-effectiveness is less easy to find. The most comprehensive study to date has been the Birthplace in England Study (Schroeder et al. 2012), in which a birth place cost-effectiveness analysis was undertaken. This prospective cohort study examined the outcomes of 64,538 women and babies according to intended place of birth at the onset of labour and found that it was less expensive for the health system for low risk women to give birth at home, especially for women having their second or subsequent baby. (Schroeder et al. 2012) The cost analyses performed in Australia to date have examined the model of care (Homer et al. 2001; Toohill et al. 2012; Tracy et al. 2013) or public versus privately provided care (Tracy et al. 2013; Tracy & Tracy 2003), but they do not directly address the comparative costs for women of similar risk in different settings. In particular, these studies do not address the question of the comparative cost to the health system in Australia of giving birth at

home or in a birth centre compared to a standard hospital labour ward for women at low risk of complications.

The aims of this review are firstly to identify economic evaluations or cost analyses comparing places of birth which include home, birth centres, both freestanding and alongside, and standard hospital labour wards. Secondly, this review aimed to explore the methodological approaches employed by the selected studies. The purpose of this aim was to assess the factors that inform the cost and cost effectiveness of these settings and to determine the most appropriate approach to inform future cost analyses on place of birth.

# Methods

## Search Method

Searches of the literature to identify economic evaluations of different birth settings were made in February 2015 of the following electronic databases: MEDLINE, CINAHL, EconLit, Business Source Complete and Maternity and Infant care. The PICO principles (population, intervention, comparison, and outcome) were used to inform keyword search terms. (Centre for Reviews Dissemination 2009; Khan et al. 2003) Reference lists of relevant articles, including reviews were also examined. The keywords and MeSH subject headings that were used are shown in Figure 1.

**Figure 1: Keywords and MeSH terms used in search strategy**

**Keywords**

- "Childbirth" or "Home Childbirth" or "Alternative Birth Methods" "homebirth" or "home birth" **and ….**
- "birth centre" "birthcentre" or "Alternative Birth Centers" or "out of hospital setting" **and …**
- "Hospital Units" or "hospital birth" or "Delivery, Obstetric" or "obstetric unit" or "delivery suite" or "birth suite" **and ……**
- "Birth Place" or "birthplace" or "place of birth" **and……**
- "model of care" or "Midwifery" or "midwife" or "midwife-led" or "caseload midwifery" or "Group Practice" or "Nurse-Midwifery Service" or "midwifery group practice" **and……**
- "Obstetric Care" or "Obstetric Patients" or "Obstetric Service" or "Private Sector" **and** …..

**AND**

Costs and Cost Analysis" or "cost" or "Health Care Costs" or "Health Facility Costs" or "Cost Benefit Analysis" or "Cost Savings" or "Economics" or "economic analysis"

**MeSH Terms**

- "Parturition/" or "childbirth.mp" or "Home Childbirth" or "home birth.mp" or "homebirth.mp."or "Maternal Health Services" **and ….**
- "Birthing Centers "or "birth center.mp." or "birthcenter.mp." or "birth centre.mp."or "Maternal Health Services" **and ….**
- "Delivery, Obstetric" or "delivery suite.mp."or "Labor, Obstetric "or "birth unit.mp."or "delivery suite.mp."or "obstetric unit.mp." or "hospital birth.mp." **and …..**
- "place of birth.mp." or "birthplace.mp." or "birth place.mp." **and ….**
- "model of care.mp." or "Midwifery" or "midwifery.mp." or "midwifery-led care.mp." or "midwife.mp." or "midwife-led.mp." or "caseload midwifery.mp." or "Continuity of Patient Care" or "Nurse Midwives" **and ….**
- "Obstetrics" or "obstetric care.mp." or "obstetric management.mp." or "medical birth.mp."or "private obstetric.mp." or "obstetrician.mp." **and ….**

**AND**

"Costs and Cost Analysis" or "Cost-Benefit Analysis" or "cost-effectiveness.mp." or "economic analysis.mp." or "Health Care Costs"

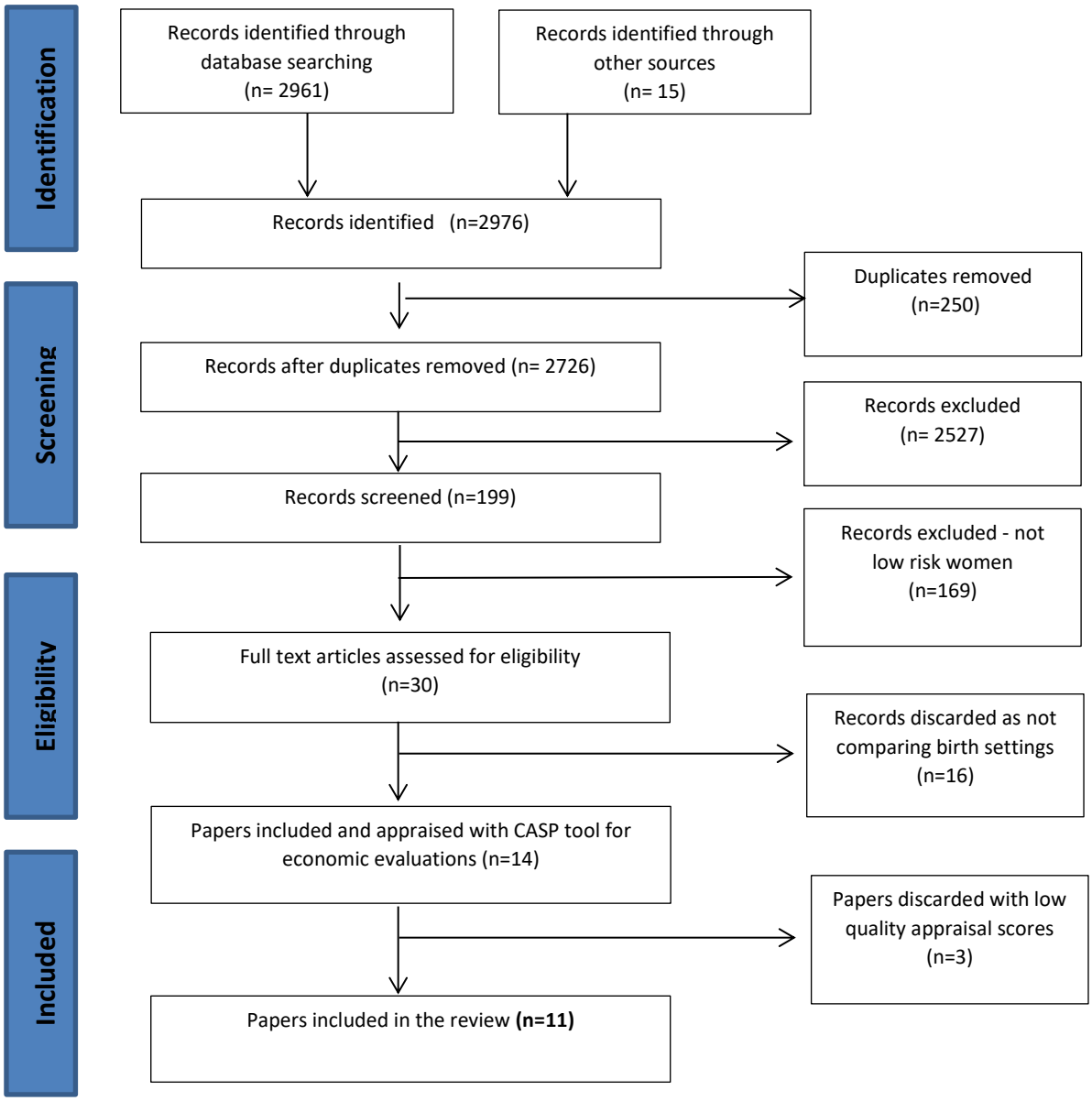
Due to the multifactorial nature of the subject, search terms were divided into groups, namely model of care and place of birth. These groups were then combined with search terms describing cost analysis or economic analysis separately.

*Search Protocol*

Original, English language studies between the years 1995 and 2015 were included. Studies that reported on costs and/or incorporated an economic analysis of models of care and place of birth for low risk women at term were reviewed. To achieve

this, the search included alternative birth settings, models of care, and economic analyses. After testing a number of combinations, the search terms associated with the concepts of place of birth and model of care were paired by group with economic analyses to achieve a reasonable number of papers to review (see figure 1). Retrieved articles were screened by two authors for their focus on the cost of place of birth specifically comparing two or more birth settings. The other critical factor in the selection of the studies was the focus on a population of women at low risk of complications. This resulted in the close appraisal of 14 articles using the Critical Appraisal Skills Program (CASP) tool for Economic Analyses. Three studies were excluded due to low appraisal scores. Figure 2 is a flowchart of search process.

**Figure 2: Flowchart of literature review process**




## Quality Appraisal

The Critical Appraisal Skills Programme (CASP) Economic Evaluations Checklist was used to appraise the methodologies of the included papers. This checklist has twelve questions adapted from Drummond et al (2005). The tool consists of questions with some guidance comments where applicable and "Yes, Can't tell, No" responses (see Figure 3). The question "What were the results of the evaluation?" did not fit the yes/no answer format therefore the overall scores added to eight.

Data were extracted by one reviewer using a template agreed on by all authors that included the following areas of interest: Study design and perspective, population, intervention, comparison and outcome (PICO), source of resource use data, details of cost included in the study, results of the cost analyses, and overall interpretation the results (Table 1).

**Figure 3: CASP questions**

- Was a well-defined question posed?
- Was a comprehensive description of the competing alternatives given?
- Does the paper provide evidence that the programme would be effective?
- Were the effects of the interventions identified, measured and valued appropriately?
- Were all important and relevant resources and outcome costs for each alternative identified, measured in appropriate units and valued credibly?
- Were costs and consequences adjusted for different times at which they occurred (discounting)?
- What were the results of the evaluation?
- Was an incremental analysis of the consequences and cost alternatives performed?
- Was an adequate sensitivity analysis performed?
- Is the programme likely to be equally effective in your area?
- Are the costs translatable to your setting?
- Is it worth doing in your setting?

# Results

Table 1 summarises the included studies. The studies in this analysis had a high degree of heterogeneity in their methods, included costs and aims. The time horizon for all 14 studies was less than one year, therefore discounting was not necessary. All papers scored a 'no' for this question on the CASP evaluation tool.

Of the 11 articles reviewed, three were from the United States of America (USA), two from Canada, two from the United Kingdom (UK), two from Europe, one from Ireland and one from Australia. Six of the studies used a cost-effectiveness model, with the remaining five studies reporting a combination of cost analyses (four) and a cost comparison. Eight of the 11 studies found a cost saving in the alternative settings, namely at home or in midwifery-led units (also referred to as birth centres). Two found no difference in the cost of the alternative settings and one found an increase in cost in providing care to women in a birth centre. The

intervention compared in this review was the alternative setting for birth and this included home (four studies), birth centres or midwifery-led units (eight studies, Schroeder et al compared both home and birth centres) which were situated either alongside a standard hospital facility (six) or as free-standing facilities separate from a hospital campus (three).

While papers were selected on the basis of including women at low risk of complications, the assessment of low risk status varied among the studies. Women were largely chosen using the criteria for selection to 'birth centre care' or 'midwife-led care' or 'eligibility for a homebirth' and this criteria was used to match the comparison cohort attending the standard hospital labour ward or 'consultant led unit'. These criteria were not routinely described in the papers therefore it is difficult to attest to the comparability of the cohorts. Schroeder et al (2012) employed the National Institute for Health and Care Excellence (NICE) definition of a woman at low risk of complications.

The perspectives of the studies included societal (Hendrix, Evers, et al. 2009; Reinharz et al. 2000), Medicaid or the Government (Anderson & Anderson 1999; Howell et al. 2014; Janssen, Milton & Aghajanian 2015; Schroeder et al. 2012; Toohill et al. 2012), the individual health service (Bernitz, Aas & Oian 2012; Hundley et al. 1995; Kenny et al. 2015) and the insurer (Stone & Walker 1995). The variation in the perspective was reflected in the identification and collection of the resource use data to measure the costs of the alternative birth settings. The majority of studies found a cost saving in providing pregnancy and birth care to women however the variation in the parameters measured leave questions as to the comparability and generalisability of these economic evaluations.

Many of the studies included in this review have reported clinical outcomes, either from Randomised Controlled Trials (RCTs) or associated studies, however this review has focussed on the cost outcomes of each study. These will be further divided by comparisons of birthplace and cost analysis methodology.

## Table 1: Details of included studies in alphabetical order

| First Author Date (country) | Study design<br><br>Perspective | Population (N=) | Intervention | Comparator | Outcome | Source of resource use data | Included costs | Cost analysis/ cost-effectiveness results | Interpretation |
|---|---|---|---|---|---|---|---|---|---|
| 1. Anderson 1999 (USA) | Cost-effectiveness analysis- Cohort study<br><br>Perspective: Medicaid/Government | Low risk women, (undefined criteria) in 1996<br><br>(N=23 380) | Intended homebirths between 1987 and 1991 attended by CNM | Hospital births unspecified attendant | Birth without intrapartum fetal or neonatal mortality | Retrospective questionnaire to Certified Nurse Midwives, Health Insurance Assoc. of America (HIAA) and other literature for medical charges | CNMs - average charges for performing Home Birth (unspecified) Medical costs estimated from average of published rates charged and the Health Insurance Association of America | Cost comparison- HB $1711 (1991) Hospital $5382 (1991) | HB is a cost effective alternative (estimated saving of 76% relative to hospital birth 1998) with lower rates of neonatal mortality and caesarean section. |
| 2. Bernitz 2012 (Norway) | Cost-effectiveness analysis of RCT<br><br>Perspective: Health care provider | Low risk women, (MU selection criteria used) between 2006 and 2010<br><br>(N=1110) | Alongside Midwifery Unit (MU) (Birth centre) care by midwives between 2006 and 2010 | Standard obstetric unit within same hospital care by midwives | Clinical procedures avoided- LSCS, Instrumental vaginal deliveries, interventions requiring operating room, EDB, augmentation of labour | Hospital accounting, activity databases and patient records | Length of stay, patient activities, service costs and patient related costs, staff resources (average), intervention costs | Cost per patient calculated (4 steps).<br><br>Top-down/bottom-up.<br>€1672 v €1950<br><br>ICER- MU dominant strategy | MU less expensive and fewer epidural blocks and augmentation of labour. Measured costs related only to birth care. |
| 3. Hendrix 2009 (Netherlands) | Cost analysis of a Prospective non-randomised controlled study<br><br>Perspective: Societal costs | low risk women (nulliparous, no indication for secondary care) in 2007<br><br>(N=418) | Intended birth at home with a midwife in 2007 | Intended birth in a short stay (SCU) 'hospital setting' with a midwife or birth in a hospital (OU) | Outcomes not reported | Cost diaries, questionnaires and birth registration forms | Means reported on professional services, procedures (USS), therapy (physio, lactation) delivery mode, Length of stay. | Sensitivity and bootstrapping Home: €3173 SCU: €2816 OU: €5208 | No difference in cost or consequences between home and the short stay unit. |

| First Author Date (country) | Study design<br><br>Perspective | Population (N=) | Intervention | Comparator | Outcome | Source of resource use data | Included costs | Cost analysis/ cost-effectiveness results | Interpretation |
|---|---|---|---|---|---|---|---|---|---|
| 4.Howell 2014 (USA) | Cost analysis – propensity score reweighting model<br><br>Perspective: Medicaid | Low risk women, (statistically matched for observable characteristics) between 2005 and 2008<br><br>(N=43859) | Planned birth in the midwife-led "Family Health and Birth Centre" (FHBC) in 2008 | Planned birth in local district hospitals | Reported in another paper: FHBC care less likely to have an LSCS, more likely to have term baby and give birth over the weekend (suggestive of less intervention overall) | Cost estimates from National average Medicaid physician fees, centres for Medicare and Medicaid services (MW), DRG- average cost per hospital stay for delivery mode,<br>NICU costs. | Antenatal, delivery and postnatal care (physician and midwives) average cost per hospital stay (DRGs), normal vaginal birth, caesarean section, admission to NICU | BC care $6055 v Hospital care $7218 (difference $1163 / delivery). | 16% reduction in costs for every pregnancy followed in a BC ($11.64 Mill / 10000 Medicaid births). This model could have a significant impact on the cost of the Medicaid obstetric episode |
| Hundley 1995 (Scotland) | Cost analysis of RCT<br><br>Perspective: Health System/ hospital | Low risk women (criteria not stated) between 1990 and 1992<br><br>(N=2844) | Labour and delivery care at midwife-led unit (MU)(costs valued at 1992 – 1993 UK costs) | Labour and delivery care in a consultant-led unit | Reported in another paper: No significant difference in mode of birth and fetal outcome. High transfer rate for nulliparous women. | Questionnaire by midwife, client (demographics). Medical record review. | Interventions, labour care, pay grade and time spent, consumables, pain relief, (market values). Staff costs and capital costs. | Cost comparison<br>9 scenarios in sensitivity analysis giving different results. | Net increase in cost per women of £40.71 attributable to staff cost. Reduction in cost of consumables in MU. |
| 6. Janssen 2015 (Canada) | Cost analysis<br><br>Perspective: Government Payer | Low risk women (eligibility requirements for a homebirth) between 2001 and 2004 | Planned homebirth, care provided by a registered midwife | Planned hospital birth care provided by a midwife or a physician | No clinical comparisons made | Linked data from administrative data sources | Fee payments to physicians and midwives from Medical Services plan (MSP), emergency transport costs, hospitalisation | Average costs<br>Planned HB: $2275<br>Hospital MW: $4613<br>Hospital Physician: $4816 | HB less expensive followed by MW care in hospital |

| First Author Date (country) | Study design<br><br>Perspective | Population (N=) | Intervention | Comparator | Outcome | Source of resource use data | Included costs | Cost analysis/ cost-effectiveness results | Interpretation |
|---|---|---|---|---|---|---|---|---|---|
| | | (N=9864) | | | | | cost, and pharmaceuticals. | | |
| Kenny 2015 (Ireland) | Cost Comparison alongside pragmatic Randomised trial<br><br>Perspective: Health Service | Low risk women (criteria not stated) between 2004 and 2007<br><br>(N=1653) | Midwife-led care in one of two alongside midwifery units (BC) between 2004 and 2007 | Consultant-led care in hospital setting | Reported in another paper: no statistically significant difference in outcomes between MLU and CLU for LSCS, induction of labour episiotomy, instrumental birth, low APGARs, and postpartum haemorrhage. Significantly less likely to have electronic fetal monitoring or augmentation of labour. | Facility-based financial information. Verified with financial and services managers. | Medical and midwifery staff costs including antenatal, intrapartum and postnatal care, investigations, interventions, inpatient stay, administrative costs (managers), overheads in the form of general administration and maintenance based on floor space occupied | Average cost:<br>MLU: €2598<br>CLU: €2780 | MLU less expensive |
| 8. Reinharz 2000 (Canada) | Cost-effectiveness analysis - observational cohort study<br><br>Perspective: Social | Low risk women (criteria not stated) between 1995 and 1996<br><br>(N=2000) | Midwife-led care in 7 birth centres (BC) (pilot project) between 1995-1996 | Matched with women who gave birth in hospital under physician care | BC care associated with higher satisfaction, fewer interventions, fewer LSCS, less severe perineal trauma, fewer low birth weight and pre-term infants but trend towards higher stillbirth rate and neonatal resuscitation | Hospital files, physician billing data (Regie de l'assurance maladie du Quebec RAMQ) | Staff salaries, fees for services, minimum wage for women, average staff salaries, fees for services , time spent by women receiving BC services, pharmaceuticals, non-physician services received (eg.chiropractor, dietician), cost to women and | Cost effectiveness<br>Direct costs<br>BC: Can$2294 ($2062-2930)<br>LW: Can$3020 ($3016- $3017) | Results differed across pilot projects. Intervention not standardised, 7 centres included. Physician costs difficult to access, possible selection bias. |

| First Author Date (country) | Study design<br><br>Perspective | Population (N=) | Intervention | Comparator | Outcome | Source of resource use data | Included costs | Cost analysis/ cost-effectiveness results | Interpretation |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | significant others of time spent away from regular activities | | |
| 9. Schroeder 2012<br>(UK) | Cost-effectiveness analysis -Prospective Cohort Study<br><br>Perspective: Health system (NHS) | Low risk women (NICE guidelines for definition) between 2008 and 2010<br><br>(N=64 538) | Planned birth at home, in an alongside midwifery nit (AMU) or freestanding midwifery unit (FMU) with midwifery care | Planned birth in an obstetric unit | Primary: adverse perinatal outcomes avoided. Secondary: maternal morbidity and number of normal births. No significant differences in the odds of adverse perinatal outcomes for planned births in any of the non-obstetric unit settings compared with the obstetric units. | Data collection forms, supplemental forms and expert-opinion focus groups. | Staffing costs, treatment, surgeries, investigations, medications. | Mean costs<br>Home: £1067<br>AMU: £1435<br>FMU: £1461<br>Hospital: £1631<br>ICER | Overall, planned HB generated greatest mean net benefit. |
| Stone 1995<br>(USA) | Cost-effectiveness analysis- decision analytic model<br><br>Perspective: Insurer | Low risk women (various definitions) who gave birth in 1986<br><br>(N=14070) | Planned birth at a free-standing BC under the care of a midwife | Planned birth at a standard hospital facility under the care of a MW and physician | Data obtained from National Birth centre Study, crude measures in units of utility. | Field interviews of financial managers, ambulance officers, DRGs | Direct costs eg, interventions, provider fees. Indirect costs eg. Fixed equipment costs, education of clinician, patient charges, ambulance transfer charges, published averages. | BC:$3385<br>Hospital:$4673 | BC remains cost effective until transfer rate exceeds 62% |

| First Author Date (country) | Study design<br><br>Perspective | Population (N=) | Intervention | Comparator | Outcome | Source of resource use data | Included costs | Cost analysis/ cost-effectiveness results | Interpretation |
|---|---|---|---|---|---|---|---|---|---|
| Toohill 2012 (Australia) | Cost effectiveness-Cohort study<br><br>Perspective: Health care system | Low risk women (met birth centre eligibility criteria at one hospital) in 2008<br><br>(N=102) | Planned birth in a midwife-led birth centre (BC) | Planned birth in a standard hospital unit | Women in the BC were less likely to have their labour induced, use pharmacological pain relief and caesarean section and more likely to breastfeed. Babies born in the hospital unit were four times more likely to be admitted to the special care nursery. | AR-DRGs, hospital costs attributed to the admission (mother and baby), personal diaries to record visits, Medicare Benefits Schedule for the GP visits. | Care provider time (midwifery and medical) costs, hospital costs, all costs attached to the hospital from 36/40 to 6/52 PN. | MGP:$4722, Standard Care :$5641 | MGP care and BC delivery less costly with better outcomes |

## Comparisons of birthplace

### *Homebirth vs Birth Centre vs Standard Labour Ward*

Four studies described cost analysis or economic analysis of homebirth, birth centres and labour wards for low-risk women. (Anderson & Anderson 1999; Hendrix, Evers, et al. 2009; Janssen, Milton & Aghajanian 2015; Schroeder et al. 2012) These varied considerably in terms of the sample size and methods. The three larger studies concluded that home birth was less costly and the fourth, which was much smaller, found no difference in cost. Schroeder et al (2012) compared birth at home, alongside midwifery units (AMU), free-standing midwifery units (FSU) and standard obstetric units (OU). They found that homebirth conferred the greatest benefit overall, compared with birth centres and labour wards. This involved a saving of £565 when women gave birth at home compared to the hospital obstetric unit and savings of £195 and £170 when compared to freestanding birth centres and alongside birth centres respectively.

In another large study of 11,592 women who gave birth at home and 11,788 in hospital In the United States, Anderson and Anderson (1999) compared mortality and caesarean section rates and costs of homebirth and hospital birth. The authors concluded that homebirth was less expensive at US$1711 compared to birth in hospital estimated at US$5382. Janssen et al (2015) in British Columbia linked data from six administrative databases from 2001 to 2004 of 9864 women who planned to give birth at home under the care of a “regulated” midwife, or in a hospital under the care of a midwife or a physician. All women met the criteria for home birth eligibility. This study demonstrated significant cost saving between birth settings, home birth being the least costly at CAN$2275, followed by planned hospital birth with a midwife CAN$4613 and hospital birth with a physician CAN$4816 (Janssen, Milton & Aghajanian 2015). The smallest study, a prospective non-randomised cost analysis of 418 women conducted in the Netherlands, found no significant difference in the cost between the alternative birth settings. (Hendrix, Evers, et al. 2009)

*Birth Centres vs Standard Labour Wards*

The remaining studies examined cost in birth centres and standard labour wards. (Bernitz, Aas & Oian 2012; Howell et al. 2014; Hundley et al. 1995; Kenny et al. 2015; Reinharz et al. 2000; Stone & Walker 1995; Toohill et al. 2012) The majority of these found a cost saving in providing birth centre care (Bernitz, Aas & Oian 2012; Howell et al. 2014; Kenny et al. 2015; Stone & Walker 1995; Toohill et al. 2012), one study reported no difference in cost (Reinharz et al. 2000) and a study in Scotland found a net increase in cost per woman however, this study included the costs of introducing this new model of care and birth setting. (Hundley et al. 1995) Again, the sample sizes and methods varied considerably. Differences included the type of alternative facility, namely alongside or free-standing birth centres, and the recruitment of the women was largely based on vaguely reported criteria.

Toohill (2012) in a small Australian cohort study of 102 women compared the costs and outcomes of women receiving Midwifery Group Practice (MGP) care, who gave birth in a birth centre, with women receiving 'standard care' by midwives or GPs, who gave birth in a standard labour ward. When the costs were compared overall, there was a significant reduction in the cost of giving birth in the birth centre under MGP care compared to standard care at AU$4722 and AU$5614 respectively ($p<0.001$). Further differences in costs between the settings were found in studies by Bernitz (2012) in Norway, and Howell (2014) in the USA. Bernitz studied 1100 women in a 4-year RCT, calculated costs per woman (using a top-down and bottom-up approach), and found women who had care in an alongside midwifery unit (AMU) were less costly to care for than those in the standard obstetric unit (SCU) (€1672 vs €1950 $p<0.001$) in the same hospital complex. An RCT in Ireland also found the cost of care of women in alongside Midwifery-Led Units (MLU) was €182 lower than in the hospital setting led by consultant doctors. (Kenny et al. 2015)

The cost-analysis by Howell (2014) involved 43,859 participants, 872 of whom gave birth in one birth centre and 42,987 who gave birth in a 'usual care' setting who were matched on observable variables on birth certificate data by propensity score modelling. This study found a 16% reduction in costs for every pregnancy conducted within a birth centre; a saving of US$1163 per birth. (Howell et al. 2014)

In Canada, Reinharz (2000) in a control-matched cohort study measured the cost effectiveness of 2000 women in seven pilot projects and found differing results across all settings. These projects examined the processes and outcomes of women who chose to give birth in midwife-led birth centres compared to women giving birth under the care of midwives or physicians in a hospital setting. The findings varied in cost and effectiveness, with overall conclusions suggesting that midwives are less costly in three of the seven birth centres and in the remaining four, cost overlaps suggested no real cost difference. Sensitivity analyses revealed that the upper limit of the midwifery groups' costs resulted in a marginally lower cost than the physician costs. (Reinharz et al. 2000)

The Scottish RCT by Hundley et al (1995) with 2844 participants examined intrapartum costs of introducing a midwifery-led birth centre compared to the standard consultant-led labour ward. Nine sensitivity analyses of differing factors were tested and the result indicated an additional cost of 10.5% for the introduction of the midwifery-led service (with a range of a 2.5% saving to 11% additional costs). The birth centre was newly established and the results of the trial showed that the setup costs of the birth centre and the higher level of staff employed to staff the new unit factored significantly in the overall cost thus making it a slightly more costly option. This was the only study that showed the costs associated with an alternative birth setting were higher than the standard hospital setting.

Using a decision analytic model, Stone and Walker (1995) measured the cost-effectiveness of birth centre birth compared to hospital birth for women with matched low risk profiles (11,814 birth centre births and 2256 hospital births). The analysis concluded that it was less costly to give birth in a birth centre (US$3385) compared to a hospital labour ward (US$4673). Effectiveness results favoured the birth centre for this low risk cohort, calculating that only when the transfer rate from the birth centre to the hospital exceeded 62%, would the cost-effectiveness reverse.

*Different uses of cost methodology*

Economic analysis is broadly characterised by two features: addressing the inputs and outputs (costs and consequences) of a given activity and identifying the critical criteria that inform the decisions around how resources are distributed or spent (Drummond et al. 2005). The basic tasks of an economic analysis are therefore to "identify, measure, value and compare the costs and consequences of the alternatives being considered" (Drummond, 2005, p.9). Distinguishing between the methods of economic or cost analysis can be difficult and sometimes a matter of semantics, as the title of published economic analyses is not always indicative of the true method of analysis. (Drummond et al. 2005) Studies that examine only costs but include a comparison of alternatives are called 'cost analyses'. When costs *and* consequences are examined simultaneously, the result is a 'cost-effectiveness' study (Drummond et al. 2005).

Six of the eleven appraised studies performed a cost-effectiveness analysis. (Anderson & Anderson 1999; Bernitz, Aas & Oian 2012; Schroeder et al. 2012; Stone & Walker 1995; Toohill et al. 2012). This was the most common methodology reported with the other method being cost analysis (Hendrix, Evers, et al. 2009; Howell et al. 2014; Hundley et al. 1995; Janssen, Milton & Aghajanian 2015; Kenny et al. 2015).

*Cost-effectiveness analyses*

Three of the cost effectiveness analyses in this review were published since 2012, two of which examined the cost of providing alternative birth settings at one health service or campus (Bernitz, Aas & Oian 2012; Toohill et al. 2012) alongside an RCT (Bernitz, Aas & Oian 2012) and a cohort study (Schroeder et al. 2012; Toohill et al. 2012). All three studies took the perspective of the health care provider. Two studies used administrative data to report costs either with a 'Cost Per Patient' (CPP) measure (Bernitz, Aas & Oian 2012) based on the hospital's activity-based costing system, or direct hospital costs derived from patient records that were then aligned with Australian-Refined Diagnostic-Related Groups (AR-DRGs) (Toohill et al. 2012). Toohill (2012) also derived the costs of primary health care episodes

(funded federally in Australia) through a diary that was given to the participants at the start of the trial as well as the woman's own Pregnancy Handheld Record (PHHR).

Schroeder et al. (2012) performed a cost-effectiveness study from the perspective of the National Health Service (NHS) and calculated the incremental cost and incremental effects of births planned to be in the different birth settings and were expressed as mean cost per woman in each birth setting and mean net benefit. Unit cost estimation combined top-down/ bottom-up costing methods and resources costed were listed and augmented by an expert advisory group involving focus groups of midwives. This data was obtained through the questionnaires and datasheets associated with the larger Birthplace in England Study. Bootstrapping and sensitivity analyses were used to address uncertainty around ratios and variation in costs.

The three remaining cost-effectiveness studies were published between the years 1995 and 2000. Stone and Walker (1995) and Anderson and Anderson (1999) examined the "National Birth Centre Study"[1] (Rooks et al. 1989). A decision analytic model was devised by Stone and Walker which allowed all logical and 'chance' events to be considered in an analysis. Direct costs were limited to "hotel costs" (inpatient accommodation costs) and antenatal care costs by a Certified Nurse Midwife (CNM), CNM fees for labour and postpartum care, medical costs for caesarean delivery and ambulance costs for transfers. Indirect costs (for example fixed equipment and clinician education costs) included the cost of the equipment needed to open the birth centre and the annual building lease. This data was obtained from field interviews with financial managers of the obstetric department and the birth centre provided patient charge data. Local ambulance companies also reported costs of transfers.

[1] The National Birth Centre Study (1989) studied 11, 814 low-risk women admitted for labour and delivery at 84 free-standing birth centres in the United States. They were followed though their labour, birth, transfers and for at least four weeks after birth.

Anderson and Anderson (1999) took the perspective of the cost to Medicaid[2] and reported charges by CNMs from 29 US states through a survey mailed out to every CNM known to the American College of Nurse-Midwives (ACNM). These charges were compared to obstetrician charges from published work (Mushinski 1998) and the Health Insurance Association of America. No resources or accommodation charges were reported in this study and the charges were obtained at different time periods, however this was adjusted for by calculating projected cost increases due to inflation.

In Canada, an observational study by Reinhartz et al (2000) used data collected from perinatal medical records, client postnatal questionnaires and physician billing information from the Regie de l'assurance du Quebec (RAMQ), the Quebec health insurance board. The costs were considered from four perspectives in total - the Health Ministry, the regional board, the client and her family. Other costs were obtained from non-physician professional associations to value visits made by women, for example a chiropractor or dietician and unit costs for drugs were calculated on generic prices where available.

*Cost analyses/studies*

Hundley et al (1995) and Kenny et al (2105) also performed an economic analysis alongside an RCT. Kenny et al (2015) estimated costs associated with medical and midwifery staff for antenatal, intrapartum and postnatal care as well as investigations and interventions and hospitalisation costs. The financial data were collected by an experienced hospital accountant and costs relating to resource use estimated and verified with financial and services managers. Midwifery managers provided advice on the various pathways women in the service may take throughout their pregnancy. Hundley (1995) performed the cost analysis from the perspective of the hospital by costing the settings separately and classifying the costs into four main groups: staff costs; consumables; capital costs; and overheads. The main method of data collection was by questionnaire to the midwife managing the birth and the women on discharge from each facility. Medical record review

[2] The Medicaid Program in the USA provides free or low-cost medical benefits to low-income people who have no medical insurance or have inadequate medical insurance. https://www.usa.gov/medicaid

also elicited information regarding consumables and interventions such as monitoring, pharmaceuticals, operative delivery and vaginal examination.

In the Netherlands Hendrix et al (2009) used the Dutch manual for costing in healthcare, which is a methodological reference for performing cost studies. This six-step reference included regarding the scope of the research, the choice of cost categories (this study measured the health sector costs and non-health care costs), resources to be included, the volume of resources, the valuation of the resources, and the calculation of the unit costs. Hendrix et al took the societal perspective and collected data identifying health care costs such as contact with health care professionals, medications, medical interventions, analgesia and hospitalisation. Non health care costs were regarded as costs to the woman and family and were collected using cost diaries, questionnaires given to the women and birth registration forms. (Hendrix, Evers, et al. 2009)

The second study in this review from the perspective of Medicaid is by Howell et al (2014). This study estimated costs based on a previous study that used propensity score reweighting and instrumental variable analysis. Major components of the cost of care were estimated for the antenatal, intrapartum and postnatal care and these included physician costs (from Medicaid fees), midwife costs (from an algorithm that calculated a proportion of the Medicaid and Medicare physician fee) and Maternal and infant hospital costs were calculated from the National Inpatient Sample and the National Perinatal Information Centre for costs incurred in the Neonatal Intensive Care Unit (NICU). Howell et al. (2014) went on to report that the most costly component of maternity care was the maternity facility cost regardless of the model of care.

The results varied among the evaluations largely due to the differing costing methods, the data collection, the measurement and valuation of the resources identified. The authors concluded in eight of the eleven evaluations that it was less costly to give birth in a setting alternate to a standard labour ward. (Anderson & Anderson 1999; Bernitz, Aas & Oian 2012; Howell et al. 2014; Janssen, Milton & Aghajanian 2015; Kenny et al. 2015; Schroeder et al. 2012; Stone & Walker 1995; Toohill et al. 2012) Two evaluations resulted in no significant difference in the cost

of the alternative setting (Hendrix, Evers, et al. 2009; Reinharz et al. 2000) and one showed an increased cost; however this evaluation included the cost of the introduction of the birth centre facility. (Hundley et al. 1995)

## Limitations

This review included international and Australian studies spanning two decades. Due to the variations in timing, method of economic evaluation, currency and local economies, it was not possible to meaningfully compare the outcomes of the evaluations between the jurisdictions and the Australian setting.

## Discussion

Labour and birth consume significant resources in every country and in Australia it is the primary reason for acute hospital admission. Transferring the cost of place of birth is critical for policy, practice and management. In light of this we aimed to locate and assess the quality of economic evaluations of place of birth and the different associated costs.

Systematic reviews of economic analyses can be difficult due to the varying study designs employed. (Centre for Reviews Dissemination 2009) There have been advances in the methodology of conducting systematic reviews of economic analyses which include the use of appraisal tools (Drummond et al. 2005) and guidelines on how to conduct these reviews. (Shemilt et al. 2008) Considering the difficulty in synthesising the diverse results obtained from economic studies from around the world, often consisting of various economic evaluation styles, the question is asked whether they have any utility. (Anderson 2010) There are limitations in generalising results from economic evaluations due to variations in methodology, specificity of context and local costs, decisions and services available (Barbieri et al. 2005), however Anderson (2009) outlined three reasons to conduct a systematic review of economic analyses. These were firstly to justify and inform decision model development to ensure there is not already a current model in effect and secondly, to identify the most relevant study or studies potentially to translate or adapt those results. Finally to identify and understand the key economic trade-offs of a given intervention that can be multi-factorial, highlighting

the contextual differences contributing to final outcomes (Anderson, 2009). These reasons fitted with our overall aim – to review the economic evaluations or cost analyses comparing places of birth to inform future work in this area.

It is important to note that all costs in this review were reported in local currency and at varying times, thus the value of reporting the monetary values rests in the comparisons between the birth settings rather than the generalisability of the actual costs reported. In fact, with increasing health care costs and greater competition for finite resources, it would seem negligent to avoid performing economic analyses on service delivery sectors; the question is which economic analysis is going to provide the best evidence? Is economic data a driver of reform? There is demand from women to expand birthing options (Australian Health Ministers' Advisory Council 2011) however there is only anecdotal evidence that cost is a large factor in the reluctance of health institutions to provide alternative birth settings for these women.

This review has presented a variety of economic analyses that have been conducted on place of birth between 1995 and 2015; however the methods tend to vary in their clarity and scope of the measurement of resource use and costs included in the calculations (see Table 1). Overcoming selection bias presents a challenge in choosing the most effective methodology of economic evaluation. Ultimately the task of an economic analysis is to provide evidence to inform decisions regarding service provision where resources are finite and alternatives need to be considered.

## Where the main costs lie

### *Home birth*

There is high quality evidence that midwifery-led care in pregnancy, labour and birth is safe, with comparative or improved outcomes for women at low risk of complications. (Brocklehurst et al. 2011; Hatem et al. 2008; Sandall et al. 2013; Sutcliffe et al. 2012) The comparative cost of birth settings is more difficult to find. How costs are measured and estimated adds to the difficulty of drawing firm conclusions regarding where the costs lie and how to make a model of care and birth setting affordable for the health system and acceptable for the women who wish to access alternative pregnancy care. These limitations included the variety of

approaches to measuring and indeed valuing resource use, data sources from which this information was obtained, and the methodologies used.

Homebirth costs included midwifery time and some consumables whereas the charges in the hospital group included accommodation for the women as well as the fixed costs of facility use and variable costs including staff time and consumables. Broadly speaking, most studies included in this review reported lower costs associated with giving birth at home or in birth centres. Given the ethical implications of performing an RCT to measure the differences in cost and outcomes of place of birth, the cohort study by Schroeder et al (2012) provided the most methodologically robust results. Prospective data collection in real time allowed the data collectors to document detailed use of resources, staff time and consumables, a method that could provide high quality data in future detailed cost analyses.

*Birth Centres*

The difference in costs for women attending birth centres were associated with fewer interventions and procedures (Bernitz, Aas & Oian 2012; Schroeder et al. 2012) shorter length of stay or lower accommodation costs and facility overheads. (Kenny et al. 2015; Schroeder et al. 2012; Stone & Walker 1995)

Cost savings can be found by moving low-risk childbearing women away from hospital settings where there are established fixed costs to consider, as well as the availability of the convenient use of technology and interventions that are motivated by increased throughput and medical practices. Logically, home births require fewer resources and do not incur accommodation costs. (Henderson & Petrou 2008) The intervention rates and use of technology are typically lower in birth centre settings, interestingly, more so in freestanding birth centres than alongside birth centres. (Schroeder et al. 2012)

*Standard Labour Wards*

Undeniably, standard labour wards carry the highest fixed costs and staff costs. Standard labour wards are necessary but the level of care is not required for all women. Many low risk women give birth spontaneously, in Australia around 50 percent (Homer et al. 2014), and probably don't require the level of resources available in the labour ward setting. This means there is a high capacity to shift care

outside the high level care settings without compromising outcomes for mothers and babies. (Brocklehurst et al. 2011; Homer et al. 2014) Economies of scale become less applicable for standard labour wards and more favourable for birth centres and homebirth as the numbers increase in out-of-hospital settings (Schroeder et al. 2011), further supporting the evidence for providing similar services for women at low risk of complications.

## Conclusion

Of the eleven studies reviewed here, eight reported a cost saving associated with giving birth in an alternative birth setting, namely at home or in a birth centre. Two of the studies found no significant difference in the cost of providing care to women who chose to give birth in an alternate setting, however the benefits for the women and the staff were notable with higher satisfaction reported by both the women and the staff working in these settings and no increase in adverse outcomes. One study reported a cost increase in providing care in a birth centre. The differences reported in these studies highlight the differences in location, health system, methods of analysis and resources included in the costing. More research needs to be conducted on cost of alternative birth settings to support the growing demand for these services for women however the difficulty in accurately measuring these costs requires careful planning of methodology if the results are to be useful to service planners.

### Post Script

At the time of this review, there were eleven studied that were eligible to include. Since that time, two economic analyses of place of birth have been published, one from the UK (Schroeder et al. 2017) and the other from the Netherlands (Hitzert et al. 2017). Schroeder et al. (2017) estimated the cost of birth comparing a birth centre and a hospital and found it was around £850 less costly for women planning birth in the birth centre compared to women planning a hospital birth. The women in the BC group also had higher rates of spontaneous vaginal birth and lower rates of epidural, and experienced continuous intrapartum midwifery care. In the Netherlands, the cost of birth at home, in a BC and in a hospital for women under the care of a community midwife was compared. This study found no difference in

the cost or the outcomes between these settings and for both nulliparous and multiparous women, planned birth at home was the most cost-effective option compared to the birth centre group (Hitzert et al. 2017).

# Chapter 4: Mapping the trajectories for women and their babies from births planned at home, in a birth centre or in a hospital in New South Wales, Australia, between 2000 and 2012

## Context

An important consideration when choosing where to give birth is the availability of timely assistance if required. This is often used as a reason to plan birth in a hospital, as all the necessary infrastructure is on-site. Transfer rates from birth settings outside a hospital vary according to parity as well as circumstance both nationally and internationally. Given that childbirth is a dynamic process, prone to changes at any stage during the labour, this consideration is not necessarily unreasonable. The trajectories of women who plan birth at home or in a birth centre have not been investigated in New South Wales.

Chapter four is a paper which provides a framework to estimate the costs of giving birth at home, in a birth centre or in a hospital taking into account transfer from a setting outside a hospital and, mode of birth and neonatal transfer to a special care nursery or neonatal intensive care. This paper relates to the second objective of this study and uses a decision tree framework to illustrate the women's trajectories. Linked administrative data from NSW was analysed to determine where women started labour, where they gave birth, their mode of birth and the trajectory of the baby following birth.

## Publication details

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# Abstract

**Background**

In New South Wales (NSW) Australia, women at low risk of complications can choose from three birth settings: home, birth centre and hospital. Between 2000 and 2012, around 6.4% of pregnant women planned to give birth in a birth centre (6%) or at home (0.4%) and 93.6% of women planned to birth in a hospital. A proportion of the woman in the home and birth centre groups transferred to hospital. However, their pathways or trajectories are largely unknown.

**Aim**

The aim was to map the trajectories and interventions experienced by women and their babies from births planned at home, in a birth centre or in a hospital over a 13-year period in NSW.

**Methods**

Using population-based linked datasets from NSW, women at low risk of complications, with singleton pregnancies, gestation 37-41 completed weeks and spontaneous onset of labour were included. We used a decision tree framework to depict the trajectories of these women and estimate the probabilities of the following: giving birth in their planned setting; being transferred; requiring interventions and neonatal admission to higher level hospital care. The trajectories were analysed by parity.

**Results**

Over a 13-year period, 23% of nulliparous and 0.8% of multiparous women planning a home birth were transferred to hospital. In the birth centre group, 34% of nulliparae and 12% of multiparas were transferred to a hospital. Normal vaginal birth rates were higher in multiparous women compared to nulliparous women in all settings. Neonatal admission to SCN/NICU was highest in the planned hospital group for nulliparous women (10.1%), 7.1% for nulliparous women planning a birth centre birth and 5.1% of nulliparous women planning a homebirth. Multiparas had lower admissions to SCN/NICU for all thee settings (hospital 6.3%, BC 3.6%, home 1.6%, respectively).

**Conclusions**

Women who plan to give birth at home or in a birth centre have high rates of vaginal birth, even when transferred to hospital. Evidence on the trajectories of women who choose to give birth at home or in birth centres will assist the planning, costing and expansion of models of care in NSW.

**Key Words**

Home Birth, Birth Centre, place of birth, midwife, transfer

## Background

In Australia, as in many high-income countries, women can choose to give birth at home, in a birth centre or in a birth unit. In New South Wales (NSW), the most populous state in Australia, there are over 97 000 births a year (Centre for Epidemiology and Evidence 2017). Annual figures from the most recent data (2016) show that in this state, 96.6% of women gave birth in a hospital labour ward, 2.2% gave birth in a birth centre and 0.2% gave birth at home (Centre for Epidemiology and Evidence 2017).

There is now strong evidence that for women with a healthy pregnancy, especially those having their second or subsequent baby, giving birth at home or in a BC is a safe option (Birthplace in England Collaborative Group 2011; Davies-Tuck et al. 2018; De Jonge et al. 2009; Hodnett, Downe & Walsh 2012; Homer et al. 2000; Homer et al. 2014; Hutton et al. 2016; Monk et al. 2014; Scarf et al. 2018; Tracy et al. 2007). The small proportion of women who have used BCs in NSW in 2016 (2.2%) or who have chosen to give birth at home (0.2%) reflects either the lack of availability or desirability of such services, notwithstanding the demand for greater choice of birth setting by women and health practitioners (Dahlen, Jackson, et al. 2011; Dahlen, Schmied, et al. 2011; McIntyre, Francis & Chapman 2011).

The Australian National Review of Maternity Services released in 2009 sought perspectives from a range of stakeholders regarding maternity services in Australia in order to inform priorities for the development of the National Maternity Services Plan (The Plan) which was released in 2011 (Australian Health Ministers' Advisory Council 2011). As a result, The Plan outlined priorities including increasing access to local maternity care by expanding the range of models of care with an associated increase in birth setting options (Australian Health Ministers' Advisory Council 2011). The Plan was a result of submissions from women who indicated they want options regarding their pregnancy care and choice of place of birth. During the Maternity Services Review, over 900 submissions were received, the vast majority (n=832) were made by women and maternity care providers (Commonwealth of Australia 2009). Consistent themes emerged such as wanting increased access to a midwife-led and continuity of care and more options for place of birth, including

homebirth and birth centres (Dahlen, Schmied, et al. 2011; McIntyre, Francis & Chapman 2011).

According to the 2016 NSW Mothers and Babies Report [1] there are 62 maternity hospitals with birth rates over 200 per year. This number comprises 47 public hospitals and 15 private hospitals. There are three possible settings in which to choose to give birth – in hospital, in a birth centre or at home in NSW, however these settings are not necessarily available across the state. A hospital labour ward (HLW) is within a hospital (public and private) and is staffed by midwives and doctors. There are five birth centres (BC) co-located within hospital grounds or adjacent to hospital labour wards, they are staffed by midwives (although obstetricians and registrars are available in some settings if interventions are required) and are designed to provide a home-like environment. There are also five free-standing midwifery led birth centres in NSW which are located within a hospital campus, albeit some distance from obstetric and neonatal specialties. Women who require transfer to higher level care at these birth centres are transported by car or ambulance to the closest maternity hospital.

## Birth trajectories

While women usually choose where they would like to give birth at the beginning of pregnancy, the process is dynamic due to complications or risk factors that may develop, making the pathway or trajectory for women who plan to give birth at home or in a birth centre difficult to predict at a service level. A woman intending a homebirth, for example, may commence her pregnancy with no significant history of illness or pathology only to find her plans changed as the pregnancy continues and a complication arises. This may result in a change of birth setting, either during the pregnancy or in labour; the latter made sometimes more difficult due to a lack of integration between the providers of homebirth and hospital services (Fox, Sheehan & Homer 2018). In countries where homebirth and freestanding birth centres are well integrated into maternity services (UK, Netherlands), transfers between places of birth are facilitated by local policies and protocols which support the need to change location, including during labour, to the preferred or more appropriate birth setting (National Institute for Health and Care Excellence 2017).

By contrast, a maternity system lacking in integration between providers and places of birth, as is common across Australia, creates barriers for a smooth transition from home to hospital where indicated (Fox, Sheehan & Homer 2018).

Transfer rates from planned homebirth to hospital vary by country as well as by parity, with predictably lower rates in multiparous women. The rates of intrapartum transfer from home to hospital in studies over the past 10 years from a number of high-income countries varied from 8.8% to 21.0% overall (Birthplace in England Collaborative Group 2011; Blix et al. 2016; Dixon et al. 2014; Halfdansdottir et al. 2015; Homer et al. 2014). When stratified by parity, the rates were 24% to 39.1% for nulliparous women and 4.8% to 12.3% for multiparous women. Transfer from a midwifery unit (either alongside or freestanding) to hospital were 12.4% to 33.9% overall (Birthplace in England Collaborative Group 2011; Dixon et al. 2014; Homer et al. 2014; Laws, Tracy & Sullivan 2010; Monk et al. 2014; Overgaard et al. 2011; Stapleton, Osborne & Illuzzi 2013) and by parity, 25.4% to 37.8% for nulliparous women and 5.3% to 14.0% for multiparous women. Reasons for intrapartum transfer range from request for analgesia and slow progress in labour (non-urgent) to fetal distress and haemorrhage (urgent) the latter being less common (Blix et al. 2012; Halfdansdottir et al. 2015; Overgaard et al. 2011; Rowe et al. 2012).

While transfer rates in NSW have been reported overall, little is known about what happens to women who commence labour in their planned place of birth, and their babies during and after transfer. Anecdotally, support for the expansion of homebirth and birth centre services has been hampered by a belief that this intrapartum change of venue adds a layer of unnecessary risk to women and their babies (Bisits 2016; Coxon et al. 2016). This study explores these events during labour, which include planned place of birth, transfer from home or a birth centre to hospital, actual place of birth, mode of birth and neonatal admission to special care nursery/neonatal intensive care unit (SCN/NICU), described as birth trajectories, for a low-risk cohort of women from NSW from 2000 to 2012. This information will aid in our understanding of the intrapartum transfer rate and subsequent interventions and assist with maternity service development and

expansion of options for women interested in birth at home or in a birth centre. It will also inform understanding of the costs in different settings, because the costs of birth at home or in a birth centre should include the cost associated with transfer where applicable.

The aim therefore was to investigate the birth trajectories of women at low risk of complications who at the end of pregnancy plan to give birth at home, in a birth centre or a hospital labour ward. The development of this decision tree framework was also undertaken to inform a future costing of these birth settings.

# Methods

## Design: Decision tree modelling

This is a retrospective population-based cohort study using linked health data. The study draws on the framework of decision analytic modelling to construct a decision tree. Typically, a decision tree model provides a simplified framework of decisions that are made at different points in a treatment schedule depending on outcomes or events at a given time, "under conditions of uncertainty" and are mutually exclusive (Drummond et al. 2005; Philips et al. 2006). The decision tree developed for this study depicts the trajectories of women as their labour progressed by analysing linked health data, moving from their plans at the onset of labour to the birth of their child. We report probabilities at each 'node' of the decision tree, stratified by parity. We illustrated these trajectories in a decision tree (Figure 1) with the events (branch) of the decision tree in table 1.

**Table 1 Description of decision branches**

| **Decision Node** | **Branch 1 Intended place of birth** | **Branch 2 Intrapartum events** | **Branch 3 Mode of birth** | **Branch 4 Neonatal events** | **Branch 5 SCN/NICU** |
|---|---|---|---|---|---|
| Planned place of birth at onset of labour by parity | Home<br><br>Birth Centre<br><br>Hospital Labour ward | Actual birth in planned setting<br><br>or<br><br>transfer to hospital labour ward | Normal Vaginal Birth (NVB)<br><br>Instrumental birth – Forceps, vacuum (IB)<br><br>Caesarean Section (CS) | Post-birth remains with mother in birth setting<br><br>or<br><br>Admission to special care nursery or Neonatal Intensive Care (SCN or NICU) | Admission to SCN/NICU <48 hours<br><br>or<br><br>>48 hours |

A decision tree is interpreted left to right, on the left is the decision node representing the planned place of birth at the onset of labour for women with a healthy pregnancy at low risk of complications. The pathways or trajectories represent the events that occurred for these women and their infants and are defined at each 'chance' node moving right, from which a branch emanates. The alternative trajectories are mutually exclusive and the probability of each branch is calculated. While decision tree analysis is used for modelling options in terms of end-points and costs, we are using the framework to depict and quantify the trajectories of women by their planned birth setting. We populated the decision tree in this study with data analysed from a linked population-based data set obtained from NSW Ministry of Health.

## Setting

This study investigates the trajectories of women in New South Wales who planned to give birth in the birth settings described above. During the study period (2000 – 2012), there were six alongside BCs and three freestanding BCs in NSW. Freestanding BCs accounted for approximately 15% of BC births between 2000 and 2012. The data did not permit separate analysis by type of BC.

The number of maternity hospitals in NSW has remained constant over the period. The majority of homebirth services were and still are provided by midwives in private practice who are employed directly by women. There are a small number of publicly funded homebirth services which are staffed by midwives employed by public hospitals (Catling-Paull, Foureur & Homer 2012; Coddington, Catling & Homer 2017).

## Data sources

Data for all women who gave birth in NSW between January 2000 and December 2012 and all babies born between January 2000 and December 2012 of greater than 400g and 20 weeks gestation were included. Four datasets were linked:

1. NSW Perinatal Data Collection (PDC): Midwives and doctors collect data routinely on all women who give birth in NSW, at the point of care, most often through electronic medical record platforms. Maternal and infant data is collected on all births greater than 20 weeks gestation or 400g birthweight.

2. NSW Admitted Patient Data Collection (APDC): This is a record of all NSW hospital inpatient services including public and private hospitals, public psychiatric hospitals, and private day procedure centres. Clinical data is recorded using the International Classification of Diseases- Australian Modification (ICD-AM) codes.

3. NSW Registry of Births, Deaths and Marriages (NSWRBDM): Data on all registered births and deaths.

4. Australian Bureau of Statistics (ABS) mortality data including primary cause and date of death.

## Sample and inclusion criteria

The cohort was derived from the Perinatal Data Collection (PDC) which records all births in NSW from public and private maternity service providers, including homebirths (Centre for Epidemiology and Evidence 2017). Women were included if they were at low risk of complications, that is:

- were 37 to 41 completed weeks of pregnancy
- had a singleton pregnancy in the cephalic presentation
- had no known medical or pregnancy complications (low-risk) including previous caesarean section and breech presentation
- had a spontaneous onset of labour
- Aged between 17 and 40 (inclusive)

Given that this study aimed to examine the trajectories of women who planned to give birth in the three available settings in NSW, we classified the women according to planned place of birth as recorded in the PDC. This dataset was obtained for the Birthplace in Australia Study, a national data linkage study of maternal and perinatal outcomes by place of birth (home, birth centre or hospital). A detailed description of the methods for selecting the women included in this study is described in Cheah et al [30]. Briefly, women were excluded if they had any identified pregnancy complication (Table 2). For the remainder who laboured spontaneously between 37 and 41 completed weeks, we assumed their place of birth at the onset of labour was as planned.

**Table 2: Complications in pregnancy: Variables used to exclude high-risk pregnancy**

| Dataset | Variables |
|---|---|
| **Perinatal Data Collection** | Maternal diabetes mellitus (pre-existing)<br>Gestational diabetes<br>Chronic hypertension<br>Pregnancy-induced hypertension<br>Pregnancy-induced hypertension – proteinuric<br>Pregnancy-induced hypertension – non-proteinuric<br>Any obstetric complication<br>Breech or non-vertex presentation<br>Born before arrival<br>Received no antenatal care |

| | |
|---|---|
| | Previous caesarean section |
| **Admitted Patient Data Collection (ICD-10-AM Codes)** | Pre-eclampsia: O14<br>Eclampsia: O15<br>Chronic hypertension: O10, O11<br>Gestational hypertension: O13<br>Diabetes in pregnancy: O24<br>Prolonged rupture of membranes O42<br>Antepartum haemorrhage: O46<br>Maternal care for intrauterine death: O36.4<br>Vaginal delivery after caesarean: O75.7<br>Infants of women who were recorded to have a congenital abnormality (any Q code) were also excluded. |

We stratified the decision tree by parity to investigate the impact and events related to planned birth settings, as the demographic details are significantly different for nulliparous women compared to multiparous women. Women who have an unplanned homebirth (born before arrival (BBA)) and those who free-birthed (that is, gave birth without a registered health provider present) were not included in this cohort. The age range indicated here corresponds with the age range categorised as 'A' in the Australian College of Midwives Consultation and Referral Guidelines (Australian College of Midwives 2014). Category 'A' refers to women at low risk of complications who fall under the scope of practice of a midwife. If a variance occurs, the Guidelines recommend the midwife consult either another midwife, a medical practitioner or refer the women to be overseen by a medical practitioner for secondary or tertiary care, depending on the significance of the variance.

## Data management and analysis

Data were received and analysed in SPSS V24. Groups were established according to the women's intended place of birth as recorded in the PDC. The trajectories were determined using descriptive statistics to map the events that occurred throughout the labour, birth and postnatal period. These events represent the intended place of birth at the onset of labour, transfer to hospital (in labour or post-partum), mode of birth, and neonatal events including admission to special care nursery and neonatal intensive care. Data indicating mode of birth were missing in

both nulliparous (120 cases) and multiparous (110 cases) hospital groups, therefore these cases were not included in the trajectories. Demographic data were stratified by parity; we used Chi Square test to compare grouped categorical data and univariate general linear model analysis of variance (ANOVA) to determine the differences in the means.

When allocating women who "transferred to HLW" from a BC for the decision tree, interventions such as epidural analgesia and instrumental birth were taken into account as some women who were recorded in the PDC to have given birth in a birth centre had received one or more of these interventions. These women were considered to have had a planned birth centre birth but were transferred to a hospital labour ward. Given these rooms are commonly adjacent to or near the labour ward for an alongside BC, the 'transfer' is assumed in this analysis. Freestanding BCs in NSW are not located near obstetric and neonatal services and as such, these women would have physically changed location. The proportion calculated in each branch are conditional on the number in the previous event (to the immediate left), adding up to 100%.

Neonatal transfer to higher-level care is reported in the NSW PDC as admission to Neonatal Intensive Care Unit (NICU) OR Special Care Nursery (SCN). Given the levels of care differ significantly in these two areas, this provides a crude measure of neonatal outcome. We calculated the length of stay of these babies and identified those who stayed in the NICU/SCN for greater than 48 hours as a measure of more serious morbidity. Cases of intrapartum stillbirth and early neonatal death were retained in the trajectories (stillbirth was retained in the group who stayed with their mother and early neonatal death in the admission to NICU group). These numbers were very small (often $n<5$, which meant they could not be reported due to ethical restraints regarding potential identification) and did not alter the conditional probabilities of the corresponding trajectory.

# Results

## Planned place of birth

A total of 496 387 women were included in the decision tree. The majority of women (464 630 93.6%) had their intended place of birth recorded as hospital, 29 951 (6.0%) intended a birth centre birth and 1824 (0.4%) intended a homebirth. There were differences in the demographic characteristics of the three groups with women intending a homebirth being older (32 years; standard deviation (SD) 4.7) than those in the birth centre group (30 years; SD 5.1) and hospital group (29; SD 5.3). A higher proportion of women in the hospital group were giving birth to their first baby (nulliparous) (45.1%) compared to the birth centre and homebirth groups (42.7% and 29.9% respectively) and the highest proportion of women with a gestational age of 40 weeks and over were women in the homebirth group (67.1%) compared with women in the birth centre (59.1%) and the hospital group (54%) (Table 3).

**Table 3 Demographic characteristics by parity**

| **Nulliparous women** | **Hospital n = 209664 (%)** | **Birth Centre n = 12782 (%)** | **Home n = 546 (%)** |
|---|---|---|---|
| **Maternal age (Years) Mean (SD)** | 27.5 (5.3) | 28.34 (5.1) | 29.8 (4.9) |
| | 17018 (8.1) | 645 (5.0) | 14 (2.6) |
| **<20** | 45614 (21.8) | 2326 (18.2) | 67 (12.3) |
| **20-24** | 68568 (32.7) | 4351 (34.0) | 177 (32.4) |
| **25-29** | 57497 (27.4) | 3897 (30.5) | 192 (35.2) |
| **30-34** | 19674 (9.4) | 1485 (11.6) | 89 (16.3) |
| **35-39** | 1293 (0.6) | 78 (0.6) | 7 (1.3) |
| **40** | | | |
| **Previous pregnancies (≥20 weeks)** | | | |
| **0** | 209664 (94.0) | 12782 (5.8) | 546 (0.24) |
| **Gestation (completed weeks)** | | | |
| **Mean (SD)** | 39.5 (1.06) | 39.6 (1.07) | 39.7 (1.1) |
| **37** | 10368 (4.9) | 517 (4.0) | 31 (5.7) |
| **38** | 26801 (12.8) | 1405 (11.0) | 51 (9.3) |
| **39** | 56144 (26.8) | 3240 (25.4) | 105 ( 19.2) |
| **40** | 83536 (39.8) | 4768 (37.3) | 229 (41.9) |
| **41** | 32815 (15.7) | 2852 (23.1) | 130 (23.8) |

| | | | |
|---|---|---|---|
| **Multiparous women** | **Hospital n = 254966 (%)** | **Birth Centre n = 17151 (%)** | **Home n = 1278 (%)** |
| **Maternal age (Years) Mean (SD)** | 30.5 (5.0) | 30.7 (4.8) | 32.46 (4.3) |
| **<20** | 3715 (1.5) | 121 (0.7) | 3 (0.2) |
| **20-24** | 35569 (14.0) | 1861 (10.9) | 51 (4.0) |
| **25-29** | 73593 (28.9) | 4753 (27.7) | 262 (20.5) |
| **30-34** | 90026 (35.3) | 6376 (37.2) | 508 (39.7) |
| **35-39** | 48420 (19.0) | 3767 (22.0) | 415 (32.5) |
| **40** | 3643 (1.4) | 273 (1.6) | 39 (3.1) |
| **Previous pregnancies (≥20 weeks)** | | | |
| **1** | 150364 (59.0) | 10727 (62.5) | 662 (51.8) |
| **2** | 65633 (25.7) | 4460 (26.0) | 373 (29.2) |
| **≥ 3** | 38969 (15.3) | 1964 (11.5) | 243 (19.0) |
| **Gestation (completed weeks) Mean (SD)** | 39.4 (1.03) | 39.6 (1.02) | 39.8 (0.98) |
| **37** | 12150 (4.8) | 558 (3.3) | 35 (2.7) |
| **38** | 35365 (13.9) | 1828 (10.7) | 112 (8.8) |
| **39** | 72906 (28.6) | 4687 (27.3) | 265 (20.7) |
| **40** | 101639 (39.9) | 6789 (39.6) | 592 (46.3) |
| **41** | 32906 (12.9) | 3289 (19.2) | 274 (21.4) |
| Note: Chi-Square Test was used to compare groups as follows: HB/BC, HB/Hospital, BC/Hospital in all categorical data. Results yielded statistically significant differences with $p<0.001$ for all categories except gestational age (weeks) between BC and Home ($p<0.003$). GLM also yielded significant differences at $p<0.001$ between means in the above pairwise comparisons. | | | |

Figures 1 and 2 depict the decision tree constructed for this study. The decision node is the planned place of birth, separately for nulliparous and multiparous women. The trajectories the women take from the start of labour are represented by the 'branches' which emanate from the chance nodes named at the top of the figure: actual place of birth, mode of birth, neonatal location and length of time in special care nursery/ neonatal intensive care unit (SCN/NICU). Each branch extending from a chance node is given a probability of that event occurring.

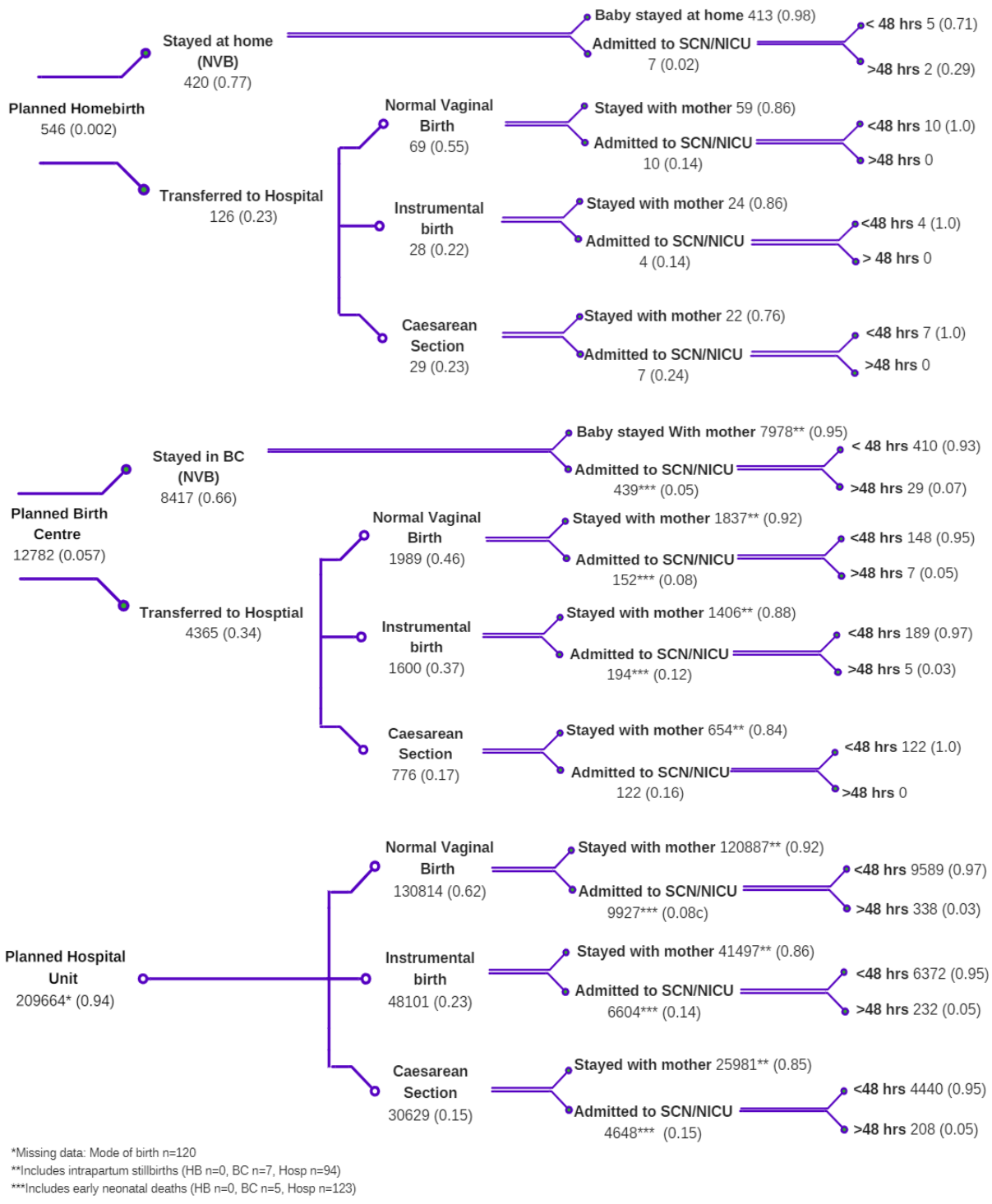
*Nulliparous women*

Of the nulliparous women, 0.2% planned to give birth at home, 5.7% planned a birth centre birth and 94% planned to give birth in a hospital labour ward. Of the women planning a homebirth in this group, 77.0% remained at home and had a normal vaginal birth (NVB). Of the 23% of women who transferred to hospital during labour, more than half (55.0%) went on to have an NVB. The rates of instrumental birth and caesarean section for nulliparous women planning a homebirth who were transferred to hospital were 22% and 23% respectively (see Figure 1). These rates are 5.1% and 5.3% respectively when all nulliparous women planning a homebirth are taken into account. Of the women planning a BC birth, 66% remained in the BC and had an NVB. Forty-six percent of the women who transferred to the hospital labour ward had an NVB. The NVB rate for women in the planned hospital group was 62%. Of the women who transferred to the hospital from a BC, the rates of instrumental birth and caesarean section were 37% and 17% respectively. Overall, women in the planned BC group had lower rates of instrumental birth and CS compared with those in the planned hospital group (12.5% and 6.1% versus 23% and 15% respectively).

*Multiparous women*

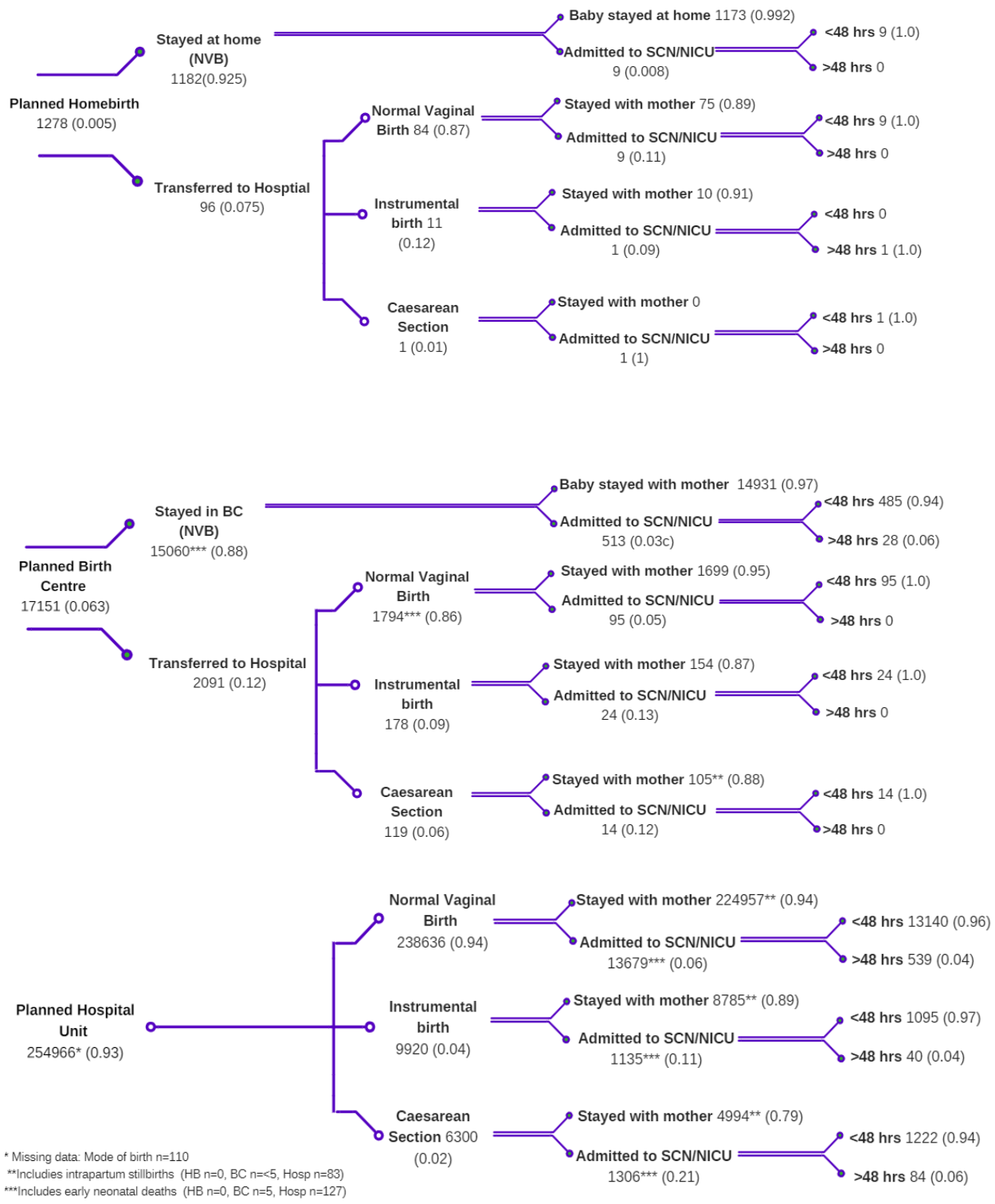
Multiparous women planning a homebirth had a 92.5% rate of NVB compared with 88.0% in a BC and 93.6% in the planned hospital group. Even following transfer, over 88% of women planning a homebirth had an NVB in hospital. In total, the vaginal birth rate in the multiparous birth centre group was 98.3%. Instrumental birth and CS rates were in the planned homebirth group were 12% and 1% respectively, following transfer (see Figure 2).

*Figure 1*: **Nulliparous women at low risk of complications between 2000 and 2012 (n= 222992)**




*Missing data: Mode of birth n=120
**Includes intrapartum stillbirths (HB n=0, BC n=7, Hosp n=94)
***Includes early neonatal deaths (HB n=0, BC n=5, Hosp n=123)

*Figure 2*: **Multiparous women at low risk of complications between 2000 and 2012 (n= 273395)**



*Neonatal trajectories*

Infants of nulliparous women had higher rates of admission to NICU/SCN than multiparous women, with the largest proportion originating from the women who planned a hospital birth (10.1%). The smallest proportion of neonates admitted to SCN/NICU were admitted following a homebirth (1.7%). Of the planned BC group overall, 7.1% of neonates were admitted to the SCN/NICU. Infants of women who were transferred from home to a hospital in labour had a 16.7% NICU/SCN admission rate however as a proportion of all planned homebirths, the overall SCN/NICU admission rate was 5.1%.

Overall, fewer infants of multiparous women were admitted to the SCN/NICU with total SCN/NICU admission rates as follows: planned homebirth 1.6%, planned BC birth 3.6% and planned hospital birth 6.3%. The highest proportion of infants of multiparous women who were admitted to SCN/NICU were in the planned hospital group, following a CS birth (21%).

## Discussion

This study has used a decision tree framework to map the trajectories of women at low risk of complications planning birth at home, in a birth centre and in a hospital labour ward. Whilst there are options of birth setting for some women in NSW, the options do not meet demand. Women who would like to give birth at home are required to pay a private provider in the most part, and anecdotally, reports of waiting lists for birth centre care are common. This study aimed to illustrate the trajectories of healthy, low risk women to provide evidence on the rates of transfer and intervention in this group. This information is important to assist in planning of birthing services, and can also be used to inform estimates of costs of different places of birth. Overall, a greater proportion of women who planned a homebirth remained at home and had an NVB, followed by women who planned birth in a BC regardless of parity. Women choosing to give birth in a hospital received a higher level of intervention in both parity categories. Nulliparous women in both the homebirth and BC groups had higher transfer rates than their multiparous counterparts, however they had higher normal birth rates than the planned hospital group. These results demonstrate similar trends in NVB and instrumental

birth rates for women at low risk of complications to international studies of place of birth (Birthplace in England Collaborative Group 2011; Hutton et al. 2016).

Transfer rates were lower compared to international evidence in both parity groups, particularly in the homebirth group. This could be attributed to a number of factors including the small number of women choosing a homebirth and careful planning and screening by the midwives who care for these women. In NSW, the majority of women who choose to give birth at home do so under the care of a midwife in private practise (MPP) which also requires personal funding, however there are a small number of publicly funded homebirth programs. The option of homebirth needs to be researched by the individual woman and extra effort required to find and engage a midwife who provides homebirth care. Women who choose a homebirth have confidence in the physiology of labour and birth, aspiration for a deeper relationship with her caregiver and a desire to be in a safe and familiar environment (Borrelli, Walsh & Spiby 2017; Burcher & Gabriel 2016; Coxon, Sandall & Fulop 2014).

For women who planned birth at home or in a BC, those who required any intervention, including an epidural block or instrumental birth, were transferred to the hospital as these interventions are beyond the scope of care delivered in a BC. The majority of women who choose a BC used facilities that were within or adjacent to a hospital, as freestanding BC births account for around 15% of BC births during this time. This close proximity to medical intervention may influence the woman's and the midwife's 'threshold for intervention'. However, a study in Sweden of adjacent birth centre facilities governed by the same hospital guidelines found that women had lower rates of intervention than their hospital labour ward counterparts (Gottvall et al. 2011), as seen in our study, however these proportions were higher than the homebirth group. Davis and Homer (2016) investigated the impact of birth place on midwives in Australia and the United Kingdom and found that cultural influences, ie. adherence to policy, medical supervision and general environment influenced their delivery of care to women, particularly in the hospital environment.

Considering the women included in this analysis had a spontaneous onset of labour, it is not surprising that a largest proportions of the admissions to SCN/NICU were following instrumental and caesarean births, which could be related to either the need for an expedited delivery or the admission was as a result of an injury incurred during the birth. Similar rates of admission to SCN/NICU were shown in international studies of place of birth including a lower rate in multiparous women and women who planned a homebirth (de Jonge et al. 2015; Halfdansdottir et al. 2015). Very few newborns were transferred to hospital following a homebirth, however the numbers are too small to draw any firm conclusions.

## Strengths and Limitations

While data linkage is a powerful means to examine perinatal outcomes at a population level, there are limitations to the granularity of the data making close investigation of specific events challenging. Transfer from a birth centre to hospital is a good example. This study intended to highlight the trajectories of healthy women who could be reasonably compared across the three birth settings. Transfer from one setting to another is sometimes not recorded in the PDC, particularly when a BC is located within a maternity unit. For this reason, we used interventions such as epidural block and instrumental birth to indicate a transfer from BC to hospital. The numbers of women choosing a homebirth in NSW is very small and the probabilities associated with each trajectory in this group are less certain. With the benefit of linking data from across health datasets from one state, we were able to develop a cohort of women with comparable observable characteristics. It is difficult, however, to account for the unmeasurable or unobserved characteristics of women which fundamentally influence their choice of place of birth. Cases of stillbirth and neonatal death have been retained within the corresponding trajectories as these eventualities contribute to the trajectory of the mother and baby. This framework forms the foundation of a future cost analysis of place of birth using Australian Refined Diagnosis Related Groups. Closer investigation of morbidity and mortality was not within the scope of this paper. However, these outcomes have been reported on a national level in the Birthplace in Australia Study.

## Conclusions

This study has depicted the birth trajectories for women at low risk of complication and addresses the assertion that birth planned at home or in a birth centre results in a high rate of transfer, therefore adding an element of complication to an already delicate process. We have shown that a large proportion of women who begin labour at home or in a birth centre, stay in their chosen setting and indeed, even when transferred, have a high rate of normal vaginal birth. It is possible that the higher rates of intervention in hospital labour wards, even in a very low-risk group of women, could be avoided if women were given a greater choice of birth setting. Given this is the first time the trajectories of women choosing a birth outside hospital has been mapped, this evidence will assist the planning, costing and expansion of models of care in NSW.

# Chapter 5: The cost of vaginal birth at home, in a birth centre or in a hospital setting in New South Wales: A micro-costing study

## Context

Cost is a driver of all healthcare service development. Government funds are limited and many services compete for finite resources. When proposing the introduction or expansion of a service, it is important to know what the current costs are, to then compare the projected cost of upscaling or implementing a new service.

This chapter relates to the third objective of this project, the identification of staff time and resources required to provide birth care at home, in a birth centre and in a hospital.

## Publication details

This work has been published in Women and Birth:

Scarf VL, Yu S, Viney R, Lavis L, Dahlen H, Foureur M, Homer C. 2019. The cost of vaginal birth at home, in a birth centre or in a hospital setting in New South Wales: A micro-costing study. *Women and Birth* (https://doi.org/10.1016/j.wombi.2019.06.003)

| |
|---|
| **Problem or issue**<br>Anecdotally, it is often perceived by health services that giving birth at home or in a birth centre is more expensive than being in a hospital for women with a healthy pregnancy. |
| **What is already known**<br>Availability of home and birth centre options for women in NSW, Australia, is limited. International and national studies have shown that birth at home or in a birth centre is a cost-effective option for women with a healthy pregnancy. This is largely due to the lower intervention rates and higher spontaneous birth rates in these women. Interventions are a strong driver of costs in maternity care. |
| **What this paper adds**<br>This paper reports the costs of providing care to women with a healthy pregnancy who plan to give birth at home, in a birth centre or in a hospital |

setting and have a vaginal birth. Midwifery time confers the highest proportion of the cost of homebirth however this is offset by the uncomplicated vaginal birth rate as overhead costs are not included in a homebirth.


# Abstract

**Background**

Women want greater choice of place of birth in New South Wales, Australia. It is perceived to be more costly to health services for women with a healthy pregnancy to give birth at home or in a birth centre. It is not known how much it costs the health service to provide care for women who plan to give in these settings.

**Aim**

The aim of this study was to determine the direct cost of giving birth vaginally at home, in a birth centre or in a hospital for women at low risk of complications, in New South Wales.

**Methods**

A micro-costing design was used. Observational (time and motion) and resource use data collection was undertaken to identify the staff time and resources required to provide care in a public hospital, birth centre or at home for women with a healthy pregnancy.

**Findings**

The median cost of providing care for women who plan to give birth at home, in a birth centre and in a hospital were similar (AUD $2150.07, $2100.59 and $2097.30 respectively). Midwifery time was the largest contributor to the cost of birth at home, and overhead costs accounted for over half of the total cost of BC and hospital birth. The cost of consumables was low in all three settings.

**Conclusion**

In this study, we have found there is little difference in the cost to the health service when a woman has an uncomplicated vaginal birth at home, in a birth centre or in a hospital setting.

# Introduction

Along with safety, the economic implications of giving birth at home or in a birth centre have been the subject of research in high income countries for some time (Scarf et al. 2016). In Australia, maternity services are the third most common service and 'single spontaneous delivery' is the most common principal diagnosis for admissions to hospital (Australian Institute of Health and Welfare 2018a). Women in New South Wales (NSW) have available to them three settings for birth: Home, birth centre and hospital, however home and birth centre settings are not universally available across the state. Homebirth can be accessed through a publically funded homebirth model attached to a public hospital (there are four such services in NSW) or through privately practising midwives where the cost is borne by the individual women. Birth centres are either co-located on a hospital campus, usually as a separate area within the hospital birth suite (alongside birth centres), or located in a separate building on the grounds of a hospital which does not provide obstetric or neonatal services (freestanding birth centres). There are currently five alongside and five freestanding birth centres in NSW. Birth centres are staffed by midwives and are all publicly funded in NSW.

While the majority of women (96.6%) give birth in a hospital birth suite (also referred to as a labour ward, delivery suite, birth unit), a small proportion of women plan birth in a birth centre (2.2%) and 0.2% plan to give birth at home (Centre for Epidemiology and Evidence 2017). The demand for greater choice of place of birth is increasing (Dahlen, Jackson, et al. 2011; Dahlen, Schmied, et al. 2011; Maternity Choices Australia 2016), which was supported by the National Maternity Services Plan released in 2010 (Australian Health Ministers' Advisory Council 2011). Strengthening the evidence on the cost savings of providing homebirth and birth centre options for women with a healthy pregnancy may assist health service managers to re-think how they provide out-of-hospital birthing services and therefore to assist further reform in the health system (Bernitz, Aas & Oian 2012; Kenny et al. 2015; Schroeder et al. 2012).

Economic evaluations are a means to give guidance to health service providers and planners, providing evidence on the actual or modelled costs of service provision

(Drummond et al. 2008). Economic evaluations of health related services and interventions draw from many data sources including clinical outcomes, interventions, resource use and financial expenditure. We undertook a micro-costing study, where actual staff time and resources were observed and recorded to estimate the cost of having a vaginal birth at home, in a birth centre or, in a hospital. We chose to examine the costs of vaginal birth only as a means to compare like with like across settings.

## Micro-costing studies

Micro-costing studies involve gathering information on the quantity and value of resources used in the delivery of a health service or procedure (Drummond et al. 2005; Frick 2009), in this case the provision of maternity care in three different settings. This method of data collection also characterises a 'bottom-up' approach. Micro-costing studies directly measure resource use by observation (time and motion, for example), activity logs and survey style data collection tools (Jacobs & Barnett 2017; Smith & Barnett 2003). These cost components are then valued and by assigning a cost for the direct resource use associated with patient care result in an estimation of costs specific to patient care (Tan et al. 2009).

## Time and motion data collection

Time and motion (or time-motion) studies have been used to gather information on clinical workflow, staff time and resource use in health settings, providing important information for service management and clinical research (Lopetegui et al. 2012). Time and motion studies can be used to measure productivity and the drivers of inefficiency in health care settings (Hendrich et al. 2008). Intensive care units (ICU) have been the subject of time and motion studies to provide clarity around activity and workload of nurses in this setting (Abbey, Chaboyer & Mitchell 2012) as well as evaluating the introduction of a clinical management plan (Gartemann et al. 2012). Time and motion techniques use an observer to follow or 'shadow' staff over a period of time and their actions are recorded on a data collection tool (Finkler et al. 1993). While it is usually only feasible to involve a small sample of participants as this method is time-consuming, it has the potential to collect a large amount of data (Abbey, Chaboyer & Mitchell 2012). ICUs are not

dissimilar to maternity settings in that the challenges presented by the patients (and women in the case of hospital birth) can be complex and rapidly changeable and much of the care is delivered one to one. Our study employed an observational time and motion technique to collect resource use data, including staff time and resources such as consumables to estimate the cost of giving birth at home, in a birth centre or in a hospital.

## Costing studies in maternity settings

Few studies have applied micro-costing methods in the maternity setting. Schroeder et al. conducted a micro-costing study in an inner city area of London comparing the cost of a birth in a freestanding midwifery unit and an obstetric unit(Schroeder et al. 2017). They collected data from the clinical notes of 'low risk' women relating to resource use such as admission time, interventions, consumables and birth outcomes. This study found an £850 cost saving for women planning birth in a midwife-led birth centre compared to women in the obstetric unit (Schroeder et al. 2017). A cost-effectiveness study in Ireland combined both 'bottom-up' and 'top-down' methods to evaluate the cost of trial of labour after caesarean versus elective repeat caesarean section (Fawsitt et al. 2013). Rather than using prospective or observational data for the bottom-up component, Fawsitt et al. (2013) developed an inventory listing all resources used during various procedures and modes of delivery. This inventory was developed in collaboration with a group of clinicians including a midwifery manager, consultant obstetrician and health economist. Costs were applied to a hypothetical model derived from literature and they found unassisted vaginal birth was found to be the most cost-effective (€627.94), followed by vacuum assisted birth (€1637.09). Emergency caesarean section was the most costly mode of birth (€4423.39) and elective caesarean section was marginally less costly at €4095.01.

A multi-centre prospective non-randomised study in The Netherlands compared the cost of giving birth at home or in a short-stay hospital setting for two groups of nulliparous women (Hendrix, Evers, et al. 2009). Data were collected from different sources, including cost diaries, questionnaires and birth registration data. The women involved in the study recorded their contact with a healthcare provider and

any medication used in the cost diaries. The questionnaires collected demographic and birth preference information in the first instance, and a second and third questionnaire collected information on other costs incurred during the pregnancy and details on transportation required during the birth and immediate postnatal period. The cost of giving birth at home was calculated at €3695 and €3950 for those women giving birth in the short-stay hospital unit. The increase in costs were found to be associated with travel and hospital admission (Hendrix, Evers, et al. 2009).

The goal of our study was to examine the comparative costs across the three publicly funded health settings using only women who gave birth vaginally in their planned place of birth. The aim of this study therefore was to determine the direct cost of giving birth vaginally at home, in a birth centre or in a hospital for women at low risk of complications, in NSW.

# Methods

## Design

A micro-costing design was utilised through observation (time and motion) and resource use data collection using a specifically developed data collection form. This study identified the staff time and resources required to provide care in a public hospital, birth centre or at home for healthy women at low risk of complications. All costs are presented in Australian dollars (AUD). Costs data were collected on women with uncomplicated vaginal births completed in the woman's planned birth place, ie. Home, birth centre or hospital. An uncomplicated vaginal birth comprises no labour intervention, no transfer from intended place of birth, spontaneous vaginal birth, and a complete third stage. The total cost to the health service includes antenatal consultations (reported to be one hour in duration for a homebirth, 30 minutes for a birth centre birth and 15 minutes for a planned hospital birth), travel to and from each antenatal appointment when conducted at the women's home, length of care in labour by the primary and secondary midwives, hospital overheads and the cost of consumables. This paper follows the structure of the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement (Husereau et al. 2013) where applicable.

Ethical approval was obtained from the NSW Population and Health Services Research Ethics Committee (Ref: 2014/02/515) and site specific approval was granted by the Local Health District involved in the data collection (Appendix A).

The setting was a local health district (LHD) in New South Wales, which offers a publicly funded homebirth service, a freestanding, and alongside birth centre and hospital birth services. The homebirth service operates out of the freestanding birth centre in the same LHD and has around 70 homebirths and 75 freestanding birth centre births per year. The alongside birth centre and hospital birth suite are located in a large, tertiary referral hospital which has around 200 and 4000 births per year respectively. The study is from the perspective of the health system.

## Observational data collection

### *Identification of resources- Homebirth*

A specifically designed data collection form, similar to an activity log, was developed and piloted with a group of privately practising midwives in the Sydney Metropolitan area (Supplementary file 1, Appendix B). The first component of the form consisted of questions regarding the time spent with women during the antenatal period including travel and telephone contact. The next section had a table of equipment required to provide birth care for women at home. The midwives were asked to complete this data collection form retrospectively and prospectively and return it with feedback on its accuracy and efficacy. The midwives agreed that the form contained all the items of equipment and consumables they regularly used at a homebirth and suggested to include additional items such as administrative time.

The same data collection form was given to a group of midwives who were employed in a publicly funded homebirth program. These midwives completed the form both retrospectively and prospectively. When the data was collated and medians were calculated, a focus group was held with the midwives from the publicly funded homebirth program to validate the findings.

### *Identification of resources - Birth centre and hospital setting*

Data were collected between the months of November 2017 and February 2018. This service consists of an alongside birth centre and hospital birth suite where the

two areas are separated by a corridor. Due to this, data for these two settings were collected concurrently, depending on the activity on the day. The researcher was situated outside the room in either the hospital birth suite or the birth centre. A standardised resource data collection tool (Supplementary file 2, Appendix B) was developed to record observational data including the time staff members spent in the room and an inventory of consumables/equipment used, as well as information on unit activity and staffing, details of the woman's medical and pregnancy history and discharge details. Each staff member who entered the birth room was identified on the resource survey by a single column labelled with their role (e.g. midwife, obstetric registrar, obstetrician etc.). This preserved the privacy of the women and removed the element of scrutiny on the activities of the midwives when they were behind the closed door.

The total time spent by the women in the birth suite or birth centre was calculated by noting the time the woman was transferred home or to the postnatal ward. The time and date of discharge was used to calculate the length of stay in the postnatal ward. Discharge data were collected from eMaternity, the hospital database used to record the birth admission, which is completed at the point of care by the midwives in the birth settings.

Following the collation and analysis of the data collected on this form, midwives who work in the birth centre and midwives who work in the birth suite attended a focus group to validate the data collected and provide insights into the time spent during antenatal appointments and any other items used routinely during birth that may have been overlooked. The midwifery managers of both services were also contacted to discuss the duration of antenatal appointments and staffing levels.

*Participants*

The population of interest consisted of women with the following characteristics: Healthy pregnancy with no medical or obstetric complications at the start of care in labour; spontaneous onset of labour; planned birth in the birth centre or hospital birth suite; singleton pregnancy with a cephalic (head down) presentation; both nulliparous (no previous births greater than 20 weeks gestation) and multiparous

(one or more births greater than 20 weeks gestation). Observations were of the midwives and other hospital staff including medical, nursing and ancillary staff.

The women were selected using a convenience sample. The midwives attending homebirths were asked to complete the data collection form for the last five homebirths they attended (retrospective) and the next five homebirths they attend (prospective). The data collected in the birth centre and hospital settings were collected over a period of three months. Midwives at all three settings attended in-service education on the research project and were familiarised with the data collection forms. Regular communication between the hospital staff and the researcher enabled timely arrival at the hospital or birth centre setting to commence data collection at a time that was convenient to both the staff and the researcher. If a second eligible woman was in labour at the same time, data was collected on her also.

*Estimating resource use and costs – sources of unit costs and prices*

Table 1 describes what costs were identified and where the costs were derived from.

**Table 1: Resources identified and costing sources used.**

| **Resource identified** | **Costing source** |
|---|---|
| Staff time (observation):<br>Midwifery and nursing<br>Junior medical officers<br>Registrar medical officers<br>Consultant medical officers | State awards indicating salary arrangements.<br>Hospital based Human Resource department consulted on salary on-costs.[a] |
| Consumables (Observation) | Hospital based equipment pricing lists *<br>Pharmacy pricing lists |
| Accommodation and overhead costs<br>AR-DRGs | National Hospital Cost Data Collection<br>Australian Public Hospitals Cost<br>Report 2015-2016 |

* Information on salary on-costs and hospital stock items was obtained from the hospital involved in the observational data collection.

## Analytical methods

Staff time was calculated, and hourly rates were applied according to the NSW Public health System's Nurses and Midwives (state) award (2018) for the midwives who were involved in the care of the women and the Public Hospital Medical Officers (State) Award (2018) for the medical staff. Staff employed in the public sector are remunerated according to an incremental pay structure based on years of service and level of education. Following discussions with maternity unit managers, assumptions were made regarding the level of experience of the staff in the different settings and hourly rates of pay were allocated according to these levels. Staff hourly rates are represented in table 6.2 and were calculated by adding hospital on costs (28%) and the annualised shift loading (29%) and was divided by 38 hours to obtain a gross hourly rate. The health service involved in the data collection employs midwives in the homebirth service at a Clinical Midwifery Specialist level so cost calculations for the publicly funded homebirth service were calculated with this hourly rate. This salary level is not necessarily adopted at all services of this type so costs were calculated using the '8th year thereafter' and '5th year' hourly rates as a comparison.

**Table 2: Staff salaries calculated with loadings**

| Staff member | Weekly award rate $ | Annualised shift loading | Shift loading $ | On cost | On cost $ | Weekly total $ | Hourly rate (/38) |
|---|---|---|---|---|---|---|---|
| **Midwife 8th thereafter** | 1685.10 | 0.29 | 488.68 | 0.28 | 470.14 | 2643.92 | 69.58 |
| **Midwife 5th year** | 1470.20 | 0.29 | 426.36 | 0.28 | 410.19 | 2306.74 | 60.70 |
| **Resident MO 3rd year** | 1901.50 | 0.29 | 551.44 | 0.28 | 530.52 | 2983.45 | 78.51 |
| **Registrar MO 3rd year** | 2227.73 | 0.29 | 646.04 | 0.28 | 621.54 | 3495.31 | 91.98 |
| **Specialist/consultant SNR** | 4325.71 | 0.29 | 1254.46 | 0.28 | 1206.87 | 6787.04 | 178.61 |
| **Neonatal registrar** | 2227.73 | 0.29 | 646.04 | 0.28 | 621.54 | 3495.31 | 91.98 |
| **Anaesthetic registrar** | 2227.73 | 0.29 | 646.04 | 0.28 | 621.54 | 3495.31 | 91.98 |

Fixed costs (hospital overheads, administrative staff costs, etc) were derived from the Independent Hospital Pricing Authority (IHPA) cost weights Australian Refined Diagnosis Related Groups (AR-DRG) 2015-2016 (IHPA 2018). AR-DRGs represent classes of patients with similar clinical conditions who needed similar hospital services. These are displayed as codes within major diagnostic categories (MDCs) and are calculated to represent the cost of an average stay with the attributed condition. AR-DRGs contain costs of an average length of stay dependent on the level of intervention and are rated by the severity of the complications and thus the resource consumption (A being the highest severity and C being the lowest in this case). Overhead costs associated with AR-DRG 'O60C' were added to the calculation of an uncomplicated vaginal birth for the women who gave birth in the birth centre and hospital setting. For women who gave birth at home, a modified overhead cost was calculated from the same AR DRG by adding the following overhead costs: non-clinical salaries, allied overheads and on-costs. These costs were chosen to represent overhead costs associated with the management and administration related to a publicly funded homebirth service which included non-clinical salaries, allied and overhead costs (IHPA 2018).

**Table 3: AR-DRG definitions[#]**

| AR-DRG code | Definition | Cost AUD |
|---|---|---|
| **O60C** | Vaginal delivery (minimal complications, singleton) - including women who had no intervention, or received any of the following: induction or augmentation of labour, epidural analgesia, narcotic pain relief, and/or minor perineal trauma. | **$4289** |

**[#]Australian Refined Diagnosis Related Groups Version 5.2 Definitions Manual**

### Statistical analysis

Analysis was undertaken using the Statistical Package for the Social Sciences® (SPSS) V25. Minimum, maximum, mean and median values were calculated for all components of the data.

## Results

Data was collected on 100 births. Table 4 contains the parity of the women observed by place of birth. One hundred women were observed in labour in three birth settings. Data was collected on 50 homebirths by the midwife attending the birth and consisted of 28 percent nulliparous women and 72 percent multiparous women. Twenty-seven women were included in the birth centre group containing 10 nulliparae (37%) and 17 Multiparas (73%). The hospital group contained 23 women, with 10 nulliparae and 13 multiparas (34% and 66% respectively). In total, there were 34 nulliparous women and 66 multiparous women in the dataset.

**Table 4: Parity of women observed by place of birth.**

| Birth Setting | Nulliparous (%) | Multiparous (%) | Total |
|---|---|---|---|
| **Home** | 14 (28%) | 36 (72%) | **50** |
| **Birth Centre** | 10 (37%) | 17 (63%) | **27** |
| **Hospital** | 10 (43%) | 13 (57%) | **23** |

| | | | |
|---|---|---|---|
| **Total** | 34 (34%) | 66 (66%) | **100** |

## Consumables

Table 5 contains the list of consumables by place of birth. Mean and median values are shown for all items and the total cost is calculated at the bottom of the table. The least amount of consumables were used at homebirths, followed by the birth centre. The maximum cost for consumables was $241.02 for a birth in the hospital followed by the birth centre at $194.93, however the median cost in these settings was $48.96 and $51.43 respectively and $10.46 in a homebirth which indicates that very few women required extensive use of consumables during birth. Overall, the cost of consumables is low across all three settings.

**Table 5: Consumables used during care in labour in three settings (AUD)**

| | | **Homebirth** | | | **Birth Centre** | | | **Hospital** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Consumables** | **Unit cost AUD** | **Range** | **Mean** | **Median** | **Range** | **Mean** | **Median** | **Range** | **Mean** | **Median** |
| **Amnihook** | 1.40 | | | | 0-1 | 0.15 | 0 | 0-1 | 0.36 | 0 |
| **'Blueys'** | 0.19 | 0-20 | 9 | 10 | 4-20 | 9 | 8 | 4-30 | 12 | 10 |
| **Blood Collection tube** | 0.12 | - | | | 0-2 | 0.26 | 0 | 0-3 | 0.64 | 0 |
| **Cannula** | 1.68 | - | | | 0-4 | 0.65 | 0 | 0-5 | 0.86 | 1 |
| **Cord clamps** | 0.71 | 1-3 | 1.42 | 1 | 0-3 | 1 | 1 | 1-2 | 1.05 | 1 |
| **Delivery set** | 4.29 | - | | | 0-1 | 0.93 | 1 | 1 | 1 | 1 |
| **Epidural block** | 25.00 | - | | | 0-1 | 0.22 | 0 | 0-2 | 0.5 | 0 |
| **Dressing pack** | 0.48 | - | | | 0-1 | 0.22 | 0 | 0-2 | 0.3 | 0 |
| **Transparent dressing** | 0.38 | - | | | 0-1 | 0.22 | 0 | 0-2 | 0.3 | 0 |
| **Fetal scalp electrode** | 7.96 | - | | | 0-1 | 0.13 | 0 | 0-2 | 0.3 | 0 |
| **Indwelling catheter + bag** | 10.98 | - | | | 0-2 | 0.4 | 0 | 0-2 | 0.68 | 0 |
| **IDC insertion** | 6.78 | - | | | 0-2 | 0.4 | 0 | 0-2 | 0.68 | 0 |
| **ID Band** | 0.13 | - | | | 1-2 | 1 | 1 | 1-2 | 1 | 1 |
| **IV giving set** | 1.47 | - | | | 0-2 | 0.5 | 0 | 0-2 | 0.73 | 1 |
| **IV Fluids (1L)** | 1.10 | - | | | 0-4 | 0.83 | 0 | 0-8 | 1.4 | 0.5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **IMI analgesia (morphine/pethidine)** | 0.55 | - | | | 0-1 | 0.15 | 0 | 0-1 | 0.14 | 0 |
| **Local anaesthetic** | 1.50 | 0-2 | 0.26 | 0 | 0-2 | 0.8 | 1 | 0-2 | 0.9 | 1 |
| **Needles** | 0.18 | 0-4 | 0.9 | 1 | 0-9 | 3.9 | 4 | 1-8 | 3.8 | 4 |
| **Nitrous Oxide (tubing)** | 1.45 | - | | | 0-1 | 0.56 | 1 | 0-2 | 0.8 | 0 |
| **Pulse oximeter probe** | 16.56 | - | | | 0-1 | 0.19 | 0 | 0-1 | 0.09 | 0 |
| **Scissors** | 0.85 | 1 | 1 | 1 | 0-1 | 0.85 | 1 | 0-1 | 0.91 | 1 |
| **Sterile gloves (pairs)** | 1.24 | 1-5 | 1.6 | 1 | 1-10 | 4.9 | 5 | 1-12 | 6.33 | 6.5 |
| **Non-sterile gloves (pairs)** | 0.08 | 0-10 | 6.5 | 8 | 1-20 | 8.4 | 7 | 5-30 | 13.33 | 10 |
| **Sponges (pack of 5)** | 1.78 | - | | | 0-2 | 1.4 | 2 | 1-5 | 1.7 | 1.5 |
| **Syringes** | 0.49 | 0-3 | 0.9 | 1 | 0-7 | 2.8 | 3 | 1-11 | 3.59 | 3 |
| **Syntocinon** | 1.60 | 0-5 | 0.14 | | 0-5 | 1.26 | 1 | 0-5 | 1.91 | 1 |
| **Thermometer probe** | 0.09 | - | | | 0-5 | 3 | 2 | 1-4 | 3 | 2 |
| **Chlorhexidine** | 2.50 | 0-1 | 0.33 | | 0-1 | 0.67 | 1 | 0-1 | 0.75 | 1 |
| **Suture material** | 5.21 | 0-2 | 0.26 | 0 | 0-3 | 1 | 1 | 0-3 | 0.95 | 1 |
| **Suture set** | 5.85 | 0-1 | 0.26 | 0 | 0-1 | 0.67 | 1 | 0-3 | 0.68 | 1 |
| **KY Gel** | 0.09 | 0-3 | 2 | 1 | 1-4 | 3 | 2 | 1-8 | 6 | 3 |
| **Sanitary pads** | 1.28 | 0-3 | 3 | 0 | 3-20 | 9 | 10 | 2-20 | 7 | 5 |
| **Vitamin K** | 1.05 | 1 | 1 | 1 | 0-1 | 0.96 | 1 | 1 | 1 | 1 |
| **Hep B vax** | 0 | | | | 0-1 | 0.93 | 1 | 1 | 1 | |
| **Total cost $** | | **8.05 - 76.75** | **24.67** | **10.46** | **7.78 - 196.38** | **65.90** | **51.43** | **15.69 – 243.92** | **76.93** | **48.96** |

## Resources used in vaginal birth

The median costs for each birth setting were $2931.07 for a homebirth, $2100.59 for birth centre birth and birth in hospital cost $2097.30. The main source of resource use for these settings was midwifery time and a modified cost for overheads was included for women giving birth at home to account for administrative and clerical support. There were no accommodation overhead costs to the health service for the actual birth or postnatal care for a homebirth.

Antenatal consultations were reported to be shorter in duration for women planning birth in a birth centre or in hospital (30 minutes and 15 minutes respectively).

The total costs included overhead costs for women in the birth centre and hospital groups, which were derived from the IHPA Public Hospital National Cost Data Collection (IHPA 2018) estimates of costs associated with a vaginal birth (AR-DRG O60C). This cost was included to account for accommodation during the postnatal period. Women who had a homebirth also accrued the cost of postnatal home visits, whereas postnatal care is included in the above overhead costs for women who gave birth in a birth centre or hospital setting.

**Table 6: Salary and non-salary costs of vaginal birth at home, in a birth centre and in a hospital (AUD)**

| | **HOME** | | | **BIRTH CENTRE** | | | **HOSPITAL** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Units (range) | Unit cost $ (range) | Total cost $ (range) | Units (range) | Unit cost $ (range) | Total cost $ (range) | Units (range) | Unit cost $ | Total cost $ (range) |
| **Salaries and wages** | | | | | | | | | |
| **Midwife AN care (hrs)** | 10 visits (5-13 visits x 1 hr) | 69.58 | 695.80 (347.90-904.54) | 9 visits (6-14 visits 0.5 hr) | 34.79 | 313.11 (208.74-487.06) | 8 visits (4-12 visits x 0.25 hr) | 17.40 | 139.20 (69.60-208.80) |
| **Midwife travel x 5 visits (hrs)** | 0.75 hr (0.08hr - 2.75hrs) | 52.19 (6.43-220.91) | 260.95 (27.83-956.73) | N/A | N/A | N/A | N/A | N/A | N/A |
| **Medical AN consult (hrs)** | N/A | | | | | | 0.25 hr | 178.61 | 44.65 |
| **Midwife 1 birth care (hrs)** | 6 hrs (2-16 hrs) | 69.58 | 417.48 (139.16-1113.28) | 6 hrs (2.5-15 hrs) | 69.58 | 417.48 (173.95-1043.70) | 7 hrs (3.25-14.25) | 69.58 | 487.06 (226.14-991.52) |
| **Midwife 2 birth care (hrs)** | 5 hrs (1.5-10 hrs) | 69.58 | 347.90 (104.37-695.80) | 0.92 hr (0-2 hrs ) | 60.70 | 55.84 (0-121.40) | 1 hr (0.25-6.25) | 60.70 | 60.70 (15.18-379.38) |
| **Midwife 3 birth care (hrs)** | N/A | N/A | N/A | 0.02 hr (0-0.5 hr) | 60.70 | 1.21 (0-30.35) | 0.3 hr (0-1) | 60.70 | 18.21 (0-60.70) |
| **O&G Resident (hrs)** | N/A | N/A | N/A | 0.1 hr (0-1) | 78.51 | 7.85 (0-78.51) | 0.75 hr (0-1) | 78.51 | 19.63 (0-78.51) |
| **O&G Registrar (hrs)** | N/A | N/A | N/A | 0.5 hr (0-1.5 hrs) | 91.98 | 45.99 (0- 137.97) | 0.75 hr (0-4.25) | 91.98 | 68.99 (0-390.92) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **O&G consultant (hrs)** | N/A | N/A | N/A | 0.1 hr (0-2 hrs) | 178.61 | 17.86 (0-357.22) | 0.05 hr (0-0.75) | 178.61 | 8.93 (0-133.96) |
| **Neonatal MO (hrs)** | N/A | N/A | N/A | 0.1 hr (0-1 hr) | 91.98 | 9.20 (0-91.98) | 0.025 hr (0-0.25) | 91.98 | 2.30 (9-23.00) |
| **Anaesthetist (hrs)** | N/A | N/A | N/A | 0.15 hr (0-0.75 hr) | 91.98 | 13.80 (0-68.99) | 0.3 hr (0-1.5) | 91.98 | 27.60 (0-137.97) |
| **NICU nurse (hrs)** | N/A | N/A | N/A | 0.03 hr (0-0.5 hr) | 60.70 | 1.82 (0-30.35) | 0.1 hr (0-1.25) | 60.70 | 6.07 (0-91.05) |
| **Non-salary costs** | | | | | | | | | |
| **Postnatal Overheads** | 6 visits (5-7 visits) | 69.58 | 417.48 (347.90-487.06) + 781* | | | 1165.00** | | | 1165.00** |
| **Consumables** | | | 10.46 (8.05 - 76.75) | | | 51.43 (7.78 - 196.38) | | | 48.96 (15.69 - 243.92) |
| **Total cost** | | | **2150.07 (1486.21-5015.16)** | | | **2100.59 (1555.47-3808.91)** | | | **2097.30 (1545.26-3949.38)** |

*Overhead costs associated with clerical and administrative support for midwives in a publicly funded homebirth service derived from AR DRG O60C

** Total overhead costs for women giving birth in a birth centre or hospital derived from AR DRG O60C

## Discussion

There is uncertainty in Australia that providing care for women who plan to give birth at home or in a birth centre is more costly for the health service compared to hospital birth, and this has not been tested in NSW. Given that childbirth is the third most common specialist service in Australia and 'single spontaneous delivery' is the most common principal diagnosis among acute overnight admissions to hospital (Australian Institute of Health and Welfare 2018b) delivering economically prudent services should be a priority for health service planners nation-wide. This study attempts to quantify the costs for the same outcomes across the three settings.

The costs of an uncomplicated vaginal birth were similar across the birth centre and hospital groups due to the similarity of the cost components. Homebirth costs were $830.48 higher than birth centre costs and $833.77 higher than the hospital. The higher cost for homebirth is largely attributable to salary and travel costs for midwives and the additional cost for administration and clerical support. The greatest difference in cost for women planning a homebirth is in the antenatal period, as time in labour and postnatal costs are comparable across the three settings. This is similar to other studies in this area. An Australian costing study of birth centre birth through Midwifery Group Practice (MGP) demonstrated a similar increase in antenatal costs for women in the birth centre group however, the total cost per women was lower (Toohill et al. 2012). A similar variation in antenatal and total costs was found in studies from Canada and the Netherlands (Hendrix, Van Horck, et al. 2009; Janssen, Milton & Aghajanian 2015) which compared planned homebirth with planned birth centre or hospital birth with a midwife or doctor. These studies reported increased costs related to antenatal consultations in the homebirth groups and 'hospital charges' in the other groups, resulting in a higher total cost for women who plan to give birth in hospital or in a birth centre, regardless of caregiver. Importantly, the estimated total cost of uncomplicated vaginal birth in our study is significantly lower than the lowest AR-DRG (O60C) allocated to vaginal birth.

Closer inspection of the consumables used revealed little difference across the three settings. Although there were items listed that would not be available in a

homebirth setting, the median number of consumables used was comparable, with the exception items such as gloves (sterile and non-sterile), IV giving sets and fluids, needles and syringes. There are inherent and unobservable differences in the characteristics of women who plan birth at home or in a birth centre (Birthplace in England Collaborative Group 2011) which can confound the results between the individual groups. We included only women who had a similar risk profile to ameliorate the potential selection bias present in women who chose birth outside a hospital.

Overhead costs contribute over half the estimate for BC and hospital birth, because antenatal consultation costs are lower in both these groups due to the shorter consultation duration and absence of travel to the consultations by the midwifery staff. In the Australian context, Homer et al. (Homer et al. 2014; Homer et al. 2019) found women at low risk of complications have lower rates of intervention and adverse outcomes. As soon as labour interventions are introduced, the costs increase significantly consistent with findings by Tracy and Tracy (2003) who found an incremental increase in the cost of labour with the introduction of interventions including induction of labour and epidural analgesia. Since women planning a home or birth centre birth have fewer interventions, the costs associated with the group as a whole would be lower in comparison with planned hospital birth. The investment of midwifery time during the pregnancy has been associated with the positive birth outcomes (Begley et al. 2011; Walsh & Devane 2012) and lower costs (Schroeder et al. 2012; Tracy et al. 2013) in many studies of midwifery-led care undertaken at home, in a birth centre or in a hospital birth setting. Overheads associated with homebirth differ in some ways. We calculated the cost of birth at home in this study assuming the cost is accounted for by the health service. Many women in NSW engage and pay for a midwife in private practise out of their own pocket, those costs are incurred by the women themselves and would add to the total cost of birth at home. Midwives working in a publicly funded homebirth service would incur certain overhead costs such as administrative support, IT services, and other corporate services. This cost has been estimated by adding the overheads contained in the AR DRG associated with administration as

accommodation and staffing are accounted for. (Independent Hospital Pricing Authority 2018)

## Limitations and strengths

Although the observational data collection for this study was carried out in one health service, the selection criteria of the women the midwives were caring for were strictly adhered to. The midwifery staff enthusiastically engaged with the research project and either facilitated the collection of data by the researcher or completed the data collection themselves with rigour and accuracy. We limited this study to successful vaginal births in the woman's chosen setting to compare the mode of birth which can occur in all three settings. Overheads associated with homebirth differ in some ways. We calculated the cost of birth at home in this study assuming the cost is accounted for by the health service. Midwives working in a publicly funded homebirth service would incur certain overhead costs such as administrative support, IT services, and other corporate services. This cost is difficult to determine as the breakdown of overheads in the AR DRG are not sufficient to accurately estimate the cost of clerical support during the care of women outside the hospital such as occurs for the women under the care of midwives in a publicly funded homebirth model. (Independent Hospital Pricing Authority 2018) A conservative estimate of the overhead costs per woman could increase the cost of homebirth by $385 (non-clinical salaries) to up to $781 if all overhead costs were applied excluding ward medical and nursing overhead costs (Independent Hospital Pricing Authority 2018).

Women requiring transfer from home or a freestanding birth centre would incur additional costs to the health service in ambulance fees and costs of interventions on arrival to hospital. Estimating all the variations of potential outcomes was beyond the scope of this study, and further research into these additional costs is warranted as this would inform the value and cost of these settings.

In Australia, public health care services provided by hospital local health districts (LHD) are state funded. LHDs have a degree of autonomy which results in variation in the availability of models of care and setting for birth, notwithstanding the existence of documents such as the Maternity Services Plan (Australian Health

Ministers' Advisory Council 2011) and Towards Normal Birth (NSW Kids and Families 2010). With this in mind, the results of this study are reasonably generalisable due to the fact that salaries and hospital costs are estimated using state award and National Hospital Pricing Authority values.

## Conclusion

To our knowledge, this is the first micro-costing evaluation of place of birth for women at low risk of complications who had a vaginal birth in their planned place of birth in New South Wales. In this study we found that when a woman successfully has a vaginal birth in her chosen setting, there is little difference in the cost to the health provider. The main costs are derived from midwifery time, with the additional cost of overheads when a woman is giving birth in a birth centre or hospital. Intervention rates are low among these women which keeps the costs down individually and as a group.

# Chapter six: Modelling the cost of place of birth: A pathway analysis

## Context

Costing childbirth is complex as the trajectories of women through the birth process can vary; a woman may begin labour with no complications and develop the need for intervention. Chapter four illustrated these trajectories using linked health data.

This chapter builds on the decision tree framework used in Chapter four by calculating the cost of each of the trajectories. This addresses objective four which undertook to identify the costs of giving birth in the three planned places of birth in NSW over a 13 year period (2000-2012) by applying Australian Refined Diagnosis Related Groups (AR-DRGs) to the identified birth trajectories (a top-down costing).

## Publication details

This paper is ready for submission.

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# Abstract

**Background**

In New South Wales (NSW), Australia there are three settings available for women at low risk of complications to give birth: home, birth centre and hospital. Between 2000 and 2012, 93.6% of babies were planned to be born in hospital, 6% in a birth centre and 0.4% at home. Availability of alternative birth settings is limited and the cost of providing birth at home or in a birth centre from the perspective of the health system is unknown.

**Objectives**

The objective of this study was to cost the trajectories of the women who planned to give birth at home, in a birth centre or in a hospital.

**Methods**

This was a population based study using linked datasets from NSW, Australia. Women included met the following selection criteria: 37-41 completed weeks of pregnancy, spontaneous onset of labour, and singleton pregnancy and at low risk of complications. We used a decision tree framework to depict the trajectories of these women and Australian Refined-Diagnosis Related Groups (AR-DRGs) were applied to each trajectory to estimate the cost of birth. A scenario analysis was undertaken to model the cost for 30 000 women in one year.

**Findings**

496 387 women were included in the dataset. Twelve potential outcome pathways were identified and each pathway was costed using AR-DRGs. An overall cost was also calculated by place of birth: $AUD4802 for homebirth, $AUD4979 for a birth centre birth and $AUD5463 for a hospital birth.

**Conclusions/implications**

The findings from this study provides some clarity into the financial saving of offering more options to women seeking an alternative to giving birth in hospital. Given the relatively lower rates of complex intervention and neonatal outcomes

associated with women at low risk of complications, we can assume the cost of providing them with homebirth and birth centre options could be cost-effective.

# Introduction

In New South Wales, Australia's most populous state, there were 95 825 births to 94 449 mothers in 2017 (Centre for Epidemiology and Evidence 2018). Of these, 92.8% of women planned to give birth in a hospital, 6.3% planned birth in a birth centre and 0.2% of women planned a homebirth (Centre for Epidemiology and Evidence 2018). Maternity care in Australia is provided by the public and private sectors, with a 74% to 26% split respectively.

The evidence of the safety and benefits of birth at home or in a birth centre for women at low risk of complications is clear (Hodnett, Downe & Walsh 2012; Homer et al., 2019; Olsen & Clausen 2012; Scarf et al. 2018). Access to these settings in New South Wales (NSW) and across Australia remains limited. There are 61 maternity services in NSW, 10 of which provide a birth centre option and three offer homebirth through a publicly funded model of care (where the midwives are employees of a maternity service) (Coddington, Catling & Homer 2017). Most women who plan a homebirth, however, engage a privately practising midwife, at their own cost; these midwives are independent practitioners.

A hospital birth service, also referred to as a birth unit, birth suite, or labour ward, is staffed by midwives and doctors and provides maternity services to women with and without medical or obstetric risk factors. These birthing services are in both public and private hospitals. A birth centre offers women the option to give birth in a 'homelike' environment where the emphasis is on the physiological process of pregnancy and birth. Birth centres are staffed by midwives and are either located on the site of a maternity hospital (alongside birth centres) or in a location which may be on a hospital campus but does not offer obstetric and neonatal emergency care (freestanding birth centres). If a woman begins labour at a freestanding birth centre and develops a complication during the labour, she will be transferred to the nearest facility which provides higher level obstetric care. Presently, there are five alongside and five freestanding birth centres in NSW, however over the study period, there were three freestanding birth centres (Monk et al. 2014). The 'transfer' process in an alongside birth centre is often a matter of re-locating a woman to a hospital birth room, most likely in the same building and often on the

same floor as the birth centre. It is, however, an important distinction: if a woman planning to give birth in a birth centre develops a complication in labour, she is effectively transferred to higher level care in the hospital labour ward. Homebirth services are provided by midwives in private practice or by midwives employed by a health service and who work out of a maternity facility, known as a publicly funded homebirth model.

Anecdotally, it is asserted that offering homebirth or birth centre services is more costly to the health service despite few studies which cost the place of birth in Australia. A study by Toohill et al. (2012) compared the cost of Midwifery Group Practice (MGP) and standard hospital care. MGP is a model of care which generally provides women continuity of midwifery carer, or group of carers and these midwives work across birth settings where available (Sandall et al. 2016; Toohill et al. 2012). Standard hospital care included hospital-based midwifery or obstetric care, or community-based General Practitioner (GP) shared care where the woman sees the GP for most of her antenatal consultations and has scheduled visits at the hospital where she plans to give birth. The majority of women in the MGP group gave birth in a birth centre. The results showed a cost saving overall for women in the MGP group compared with the hospital group applying a hospital based costing system (AU$4,696 vs $5,521) and (AU$4,722 vs $5,641) when applying Australian Refined Diagnosis Related Groups (AR-DRGs) (Toohill et al. 2012). Similar results were found by Tracy et al, however the M@NGO study estimated costs related to model of care (continuity versus no continuity) rather than place of birth (Tracy et al. 2013).

A recent systematic review of economic analyses of place of birth has shown a cost saving found for women giving birth at home or in a birth centre in eight of the eleven included studies, no difference in cost in two of the studies and a slight increase in one study which included initial set-up costs of a new birth centre (Scarf et al. 2016). A recent comparison of low-risk women choosing to give birth in a freestanding birth centre with a hospital obstetric unit in the UK estimated a saving of approximately £850 per woman (Schroeder et al. 2017). Huynh et al. (2013) conducted a review of the cost of pregnancy in the United States of America (USA)

to investigate the drivers of cost for payers in light of the increasing costs associated with pregnancy notwithstanding the decreasing birth rate. This review reported the varied results of the studies which included drivers such as inpatient care, pregnancy complications, pre- and post- term birth and pre-existing morbidity. The overall mean cost per hospital stay ranged from US$3,306 to US$9,234 however, costs associated with pre-term birth were as high as US$326,953 for an infant born at 25 weeks gestation (Huynh et al. 2013). The authors concluded that medical resource utilisation is increased, and therefore so are costs, with increasing complications during pregnancy. These findings are similar to those in an Australian study more than a decade ago estimating the cost of interventions in labour, which found the relative cost of birth increased by up to 50% for first-time mothers related to accumulating interventions (Tracy & Tracy 2003). Recent analyses of the costs by place of birth is lacking hence this study was undertaken.

The aim of this study is to estimate the cost of giving birth at home, in a birth centre or in a hospital for women at low risk of complications, by applying AR-DRG and other costs to each potential pathway identified in a decision tree developed using population-based data for pregnant women at low risk of complications in New South Wales.

## Methods

This study used a decision analytic modelling framework to construct a decision tree which illustrated the pathways of women at low risk of compilations who gave birth in New South Wales between 2000 and 2012 (Scarf 2019). The pathways were developed by identifying planned place of birth, and then using descriptive statistics, we determined each pathway including planned place of birth, transfer to hospital labour ward, mode of birth and admission to neonatal care unit. Once the pathways were determined, an estimate of the cost of each pathway was applied to the terminal node by using Australian Refined Diagnosis Related Groups (AR-DRGs) (Table 1). Given that the women in this study have experienced a healthy pregnancy and have spontaneously gone into labour, we chose the AR-DRGs associated with minimal and intermediate complications across all birth settings.

**Table 1: AR-DRG definitions included in cost estimations**

| AR-DRG code* | Definition | Cost** |
|---|---|---|
| **O60C** | Vaginal delivery (minimal complications, singleton) - including women who had no intervention, or received any of the following: induction or augmentation of labour, epidural analgesia, narcotic pain relief, and/or minor perineal trauma. | **$4515** |
| **O60B** | Vaginal delivery (intermediate complications) - including women who had any of the following: multiple birth, instrumental vaginal birth with vacuum or forceps (not in operating theatre), post-partum haemorrhage (PPH), third or fourth degree perineal tear, episiotomy, or other 'non-severe' complications. | **$6108** |
| **O01C** | Uncomplicated Caesarean section, with or without labour. | **$9853** |
| **P68D** | Admission of neonate ≥37 weeks gestation, with minimal complications requiring observation for around 48 hours | **$4016** |
| **P68C** | Admission of neonate ≥ 37 weeks gestation, with intermediate complications requiring observation for 2-3 days | **$5562** |

*Australian Refined Diagnosis Related Groups Version 5.2 Definitions Manual

**IHPA National Hospital cost Data Collection Australian Public Hospitals 2016-17.

## Data Sources

We obtained linked data from the NSW Centre for Health Record Linkage (CHeReL) which linked data from the NSW Perinatal Data Collection (PDC), the NSW Admitted Patient Data Collection (APDC), the Registry of Births, Deaths and Marriages (NSWRBDM) (death registrations only), and the Australian Bureau of Statistics (ABS) mortality data. We used this data to create a dataset containing women who planned to give birth at home, in a birth centre or in a hospital, for the Birthplace in Australia Study (Cheah et al. 2019). The NSW Perinatal Data Collection (PDC) is a record of routinely collected data on all women who give birth in NSW, collected at the point of care (by midwives and doctors), most often through electronic medical record platforms. Maternal and infant data are collected on all livebirths and stillbirths greater than 20 weeks gestation or 400g birthweight (the Australian definition of viability) regardless of place of birth. The NSW APDC contains records of all NSW hospital inpatient separations (discharges, transfers, deaths) from public and private hospitals, public psychiatric hospitals, public nursing homes and private day procedure centres. Clinical data include identifying and demographic data, International Classification of Diseases-Australian modification codes (ICD-10-AM) and procedure codes. The NSWRBDM is a permanent record of all registered births

and deaths kept at the RBDM and the Australian Bureau of Statistics (ABS) compiles mortality data including primary cause and date of death.

## Population

Women were included if they were at low risk of complications, that is, 37 to 41 completed weeks gestation, pregnant with a single baby in the head down or 'cephalic' presentation. These women had no known medical or pregnancy complications such as high blood pressure, diabetes, previous caesarean section or any condition which would place the woman or baby in a high-risk category. Women were also included if they had a spontaneous onset of labour (that is, no induction of labour) and were aged between 17 and 40 years (inclusive). Women who had an unplanned homebirth (born before arrival) or gave birth intentionally without a registered health provider present (free-birth) were not included in this cohort.

Women were excluded if they experienced any obstetric or medical complication, mal-presentation (fetus in a position other than head-down), had a previous caesarean section, did not attend antenatal care or had their labour induced. Relevant variables and ICD-10-AM codes were identified from the PDC and APDC, a complex process which is described in full in Cheah et al. (2019).

## Setting

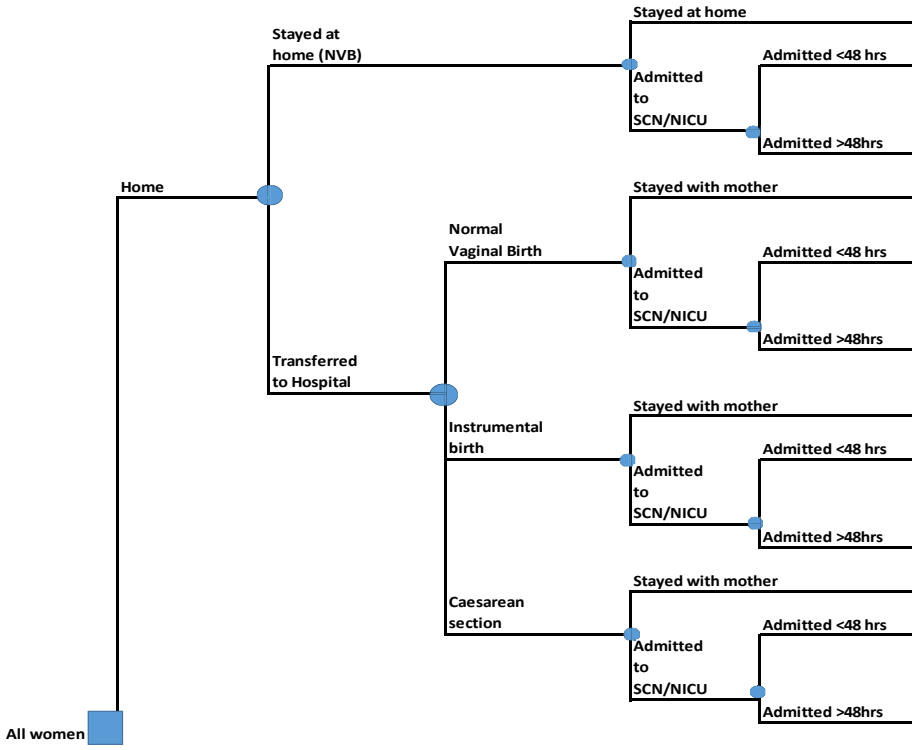
This study expands on the investigation of the trajectories of women who plan to give birth at home, in a birth centre (both alongside and freestanding) or in a hospital (Scarf et al 2019). Between 2000 and 2012, there were six alongside birth centres and three freestanding birth centres in NSW. The 'transfer' process from an alongside birth centre is often a matter of re-locating a woman to a hospital birth room, most likely in the same building and often on the same floor as the birth centre. It is, however, an important distinction: if a woman planning to give birth in a birth centre develops a complication in labour, she is effectively transferred to higher level care in the hospital labour ward. Homebirth services are provided by midwives in private practice or by midwives employed by a health service and who work out of a maternity facility, known as a publicly funded homebirth model.

The health service perspective is taken in this study. We received approval from the NSW Population and Health Services Research Ethics Committee, approval number HREC/14/CIPHS/15 (Appendix B).

## Decision Tree Framework

Decision analytic modelling provides a framework or structure that depicts the consequences of alternative options or treatments (in this case, place and mode of birth, neonatal admission to SCN/NICU) (Briggs, Sculpher & Claxton 2006). The decision tree, interpreted from left to right, depicts the pathways of the women as their labour progressed, specifically noting where labour began, transfer from home or a birth centre to a hospital, mode of birth (normal vaginal birth, instrumental birth- vacuum or forceps birth, and caesarean section) and admission to special care nursery/neonatal intensive care (SCN/NICU) for the baby. Figure 1 depicts the basic framework of the decision tree developed for this study. The decision node on the left represents the planned place of birth at the onset of labour. To the right of the decision node are chance nodes which represent the events that unfolded for the women and their infants. The branches which emanate from these chance nodes are mutually exclusive. The decision framework was chosen as it provides a visual structure which illustrates the pathways the women took using the linked dataset, and allows us to assign costs to each pathway.

**Figure 1: Decision tree framework**




## Pathway costs

Once the pathways were mapped in the decision tree, costs were allocated to each pathway. Included in the cost estimations were Australian Refined Diagnosis Related Group (AR-DRG) categories. AR-DRGs classify admitted patient episodes into groups with similar conditions and then match the resources required by the institution to provide the service (IHPA 2019). The AR-DRGs associated with childbirth are in the major diagnostic category (MDC) 14: Pregnancy, childbirth and the puerperium (codes: O01A-O66B), the relevant codes are described in Table 1. Admission to the Special Care Nursery (SCN) / Neonatal Intensive Care (NICU) was also included, however, in the NSW Perinatal Data Collection, there is one variable which records admission to SCN/NICU, and doesn't distinguish between the two. In the cases where a baby was admitted to SCN/NICU, we were able to determine from the data if the admission was for greater than or less than 48 hours, and applied the corresponding AR-DRG. For simplicity, a baby who is not admitted to the ward (as is the case when the infant is healthy and under the full care of the

mother) does not attract an AR-DRG and is thus costed at $0. This was assumed across the three birth settings for babies not admitted to the SCN/NICU.

To estimate the cost per woman, we calculated the total cost per pathway by multiplying the pathway cost with the number of women in each pathway group. We then added the totals of the pathways by place of birth and divided each total with the number of women in each planned place of birth.

**Table 2: Factors included in cost estimates**

| Planned place of birth | Mode of Birth AR DRG ($) | NICU admission AR DRG ($) | Total unit cost $ |
|---|---|---|---|
| **Home** | | | |
| **Homebirth - SVB** | O60C (4515) | NA | 4515 |
| **HB SVB + TF to NICU <48 hrs** | O60C (4515) | P68D (4016) | 8531 |
| **HB SVB + TF to NICU >48 hrs** | O60C (4515) | P68C (5562) | 10077 |
| **Mat TF + SVB** | O60C (4515) | NA | 4515 |
| **Mat TF + SVB + NICU <48hrs** | O60C (4515) | P68D (4016) | 8531 |
| **Mat TF + SVB + NICU >48hrs** | O60C (4515) | P68C (5562) | 10077 |
| **Mat TF + IB** | O60B (6108) | NA | 6108 |
| **Mat TF + IB + NICU <48hrs** | O60B (6108) | P68D (4016) | 10124 |
| **Mat TF + IB + NICU >48hrs** | O60B (6108) | P68C (5562) | 11670 |
| **Mat TF + CS** | O01C (9853) | NA | 9853 |
| **Mat TF + CS + <48hrs** | O01C (9853) | P68D (4016) | 13869 |
| **Mat TF + CS + >48hrs** | O01C (9853) | P68C (5562) | 15415 |
| **Birth Centre** | | | |
| **BC SVB** | O60C (4515) | NA | 4515 |
| **BC SVB + NICU <48hrs** | O60C (4515) | P68D (4016) | 8531 |
| **BC SVB + NICU >48hrs** | O60C (4515) | P68C (5562) | 10077 |
| **BC IB** | O60B (6108) | NA | 6108 |
| **BC IB + NICU <48hrs** | O60B (6108) | P68D (4016) | 10124 |
| **BC IB + NICU >48hrs** | O60B (6108) | P68C (5562) | 11670 |
| **BC CS** | O01C (9853) | NA | 9853 |
| **BC CS + NICU <48hrs** | O01C (9853) | P68D (4016) | 13869 |
| **BC CS + NICU >48hrs** | O01C (9853) | P68C (5562) | 15415 |
| **Hospital** | | | |
| **Hosp SVB** | O60C (4515) | NA | 4515 |
| **Hosp SVB + NICU <48hrs** | O60C (4515) | P68D (4016) | 8531 |
| **Hosp SVB + NICU >48hrs** | O60C (4515) | P68C (5562) | 9851 |
| **Hosp IB** | O60B (6108) | NA | 6108 |
| **Hosp IB + NICU <48hrs** | O60B (6108) | P68D (4016) | 10124 |
| **Hosp IB + NICU >48hrs** | O60B (6108) | P68C (5562) | 11670 |
| **Hosp CS** | O01C (9853) | NA | 9853 |
| **Hosp CS + <48hrs** | O01C (9853) | P68D (4016) | 13869 |
| **Hosp CS + >48hrs** | O01C (9853) | P68C (5562) | 15415 |
| **Abbreviations:** BC- birth centre; CS-caesarean section; HB- homebirth; Hosp- hospital; IB-instrumental birth (forceps, vacuum); NICU- neonatal intensive care unit; SVB-spontaneous vaginal birth; TF- transfer | | | |

### Scenario analysis

In a scenario analysis, we recalculated the pathway costs and included antenatal consultation costs. The Independent Hospital Pricing Authority identified a national non-admitted cost per maternity patient of $2104 ($1550 allocated to antenatal care and $554 for postnatal care) (IHPA 2017) which we used to recalculate the cost per woman by place of birth.

Using the costs calculated including AR-DRGs and antenatal consultation costs, we proposed five different scenarios to model the cost to upscale publicly funded homebirth and birth centre options. *Scenario 1* estimates the total cost to the health service using the current proportions of 0.4% of women planning a homebirth (current rate in NSW), 6% planning a birth centre birth and 93.5% planning a hospital birth. For *Scenario 2,* we calculated the cost of birth in these settings if the proportions were increased to 1% homebirth, 9% birth centre birth and decreased to 90% hospital birth. *Scenario 3* is a calculation of the costs of birth in the three settings if these services were up-scaled to match services in the United Kingdom, which is 2.5% homebirth, 5% birth centre and 92.5% hospital obstetric unit (Birthplace in England Collaborative Group 2011). *Scenario 4* estimates the cost of scaling up homebirth to 1% and birth centre birth to 15% and *Scenario 5* proposes an upscaling to 2.5% homebirth and 15% birth centre birth. We calculated the total cost of these scenarios for a population of 30,000 women. This is the estimated number of childbearing women in NSW who meet the criteria of low-risk pregnancy and spontaneous onset of labour.

## Results

### Planned place of birth

There were 496,387 women identified as meeting the criteria for inclusion (Table 4). Of these, 0.4% planned a homebirth, 6% planned a birth centre birth and 93.6% planned birth in a hospital. There were differences in the demographic characteristics across the three birth settings. Women planning a homebirth were older (mean=31.7 years, standard deviation (SD) =4.7) compared with women who planned birth in a birth centre (mean=29.1 years, SD=5.1) or in a hospital (mean=28.9, SD=5.3). There was a higher proportion of women having their first

baby (nulliparous women) in the hospital and birth centre groups (45.1% and 42.7% respectively) compared to the homebirth group (29.9%). We included women who were at term (37 to 41 completed weeks gestation) and who went into spontaneous labour. Overall, the highest proportion of women laboured at or beyond 40 weeks, with 67.1% in the homebirth group, 57.1% planning a birth centre birth and 54% planning a hospital birth.

**Table 3: Demographic characteristics**

| | **Hospital n = 464,630 (%)** | **Birth Centre n = 29,933(%)** | **Home n = 1824 (%)** |
|---|---|---|---|
| **Maternal age (Years) Mean (SD)** | 28.9 (5.3) | 29.7 (5.1) | 31.7 (4.7) |
| **<20** | 20,733 (4.5) | 767 (2.6) | 19 (1.0) |
| **20-24** | 81,183 (17.1) | 4189 (14.0) | 118 (6.2) |
| **25-29** | 142,161 (30.0) | 9110 (30.4) | 439 (23.2) |
| **30-34** | 147,523 (31.1) | 10,271 (34.3) | 700 (37.0) |
| **35-39** | 68,094 (14.4) | 5251 (17.5) | 504 (26.7) |
| **>40** | 4936 (1.1) | 345 (1.2) | 111 (5.9) |
| **Previous pregnancies (>20 weeks)** | | | |
| **0** | 209,664 (45.1) | 12,782 (42.7) | 546 (29.9) |
| **1** | 150,364 (32.4) | 10,727 (35.8) | 662 (36.3) |
| **2** | 65,633 (14.1) | 4460 (14.9) | 373 (20.4) |
| **> 3** | 38,969 (8.4) | 1964 (6.6) | 243 (13.3) |
| **Gestation (weeks) Mean (SD)** | 39.5 (1.04) | 39.62 (1.04) | 39.73 (1.02) |
| **37** | 22,518 (4.8) | 1073 (3.6) | 66 (3.6) |
| **38** | 62,166 (13.4) | 3231 (10.8) | 163 (8.9) |
| **39** | 129,050 (27.8) | 7930 (26.5) | 370 (20.3) |
| **40** | 185,175 (39.9) | 11,558 (38.6) | 821 (45.0) |
| **41** | 65,721 (14.1) | 6141 (20.5) | 404 (22.1) |

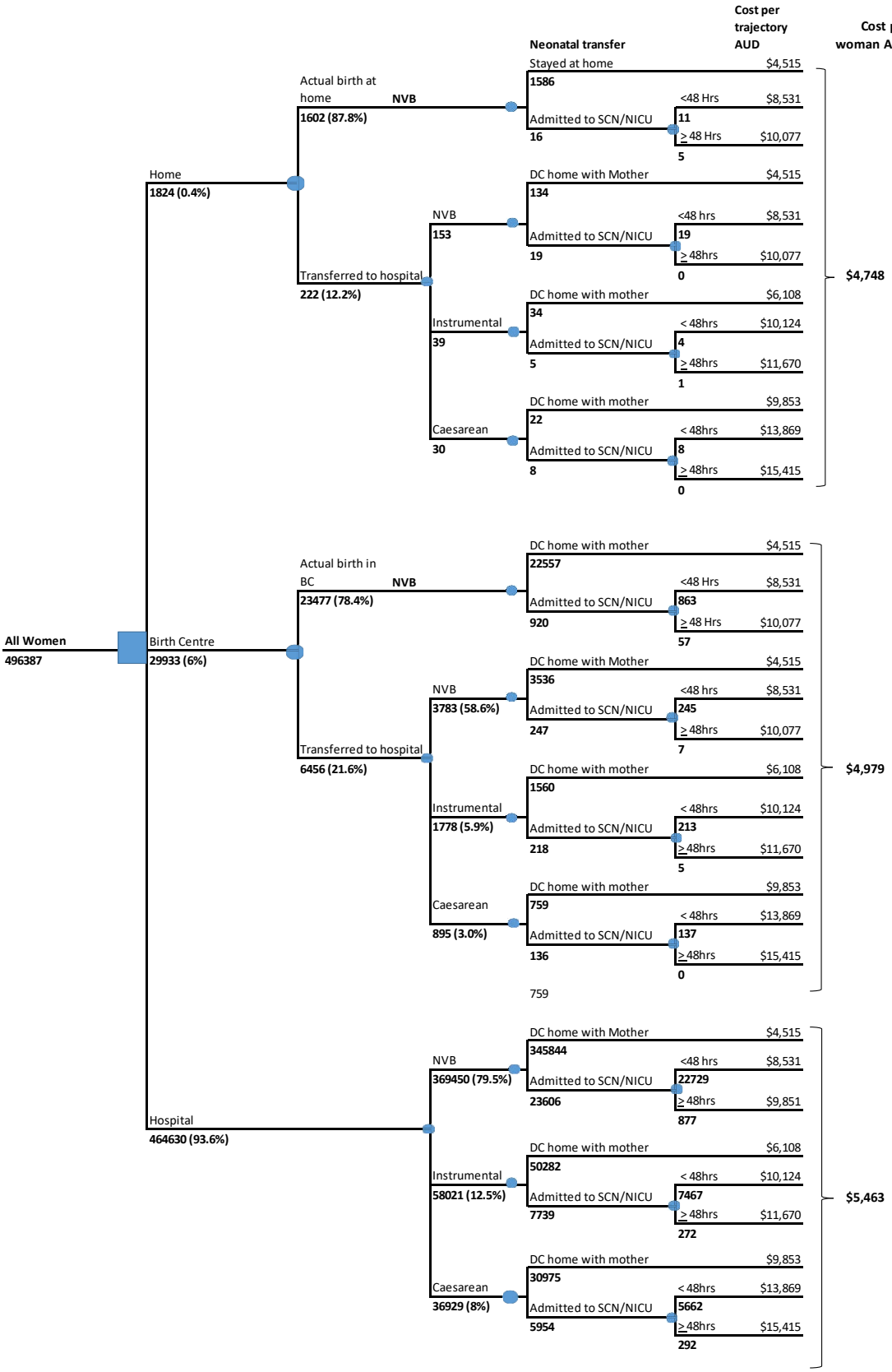
## Pathway costs of place of birth

The women planning birth at home or in a birth centre had twelve potential outcome pathways. The women planning a hospital birth have the most direct pathway, differing only by mode of birth and neonatal outcome. Women in the planned birth centre and homebirth group differed by transfer and then mode of birth and neonatal outcome. Figure 2 illustrates these potential pathways and the number of women in the sample who followed each pathway are presented below each branch. A description of the conditional probabilities of each pathway has been presented in chapter four. Briefly, the normal vaginal birth rate in women

planning a homebirth was 96.2% (including women who transferred to hospital), 91.1% for women planning birth in a birth centre (including transfers) and 79.5% in the hospital birth group. The transfer rate from home or a birth centre to hospital was 12.2% and 21.5% respectively. Instrumental birth rates for the three settings were 2.1% (homebirth), 5.9% (Birth Centre) and 12.5% (hospital), and caesarean sections occurred in 1.6% of planned homebirths, 3.0% of planned birth centre births and 7.9% of births planned in hospital.

Each pathway accrued a cost (Table 2) depending on the resources used. In Figure 2, for example, a woman planning a homebirth who is transferred to hospital for an instrumental birth and whose baby is well enough to be discharged home with her incurred a cost of $6108. A woman planning a birth centre birth or a hospital birth with the same outcome incurred the same cost. In these three pathways the AR-DRG was the same (O60B). The difference by place of birth lies in the rate of intervention, which when tallied across each birth setting, amounted to a difference per woman of $484 more in the hospital group compared with the birth centre, $715 more in the hospital group compared with homebirth and $231 more in the birth centre compared with homebirth.

## Figure 2: Pathway costs and mean costs of birth setting



## Proposed Scenarios

The following scenarios calculate the total cost to the health system for 30 000 women in NSW by place of birth when AR-DRGs only are used and when AR-DRGs plus an estimated cost of antenatal care is included (Table 4).

**Table 4: Modelling cost by place of birth per year in NSW**

| N=30000 | Proportion | AR DRG only | Estimated AN care and AR DRG |
|---|---|---|---|
| **Scenario 1: Current proportions** | | | |
| **Home** | 0.004 | $569,760 | $826,560 |
| **Birth Centre** | 0.06 | $8,962,200 | $12,814,200 |
| **Hospital** | 0.936 | $153,401,040 | $213,492,240 |
| **Total** | 1 | $162,933,000 | $227,133,000 |
| **Scenario 2: Upscaling to 1% homebirth and 9% Birth Centre** | | | |
| **Home** | 0.01 | $1,424,400 | $2,066,400 |
| **Birth Centre** | 0.09 | $13,443,300 | $19,221,300 |
| **Hospital** | 0.9 | $147,501,000 | $205,281,000 |
| **Total** | 1 | $162,368,700 | $226,568,700 |
| **Difference** | | | -$564,300 |
| **Scenario 3: Upscaling 2.5% homebirth 15% birth centre (similar to UK proportions)** | | | |
| **Home** | 0.025 | $3,561,000 | $5,179,500 |
| **Birth Centre** | 0.05 | $7,468,500 | $10,624,500 |
| **Hospital** | 0.925 | $151,598,250 | $210,983,250 |
| **Total** | 1 | $162,627,750 | $226,827,750 |
| **Difference** | | | -$305,250 |
| **Scenario 4: Upscaling to 1% homebirth and 15% birth centre** | | | |
| **Home** | 0.01 | $1,424,400 | $2,066,400 |
| **Birth Centre** | 0.15 | $22,405,500 | $30,996,000 |
| **Hospital** | 0.84 | $137,667,600 | $191,595,600 |
| **Total** | 1 | $161,497,500 | $224,658,000 |
| **Difference** | | | -$2,475,000 |
| **Scenario 5: Upscaling to 2.5% homebirth and 15% birth centre** | | | |
| **Home** | 0.025 | $3,561,000 | $5,179,500 |
| **Birth Centre** | 0.15 | $22,405,500 | $30,996,000 |
| **Hospital** | 0.825 | $135,209,250 | $188,174,250 |
| **Total** | 1 | $161,175,750 | $224,349,750 |
| **Difference** | | | -$2,783,250 |

Scenario 1 estimated the total cost to the health service for a cohort of 30,000 women in NSW per year using the current proportions of women planning birth at home, in a birth centre and in a hospital. The average cost per place of birth was calculated to be $4748 for homebirth, $4979 for birth in a birth centre and $5463 for planned hospital births (Figure 2). When the estimated cost of antenatal care is included, the cost increases by $2104, resulting in a total cost of birth at home, in a birth centre and in a hospital of $826,560, $12,814,200 and $213,492,240 respectively.

In scenario 2, we recalculated the costs the three places of birth increasing the proportions of planned births to 1% at home, 9% in a birth centre and 90% in a hospital. When antenatal costs are included, the total cost saving per year was $564,300, reducing the total expenditure by 0.25% when compared to the costs associated with the current proportions of 0.4% homebirth, 6% birth centre and 93.6% hospital birth (Scenario 1).

Scenario 3 estimates the costs when homebirth and birth centre services are increased to 2.5% and 5% respectively, as is the case in the UK. The total saving to the health service per year amounts to $305,250 when antenatal costs are included, when compared to the current proportions.

We further tested the scaling up of homebirth and birth centre services to 1% and 15% in scenario 4 and 2.5% and 15% in scenario 5 and calculated an annual cost saving of $2,475,000 and $2,783,250 respectively. These scenarios amounted to a saving of over 1%.

## Discussion

This is the first study to examine cost by place of birth using standardised cost weights, that is, AR-DRGs. We found differences in the cost per woman by place of birth which can be attributable largely to mode of birth. During the development of the NSW dataset, we endeavoured to create a cohort as similar as possible however we recognise that there would be unobservable characteristics in the women included which may influence the results. Our selection processes enabled us to identify women with key characteristics which placed them closely aligned,

specifically, spontaneous onset of labour, cephalic presentation, 37-41 completed weeks gestation (at term), with no documented pre-existing medical or pregnancy complication (Cheah et al. 2019). The greatest proportion of women who attracted the AR-DRG with the lowest value (O60C) were in the homebirth group (96.2%) followed by 91.1% in the birth centre group and 74.4% in the hospital group.

The impact of the complex outcomes for women in all groups contributed to the incremental increase in cost from homebirth to birth centre to hospital. For women planning a homebirth for example, the proportion of neonates admitted to NICU/SCN was 2.3% (<48hrs) and 0.33% (≥48hrs) which attracts a cost of between $8947 and $15831 depending on the mode of birth. Neonates of women planning birth in a birth centre had an SCN/NICU admission rate of 4.9% (<48hrs) and 0.46% (≥48hrs) in the hospital birth group, the neonatal admission rates to SCN/NICU were 7.7% (<48hrs) and 0.31% (≥48hrs) with costs of between $8531 and $15415 again, depending on the mode of birth.

The national costing authority in Australia, the Independent Hospital Pricing Authority (IHPA) found that non-admitted (antenatal and postnatal) care was similar across most childbearing women with the exception of women with very complex pregnancies. The cost of the admitted birth episode (and in the case of a homebirth, the "admission" relates to the birth episode at home/ transfer to hospital) differed significantly as the driver for that cost was mode of birth indicating that significant savings can be made by "clinically warranted reductions in the rate of interventions during birth" (IHPA 2017 p24). Research has shown significant differences in modes of birth related to birth setting, including increased spontaneous vaginal birth rates for women planning birth at home or in a birth centre (Birthplace in England Collaborative Group 2011; Homer et al. 2014; Homer et al. 2019). This translates to a lower cost per birth when comparing birth setting (Bernitz, Aas & Oian 2012; Schroeder et al. 2012; Schroeder et al. 2017). There are countries, however, which employ very few DRG categories to cost childbirth. In a study by Or et al (2012) of European countries, the variation of DRG-related birth codes ranged from three in Austria and Poland (where the payment for vaginal birth and caesarean section were the same) to seven in England and eight in

Germany describing several birth complications (Or et al. 2012). This has the potential to provide a perverse incentive to service providers to be more prone to intervention during birth to increase funding from government (Anthun, Bjørngaard & Magnussen 2017; Duckett; 2008).

When we proposed an up-scaling of services to enable women to plan a birth at home or in a birth centre, the cost to the NSW health service resulted in a slight decrease in cost over a 12 month period. While the increase in homebirth options were considerable comparatively (scenarios 2 and 4 represented a 250% increase in homebirth and scenarios 3 and 5 were a 625% increase in homebirth) the proportions remained very small. Considering the absolute increase of services was modest, it would be feasible to offer a greater number of women options including publicly supported homebirth and birth centre care while utilising the existing infrastructure. There may be additional costs related to training and accreditation of staff and facilities, which would ultimately be recouped over time with the prospected decrease in intervention. A limitation of proposing this increase in service options is that there exists only anecdotal reports of the demand by women to enter into a program which offers an alternative to hospital birth; reports of waiting lists cannot be quantified and further research into the apparent demand is warranted.

## Strengths and limitations

This study represented the provision of homebirth services in a publicly-funded model however, in NSW, more than half of homebirths were attended by midwives in private practice. Smooth transfers to hospital require a networked or integrated service. Additionally, transfer costs were not included in the total cost for women who transferred to hospital from home as not all transfers occur via ambulance. If an ambulance was required, we calculated an additional $416 for transfer assuming a ten kilometre distance from the nearest maternity facility (NSW Health 2019). In countries where different birth setting options are integrated into the health system, for example the United Kingdom, New Zealand or the Netherlands, the decision for women about where they will give birth is more contemporaneous, and the transfer processes are well understood and facilitated by the health services

(Grigg et al. 2015; Offerhaus et al. 2015; Rowe et al. 2013). In Australia, home birth is uncommon and integration into the health services varies across individual services, as do attitudes relating to the acceptability and demand among midwives and obstetricians (Dahlen, Schmied, et al. 2011; McLachlan et al. 2016). Fox et al (2018) explored the processes and interactions that occurred during transfer from home to hospital during a birth for both women and health professionals. They found the divergence of philosophical beliefs related to safety and risk negatively influenced their understanding and respect for the women and the midwives who were attending their birth. This resulted in an "us and them" dynamic which created an atmosphere of conflict rather than collaboration in some transfer cases (Fox, Sheehan & Homer 2018). The cost of transfer also varies with the distance from the maternity facility, which may increase (or decrease) the cost of transfer from home or a freestanding birth centre.

## Conclusion

The findings from this study provides some clarity into the financial saving of offering more options to women seeking an alternative to giving birth in hospital. Maternity service provision is complex and admission for intrapartum care drives the costs related to overheads, interventions and outcomes. Given the relatively lower rates of complex intervention and neonatal outcomes associated with women at low risk of complications, we can assume the cost of providing them with homebirth and birth centre options could be cost-effective.

# Chapter 7: Discussion

## Introduction

This study was undertaken in NSW where the vast majority of healthy women plan to give birth in hospital, with a small proportion planning birth at home or in a birth centre. This is in part determined by the availability of options other than hospital birth. Potentially more women would opt to give birth in a birth centre or at home ((Dahlen, Jackson, et al. 2011; Dahlen, Schmied, et al. 2011, McIntyre, Francis & Chapman 2011). Developing more of these services has often been difficult due to a lack of information about the resource requirements and implications, and possibly a lack of political will or vision. To better plan to meet the needs of the population of low risk women, for whom birth in a birthing centre or at home could be an option, a greater understanding of the cost and safety of alternative birth settings is needed.

This study provides new evidence that birth at home or in a birth centre for women at low risk of complications is less costly than hospital and may confer a cost saving if scaled up to greater proportions than currently exist. This chapter synthesises the overall results of the thesis, addresses the multiple barriers to change, and discusses the potential for expansion of options for place of birth for women in NSW and potentially other Australian states.

## Overview of findings

The overall aim of this study was to generate evidence on the relative costs of providing maternity care for women at low risk of complications in the three available birth settings in New South Wales: home, birth centre or hospital. This research demonstrated through a systematic review that for women planning to give birth at home or in a birth centre had significantly higher odds of having a normal vaginal birth and lower rates of sever perineal trauma and sever post-partum haemorrhage. There were no statistically significant differences in perinatal mortality by planned place of birth. Similarly, the systematic review of comparative costs found that 10 of the 11 studies reported either no difference in cost, or a cost saving, associated with giving birth at home or in a birth centre compared with a hospital labour ward. The remaining study which reported an increased cost in birth

centre care, was largely due to set up costs and higher staff costs. Overall, there were benefits for the women and staff were notable with no increase in adverse outcomes.

This research used a new approach to considering the costs of the different places of birth by first mapping the trajectories for women planning to give birth in the three settings. A decision tree framework was developed using de-identified, population-based linked data. This framework illustrated the probabilities of giving birth in the chosen setting, mode of birth and the admission of the baby to a special care nursery or neonatal intensive care unit (SCN/NICU). Women who planned to give birth at home or in a birth centre had higher rates of normal vaginal birth, even following transfer to hospital, and their infants had lower rates of admission to the special care nursery or neonatal intensive care unit. This evidence was used to cost the trajectories in Chapter six.

A micro-costing design was used to identify the staff time and resources required to provide care in a public hospital, birth centre or at home. This was achieved through closer observation of a small cohort of women using a micro-costing method. The result of the micro-costing study, contained in Chapter five, show that the main costs are derived from midwifery time and, when a woman successfully has a vaginal birth in her planned setting, there is little difference in the cost to the health service.

Finally, Chapter six expands on the decision tree framework developed in Chapter four, and AR-DRGs were used to cost each trajectory. The results show that the cost of giving birth at home is the least costly option for the health service, followed by birth in a birth centre. When an up-scaling of services to enable women to plan a birth at home or in a birth centre was proposed, the cost to the NSW health service resulted in a slight decrease in cost over a 12 month period.

In summary, the findings identified in chapters two and three indicate that the current literature provides the evidence in support of offering women choice of place of birth, when appropriate. Homebirth and birth in a birth centre is safe and less costly for women at low risk of complications. Given that midwifery-led care is

so closely associated with these birth settings in Australia, integrating the evidence of outcomes from studies investigating this model of maternity care (Sandall et al. 2016) further supports greater choice for women who would like to plan birth outside the hospital setting with midwife-led continuity of care. Chapters four to six build on the evidence that, for women at low risk of complications, planning to give birth outside the hospital may be a cost saving measure, particularly if the infrastructure supports a more fluid service delivery model which facilitates seamless transfer from out of hospital settings and the continuation of care from a known midwife.

This chapter now provides a discussion of what could happen next to provide greater choice of place of birth and model of care for childbearing women. Issues such as quality of care, safety, risk and choice for women will be addressed in the context of making these a priority when planning and delivering maternity services.

## Quality and safety, risk and choice

### *Defining quality maternity care*

Whilst this research focussed on estimating the cost of birth in the three available settings, at the heart of providing these options for women is the consideration of safety and risk. Fundamental to this is a commitment to providing high-quality maternity care which reduces risk, and ensures safety. Midwifery care is central to maternity care in Australia and around the world and has been closely examined by midwifery leaders over recent years (Horton & Astudillo 2014). In a series published in *The Lancet*, Renfrew et al. (2014) undertook to map the midwifery scope of practice and the contribution midwifery makes in the provision of quality maternity care (Renfrew et al. 2014). This examination of midwifery care resulted in a framework which clearly describes how maternal and newborn care is provided and by whom. It is clear from the resultant framework for Quality Maternal and Newborn Care (QMNC) that midwifery scope of practice extends to all but the advanced interventions performed by medical, obstetric and neonatal trained practitioners. The QMNC framework identifies key characteristics of quality maternity care which are categorised into five domains: Practice categories, organisation of care, values, philosophy and care providers (Renfrew et al. 2014). It

illustrates clearly what a health system needs to deliver high-quality care in any context and specifically highlights the need for interdisciplinary teamwork and service integration.

The QNMC framework can be used as a blueprint for education (Griffith University 2017), service development, workforce planning and resource allocation and has been employed in mapping services to assess their acceptability to the needs of the women, the care providers and the health service (Cummins et al. 2019; Symon et al. 2019; Symon et al. 2016). These studies found that the QMNC framework was useful in comparing the views of different practitioners and used the framework to identify areas of agreement between disciplines, and gaps in service provision and formed the beginnings of a conversation towards solutions at a service level to improve the experience for both women and practitioners (Symon et al. 2019). Cummins et al. (2019) specifically looked at midwifery-led continuity of care models and were able to identify facilitators and barriers to the expansion of this model of care in the Australian context using the QMNC framework (Cummins et al. 2019).

*Defining safety and risk: Perspectives of midwives and doctors*

The systematic review of studies on maternal and neonatal outcomes by place of birth (Chapter 2) showed no statistically significant difference in infant mortality, and lower odds of intervention and maternal morbidity for women who planned to give birth at home or in a birth centre (Scarf et al. 2018). Other studies and reviews have essentially shown the same findings (Birthplace in England Collaborative Group 2011; Davies-Tuck et al. 2018; de Jonge et al. 2015; Homer et al. 2014; Homer et al. 2019; Hutton et al. 2019). Despite the evidence from this paper and many others, the politics of birth has meant that, in Australia at least, movement to providing more homebirth and birth centre services has been very slow.

Some of the resistance to change seems to be driven by fundamental challenges in the notions of risk, safety and choice. For example, the view of birth by midwives compared to doctors is divergent in many countries, particularly in the case of planned birth at home. When the position statements of midwifery and obstetric professional colleges from Australia, the UK, New Zealand, Canada and the United States in 2016 were explored, the treatment of the evidence used to develop the

statements differed between the professional colleges. Safety was cited as the main consideration of all professional colleges when it came to homebirth but colleges who did not support homebirth, which comprised medical colleges (Royal Australian and New Zealand College of Obstetricians and Gynaecologists [RANZCOG] and the American Congress of Obstetricians and Gynaecologists [ACOG]), focussed on adverse perinatal outcomes (Licqurish & Evans 2016; Roome et al. 2016). Professional colleges in support of this option for women, (Australian College of Midwives [ACM], Royal College of Obstetricians and Gynaecologists [RCOG], Royal College of Midwives [RCM] and the Canadian Association of Midwives [CAM]) used a broader definition of safety which included the reduction in interventions, and emotional and psychological safety as well as maternal and neonatal outcomes (Roome et al. 2016). These latter colleges comprised mostly the midwifery discipline, with the exception of the UK where the obstetric college showed support.

Locally, the ACM in its position statement on homebirth, describes informed decision-making and evidence-informed care, with the midwife working in partnership with the woman and her family to make the decision about the appropriate place of birth as important tenets (Australian College of Midwives 2016). In contrast, the RANZCOG document declares its support for women having informed choices, including the choice of place of birth (RANZCOG 2017). However, the recommendations are prefaced by the statement "Where a woman undertakes a planned homebirth in full awareness of the associated additional risks…" (RANZCOG 2017, p. 4) which suggests an underlying attitude of concern in relation to homebirth by this professional college.

There are several principles that the ACM and RANZCOG agree on in their homebirth statements: women's right to choose their place of birth; that the best evidence is provided to women during the decision making process; and that women are cared for by skilled, regulated practitioners who have established links with the health system. Undeniably, when labour and/or birth are not progressing safely, being at home complicates the solution to the issue; transfer is required. The converse could be applied to healthy women in hospital. The evidence presented in

Chapters 4 and 6 of this thesis, along with the evidence in the meta-analysis in Chapter 2 suggests that low risk women who intend to give birth in hospital at the onset of labour have a higher rate of intervention than women who intend to give birth in a birth centre or at home. This prompts the question that has been recently asked: is hospital safest place for women who are experiencing a healthy, normal labour and birth (Dahlen 2019)? It is reasonable to reframe the assertion that hospital is the only safe option for birth; the view of many in the clinical, policy and planning sectors.

*Place of birth: Availability and choice*

While choice in place of birth may be said to be supported (Australian Health Ministers' Advisory Council 2011), the reality is quite different, in much of Australia. In the sample of births examined in this thesis, only 0.4% or women chose to give birth at home, and only 6% in a birth centre, but this reflects the availability of these alternatives as much as it does the choice of the women. Currently in NSW, there are three publicly funded homebirth programs, approximately 15 privately practising midwives offering homebirth services and 10 birth centres. For a population that has more than 94,000 births annually, the current supply of alternatives does not provide low risk women with an unconstrained choice. Anecdotal reports of waiting lists for birth centres and publicly funded homebirth services suggest that there is strong demand for alternative places of birth to hospital. Dawson et al. (2016) investigated the availability, implementation and sustainability of midwifery group practice across Australia and found that access to these models was limited (Dawson et al. 2016). This is significant as access to birth centres and homebirth is often the only way women can access midwifery continuity of care, which is probably another reason why they are sought.

There is also limited information for women regarding options for place of birth and models of care in the public sector making 'choice' an elusive concept. In NSW, information relating to birthing options exists on individual maternity hospital websites, however, there is wide variation in the detail and presentation of information outlining the process of "booking in" for pregnancy and birth care. For example, on one large maternity hospital website in the Sydney metropolitan area,

women seeking the birth centre birth are advised to call the birth centre directly to speak to a booking clerk, assuming they knew to look for this service in the first place (SLHD 2019). On another metropolitan hospital website, women are presented with care provider options (GP shared care, public obstetric or midwifery care (in an outpatient clinic) and midwifery group practice) but there is no explicit information on options for birth setting, even though the hospital in question has birth centre facilities (SESLHD 2019). This means that women are unlikely to find place of birth information readily, or to perceive home birth or birth centre as an available option unless they have already considered this possibility and are directly seeking the information. This lack of service-based information available to pregnant women has the likely outcome of directing women into the hospital system, usually via their GP. In effect this means that many women do not perceive a choice about place of birth, even when they are aware of different models of care.

*Service integration and transfer*

One frequently proposed barrier to supporting birth at home or in a birth centre is the potential need for transfer if a complication arises during labour or birth. The trajectories of women in this cohort of healthy women provides information about the transfer rates (Chapter 4). The rate of transfer for nulliparous women was 23% for planned homebirth and 37% for women transferring from a birth centre. The proportions were lower for multiparous women, with a transfer rate of 7.5% from planned homebirth and 12% from a planned birth centre birth. These rates were comparable to intrapartum transfer rates in high-income countries which offer out of hospital birthing options which ranged from 25.4% to 39.1% for nulliparous women and 4.4% to 14.0% for multiparous women in countries such as Norway, Iceland and New Zealand (Blix et al. 2016; Dixon et al. 2014; Halfdansdottir et al. 2015).

It has been shown in other countries that a well-integrated maternity system is associated with greater safety, less risk and better outcomes (Renfrew et al. 2014). In the USA, states with midwifery services that were well integrated into the wider system had significantly higher rates of spontaneous vaginal birth, vaginal birth

after caesarean, and breastfeeding and lower rates of neonatal mortality, caesarean birth and preterm birth (Vedam et al. 2018). Maternity service integration includes features such as a capacity for seamless transition from home or birth centre to hospital, ideally allowing the practitioner to continue care within the transfer facility. Birth centre services in NSW are generally well integrated as they 'belong' to the referring hospital. The freestanding services (Ryde, Belmont, Byron Bay and Wyong) are also well integrated into the nearby maternity units and risk assessment processes have been developed that help maintain safety including mapping the current and future workflow, identifying risks to the women, the staff and the service, ranking the identified risks and identifying the "controls" which assist in decision making and operational considerations such as transfer and referral (Monk et al. 2014; Raymond et al. 2019).

Homebirth services have been more challenging to integrate. Publicly-funded homebirth services are run from a hospital services and so are linked and integrated into the service (Catling-Paull, Coddington, Foureur & Homer 2013). Private practising midwives (PPM) have often found integration more difficult especially since professional indemnity insurance was removed for homebirth and many private providers were excluded from providing care to the woman in the event of transfer. A number of states and territories have tried to develop systems to enable PPMs to have seamless referral and transfer mechanisms into the local hospitals but this has been a challenge. Only Queensland seems to have managed this on a widespread scale with their system of established 'visiting rights' to public maternity facilities for PPMs which facilitates transfer from home to hospital and allows the midwife to continue to provide care to the woman once she is admitted to hospital, in collaboration with other members of the healthcare team (Fenwick et al. 2017). At present, only one hospital in the Sydney metropolitan area has also established an agreement like this to grant visiting rights to PPMs.

In summary, in NSW there are fundamental barriers to women having a real choice of place of birth. Agreement between the professions, health service providers and policy makers on what constitutes high-quality maternity care would be an important step towards planning future maternity services. The evidenced-based

QNMC framework could be employed as a template by which maternity services may be evaluated and planned. Further to this, agreement between the midwifery and obstetric disciplines on what the priorities are for all women to access appropriate, safe maternity care in the setting that either they choose or is most suitable for their needs. Included in the development of services should be well understood collaborative agreements relating to transfer of care and/or location when required. If PPMs had greater access to maternity hospital facilities, much the same as a visiting medical officer, there may be a shift in attitude towards collaboration and recognition of a woman's choice to give birth where is most appropriate for her needs both physically and emotionally, while enhancing the safety of this birth option.

## Costing maternity services

### *Bottom up and top down*

Lack of information on the costs of services is another important barrier to of scaling-up of availability of birth centres or homebirth services. Costing the place of birth is complicated because of factors related to different risk profiles, differences in models of care location and geography and the limited information about homebirths. Adding to the complexity of funding is the models of care engaged in the different birth settings. Midwives who work in a hospital antenatal clinic, birth unit and postnatal ward generally work shifts and staff the separate areas dependent on the activity of the ward. Midwives engaged in the Midwifery Group Practice/Caseload Models of care manage their own workload (Crowther et al. 2019) and they cover an average weekly workload of 38 hours (fulltime). These midwives are paid an annualised salary as described in Chapter 5 of this thesis. Differences in the deployment of the workforce in a given service make the planning and budgeting more difficult, however midwifery continuity of care models have been found to have cost advantages (Gao et al. 2014; Tracy et al. 2014).

In my micro-costing study (Chapter 5), the median cost of an uncomplicated vaginal birth at home, in a birth centre or in a hospital was similar. However, the composition of these costs by place of birth differed in two main ways: the cost of

midwifery time and the cost of accommodation in hospital, or 'hotel' costs. For women in the homebirth group, a large proportion of the $2150 comprised midwifery time engaged in antenatal care, including travel time ($956). Comparatively, the cost of antenatal care for women in the birth centre and hospital groups was $313 and $139 respectively. The median cost of midwifery and other staff time in labour in the three settings were more similar, with the addition of the potential for a doctor or doctors to be involved in the birth centre and hospital settings. Postnatal costs comprised midwifery time for the homebirth women and hospital overhead costs which include accommodation and staffing. These differences in the composition of the costs is important as it reflects several aspects of the difference in the delivery of care to women in these three birth settings.

At the service level, when place of birth was costed using AR-DRGs (Chapter six), the difference in cost of birth between the three settings was $231 (HB/BC), $715 (HB/Hosp) and $484 (BC/Hosp). Using an estimate of the low risk birthing population in one year in NSW, these costs were used to estimate the cost of giving birth in each setting over a one year period based on different proportions of women in each setting. The most conservative scenario which afforded a cost saving to the health system ($564,300/year) was Scenario 2, which was based on 1% of women choosing a homebirth, 9% of women choosing a birth centre birth and 90% of women choosing a hospital birth. By varying the proportions in each setting by realistic and achievable numbers it is possible to predict the potential savings from greater availability of homebirth and birth centre birth. For example when the proportions were set at 1% homebirth, 15% birth centre and 84% hospital birth, the cost saving amounted to $2,475,000 per year and when this was varied to a scenario with 2.5% home births and 15% birth centre births, the saving was $ $2,783,250.

These scenarios represent quite a modest change in birth services, since in all scenarios at least 84% of women would continue to give birth in a hospital setting. Nonetheless, 1% and 2.5% for of births being at home represents a significant increase on the current proportion of 0.04%, and 15% represents almost a tripling

of the number of women currently accessing a birth centre in NSW. Such an increase would represent greater choice for women. There would potentially be costs related to setting up birth centres, however setting up a homebirth service would only incur the cost of the workforce.

*Why are there potential savings from increased home birth and birth centre births?*

Birth centres and homebirth services generally provide a high level of midwifery continuity of care, which in itself is associated with cost savings (Donnellan-Fernandez et al. 2019; Janssen, Milton & Aghajanian 2015; Kenny et al. 2015; Tracy et al. 2013; Tracy et al. 2014). Evidence of improved outcomes for women receiving midwife-led continuity models is well established (Sandall et al. 2016). While this study did not make assumptions about midwifery continuity of care models, there would be a potential double effect at play: place of birth *and* continuity of care are likely to be a cost-saving combination. The midwifery care received by the women in these birth settings contributes to positive outcomes which can be translated into cost savings at various stages of pregnancy, birth and postpartum.

The higher level of midwifery time for women planning a homebirth means a greater resource cost in terms midwifery salary. However, women who are not admitted to hospital save the health service costs related to accommodation and interventions. Similar savings are achieved through fewer interventions and maternal morbidity in both the home and birth centre groups (Homer et al. 2014; Homer et al. 2019; Scarf et al. 2018). There are also potential other sources of cost savings from increased birth centre and at home births. For example, women who give birth at home are significantly more likely to be breastfeeding at six to eight weeks post-partum (Hutton et al. 2016; Hutton, Reitsma & Kaufman 2009), and breastfeeding has been associated with cost savings related to its protective effect against childhood illnesses and breast cancer in women who have breastfed (Pokhrel et al. 2015).

The variation in the results from Chapters 5 and 6 may explain why it is perceived that providing the option for women to give birth at home or in a birth centre is more costly. Within the health care system, different stakeholders have different views as to the expense of home and birth centre births. The health system bundles

together the costs borne by, for example, the midwifery manager and the hospital as a whole. In practice, midwife salaries are funded by a workforce budget, but savings from reduced interventions accrue to another budget and are funded from a different mechanism. Therefore, midwifery salaries are costly but the overall cost of care is reduced when pregnancy care is costed as a whole. This highlights the difficulty in advocating for midwife-led care and alternative options for place of birth. There is a downside to outcomes-based hospital payments generated through AR-DRGs. Changes to practice which result in less resource-intensive interventions create a flow-on effect, the benefit of which is not felt at the hospital level. Hospital admissions which attract a lower AR-DRG reimbursement result in a reduction in funding to the hospital. An overhaul of the funding mechanisms, including changes from remunerating interventions on a sliding scale to having a flatter reimbursement for mode of birth, would be required to avoid the perverse incentive.

*Scaling up access to birth at home and in a birth centre*

Evidence from this study suggests that while women in NSW have access to universal maternity services, access to home and birth centre birth is limited. This is acknowledged in The National Maternity Services Plan (the Plan), and prioritises access for women, particularly in rural and remote areas, stating that "Australian governments facilitate increased access to midwifery-managed models of care for normal risk women, e.g. midwifery group practice or birthing centres, while maintaining support for choice of, and access to, medically managed models of care" (Australian Health Ministers' Advisory Council 2011) (p30). The Plan was released in 2011 and evidence of attempts to increase access to these services is not available. Improving access for women with a healthy pregnancy to give birth at home or in a birth centre could be a cost-saving option for the health service. Given that intervention is a large driver of cost in maternity services, the avoidance of unnecessary intervention should be prioritised by services, policy makers and planners. The comparison of outcomes for women with similar risk profiles between home, birth centre and hospital reveal the highest rates of intervention exist for women in the hospital group, leading to higher costs to the health service.

Currently, only 6% of women in NSW access the birth centre option and 0.04% plan to give birth at home. The results in this study showed that there are savings to be made and these options could be safely extended to those women who plan to give birth in a hospital due to there being no other option.

*Exploring options to expanding availability of alternatives for place of birth*

Successful collaboration hinges on "buy-in" from all parties (Heatley & Kruske 2011). Downe et al. (2009) identified possible characteristics of effective collaboration which focussed around respect, trust, communication, interdependence and shared responsibility (Downe, Finlayson & Fleming 2010). Improving quality care and greater access to maternity services for women and their families' needs to be a critical public health objective in NSW. On this basis a number of suggestions are made.

Presently, a comprehensive record of the availability of birth centre and homebirth services does not exist which means that women are not currently able to find out what is available, the details of the services and their outcomes. This calls for a coordinated and systematic approach to firstly map the services across the state, evaluate the demand (in the first instance, investigate waiting lists for existing services) and appraise the gap in the current availability of homebirth and birth centre services.

Secondly, all maternity service stakeholders would need to plan for the expansion of birth options outside the hospital setting. Agreement exists between the midwifery and medical disciplines on many aspects of maternity care. A good example of that is the National Midwifery Guidelines for Consultation and Referral (Australian College of Midwives 2014) which were developed in collaboration with midwifery, obstetric, and consumer stakeholders from around Australia. Convening a task force to work together on strategic initiatives that will increase access to safe, affordable maternity care while improving inter-disciplinary relationships could be a positive move towards an integrated maternity system. The new National Strategic Approach to Maternity Services (NSAMS) represents one way to provide this.

Since 2011, a group in the USA has staged four Home Birth Summits, bringing together a multidisciplinary group of stakeholders from many perspectives in maternity care (Home Birth Summit 2019). Delegates included consumers, midwives, obstetricians, hospital administrators, legislators, public health specialists and researchers. The focus of these summits was to discuss ways to improve maternity services for women in the USA, and a suite of common ground statements were developed which informed an implementation strategy.

In Australia, a study conducted alongside the M@NGO trial (Tracy et al. 2013) in 2010 investigated the efficacy of the collaboration between the medical and midwifery staff overseeing the care for women in an MGP group (Beasley et al. 2012). This study concluded that a high degree of inter-professional collaboration was attainable and consistent decision making and professional satisfaction featured highly for both professional groups (Beasley et al. 2012).

Thirdly, there needs to be a coordinated and systematic approach to policy development, working with state and federal governments to expand public maternity services which include birth options outside the hospital setting, for both metropolitan and regional areas in NSW. This study has demonstrated that there are cost savings and the potential for improved clinical outcomes for women who plan birth at home or in a birth centre. Policy exists on maternity services planning and this evidence and the evidence on the safety of home and birth centre birth is clear; it's waiting to be put into practice.

## Strengths and limitations

This study is the first to my knowledge examine the cost of maternity care in NSW at a state level. It used linked population health data, as well as observational data to estimate the cost of birth in the three available settings for women at low risk of complications, using both 'top-down' and 'bottom-up approaches'. By mapping the trajectories of healthy women through their planned place of birth, I was able to illustrate the transfer rates, mode of birth and neonatal admission to the SCN/NICU. These trajectories provided a framework to cost each pathway by applying the relevant AR-DRG to each terminal point. Whilst this is a somewhat blunt measure, it

provided an estimate of cost of each place of birth based on actual population health data.

There are limitations to using linked population health data, including selection bias (the women self-select their planned place of birth, and this self-selection may be correlated with other factors such as intervention rates) and the reliability of the data collection. Another limitation is that data on changes to planned place of birth close to labour onset made intrapartum transfer difficult to identify. However, by linking the datasets, a more accurate picture of each women's pregnancy and birth was able to be developed (Lain et al. 2012). The number of homebirths identified in the data in NSW over the 13 year period was very small and this added uncertainty to the probabilities associated with each trajectory. Additionally, investigation of perinatal mortality was beyond the scope of my study, thus this cost has not been included.

There is also difficulty in identifying confounders beyond those collected in the administrative data used in Chapters 4 and 6. There are many unobservable characteristics which drive women's decision-making regarding their pregnancy and birth care. Women who choose to give birth outside a conventional hospital setting are older and more educated, however there are other unmeasured motivations to do so: individual perception of risk; previous experiences and social influences both in favour and against alternative settings. These confounders influence decision making on the part of the woman and the health services that are beyond the scope of this piece of work and warrant further research.

This study was limited to one state (NSW) which has implications for generalisability if there are differences in the availability of birth settings in other states or differences in salary awards that affect estimates of cost. The results in Chapter 6 are based on National AR-DRG so it is reasonable to assume that this method could be employed to cost state-specific data on the pathways of women who plan birth in these settings.

The micro-costing study was limited to one local health service, and costed vaginal birth. Further investigation of costs associated with interventions for women who

plan birth at home or in a birth centre would augment the estimation of the costs of these settings.

This study took the perspective of the health service when allocating costs of resource use in maternity services in the public sector. Costs from the consumer's perspective were beyond the scope of this study. For example, ongoing treatment for complications and recovery time following birth were not included. Undeniably, these are important costs to consider and warrant further investigation in future research.

## Conclusion

This study has demonstrated that giving birth at home or in a birth centre is as safe as, and no more costly, than giving birth in a hospital for women with a similar low risk profile. It has also shown that access to these birth setting options is limited to a very small proportion of women in NSW. When the cost of providing these services was estimated, it was found to be no more costly to the health service. However, due to the lack of reporting, it is difficult to determine the demand for these services.

Future work is now needed to plan the development and expansion of homebirth and birth centre options for women. This requires a clear vision and close inter-professional agreement between midwives, obstetricians, general practitioners, health service planners and policy makers. The evidence is there, frameworks to guide planning exist. What is needed now is advocacy from the professions, services, and the women, and the political will to make the move away from acute care settings, where the inevitability of intervention looms. Real action based on evidence will see NSW maternity services moving to a system which can be flexible enough to cater for seamless homebirth transfer and collaboration, and birth centre care led by midwives with the support of 'the system' when necessary.

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# Appendices

Appendix A

1. Supplementary Table 1- excluded articles
2. ResQu Index
3. Supplementary Table 2 – statistical techniques
4. Supplementary Figure – forest plots

***Supplementary Table 1: Reasons for exclusion from systematic review (N=58)***

| Author, Year | Risk factors in cohorts not comparable OR include high risk factor/s | Not intention to treat design – based on actual place of birth | Intended birth place determined at booking or not stated | Satisfaction or qualitative results only | Independent variable is model of care rather than birth place | Outcomes not relevant to systematic review | Other reason |
|---|---|---|---|---|---|---|---|
| Abbreviations included at end of table | | | | | | | |
| Amelink-Verburg et al, 2008 (1) | | | | | | Referral (transfer) | |
| Begley et al, 2011 (2) | | | ✓ | | | | |
| Benatar et al, 2013 (3) | ✓ | | | | | | |
| Borquez & Wiegers, 2006 (4) | | ✓ | | ✓ | | | |
| Chang & MacOnes, 2011 (5) | | ✓ | ✓ | | | | Includes pregnancies up to 44 weeks, births attended by non-certified midwives |
| Cheng et al, 2013 (6) | ✓ | | | | | | Includes women with previous CS |
| Christiaens & Bracke, 2009 (7) | | | | ✓ | | | Two countries |
| de Cock et al, 2015 (8) | | ✓ | | | | Breastfeeding | |
| de Jonge et al, 2009 (9) | | | | | | | Data included in 2014 paper |
| de Jonge et al, 2015 (10) | | | | | ✓ | | |
| Evers et al, 2010 (11) | ✓ | | | | | | Low risk HB vs high risk OU |
| Fahy et al, 2010 (12) | | ✓ | | | | Third stage management | |
| Fraser et al, 2000 (13) | ✓ | | | | ✓ | | |
| Geerts et al, 2014 (14) | | | | ✓ | | Sense of control | |
| Gottvall et al, 2004 (15) | | | ✓ | | | | |
| Gottvall et al, 2005 (16) | | | ✓ | | | | |

| Author, Year | Risk factors in cohorts not comparable OR include high risk factor/s | Not intention to treat design – based on actual place of birth | Intended birth place determined at booking or not stated | Satisfaction or qualitative results only | Independent variable is model of care rather than birth place | Outcomes not relevant to systematic review | Other reason |
|---|---|---|---|---|---|---|---|
| Abbreviations included at end of table | | | | | | | |
| Gottvall et al, 2011 (17) | | | ✓ | | | | |
| Grigg et al, 2015 (18) | | | ✓ | | | | |
| Grunebaum et al, 2013 (19) | | ✓ | | | | | Midwife certification not reported. Includes macrosomic and post-term infants |
| Grunebaum et al, 2014 (20) | | ✓ | | | | | |
| Grunebaum et al, 2016 (21) | | ✓ | | | | | |
| Hildingsson et al, 2010 (22) | | | | | | | Planned HB vs elective CS |
| Holt et al, 2001 (23) | ✓ | | | | | | |
| Hutton et al, 2009 (24) | ✓ | | | | | | Includes women with previous CS |
| Hutton et al, 2016 (25) | ✓ | | | | | | Includes women with previous CS |
| Iida et al, 2012 (26) | ✓ | | | ✓ | | | |
| Jackson et al, 2003 (27) | | | ✓ | | ✓ | | Some retrospective recruitment. |
| Janssen et al, 2002 (28) | ✓ | | | | | | Includes women with previous CS |
| Janssen et al, 2006 (29) | | | | ✓ | | | |
| Janssen et al, 2009 (30) | ✓ | | | | | | Includes women with previous CS |

| Author, Year | Risk factors in cohorts not comparable OR include high risk factor/s | Not intention to treat design – based on actual place of birth | Intended birth place determined at booking or not stated | Satisfaction or qualitative results only | Independent variable is model of care rather than birth place | Outcomes not relevant to systematic review | Other reason |
|---|---|---|---|---|---|---|---|
| Abbreviations included at end of table | | | | | | | |
| Johnson & Daviss, 2005 (31) | ✓ | | | | | | Two countries. Comparison group: all term, singleton, vertex US births not just OU births (double counting of HB) |
| Kataoka et al, 2013 (32) | | ✓ | | | | | Hospital transfers excluded |
| Kennare et al, 2010 (33) | ✓ | | ✓ | | | | Mixed risk in planned OU cohort, although analysis adjusts for obstetric complications |
| Laws et al, 2014 (34) | ✓ | | | | | | Mixed risk, although analysis adjusts for obstetric complications. Matching by date of birth |
| Lindgren et al, 2008 (35) | ✓ | | | | | | Breech presentations included HB cohort; includes other high-risk pregnancies. |
| Maassen et al, 2008 (36) | | | | | ✓ | | Cohorts: primary vs secondary care |
| Malloy et al, 2010 (37) | ✓ | ✓ | | | | | Non-vaginal deliveries excluded |
| McFarlane et al, 2014 (38) | | | ✓ | ✓ | | | |
| Monk et al, 2014 (39) | | | ✓ | | | | |

| Author, Year | Risk factors in cohorts not comparable OR include high risk factor/s | Not intention to treat design – based on actual place of birth | Intended birth place determined at booking or not stated | Satisfaction or qualitative results only | Independent variable is model of care rather than birth place | Outcomes not relevant to systematic review | Other reason |
|---|---|---|---|---|---|---|---|
| Abbreviations included at end of table | | | | | | | |
| Nesheim et al, 2010 (40) | | | | | ✓ | | Both cohorts are hospital units |
| Offerhaus et al, 2013 (41) | | | | | | Transfer | |
| Offerhaus et al, 2014 (42) | | | | | | ✓ | Main focus is change over time in CS rate, although intended BP considered |
| Overgaard et al, 2012 (43) | | | | ✓ | | | |
| Rijnders et al, 2008 (44) | | | | ✓ | | | Recall of experience after 3 years |
| Rowe et al, 2012 (45) | | | | | | Transfer | |
| Rowe et al, 2013 (46) | | | | | | Transfer | |
| Snowden et al, 2015 (47) | ✓ | | | | | | OR combines births planned at home + in BC. Includes obstetric complications, adjusted for in analysis. |
| Stramrood et al, 2011 (48) | | | | ✓ | | PTSD | |
| Symon et al, 2007 (49) | | ✓ | | ✓ | | | Maternal risk self-reported |
| Symon et al, 2011(50) | | | | ✓ | | | |
| Tingstig et al, 2012 (51) | | | ✓ | ✓ | | | |
| Tracy et al, 2007 (52) | | ✓ | | | | | |
| Van der Hulst et al, 2004 (53) | | | | ✓ | | Intention about BP | |

| Author, Year | Risk factors in cohorts not comparable OR include high risk factor/s | Not intention to treat design – based on actual place of birth | Intended birth place determined at booking or not stated | Satisfaction or qualitative results only | Independent variable is model of care rather than birth place | Outcomes not relevant to systematic review | Other reason |
|---|---|---|---|---|---|---|---|
| Abbreviations included at end of table | | | | | | | |
| Van Haaren-ten Haken et al, 2015 (54) | | | ✓ | | | | Outcomes during pregnancy relate to antenatal preferences re birth place |
| Watts et al, 2003 (55) | | | | ✓ | | | Unclear eligibility criteria for hospital cohort<br>Transfer data combine HB and BC |
| Wax et al, 2010 (56) | | ✓ | | | | | Includes HB without skilled attendants. |
| Wernham et al, 2016 (57) | | | | | ✓ | | |
| Witteveen et al, 2016 (58) | | | | | | Planned birth place | |
| Abbreviations:<br>BC=birth centre; BP=birth place; CS=caesarean section; HB=home birth; OR=odds ratio; OU=obstetric unit=hospital birth; PTSD=post-traumatic stress disorder | | | | | | | |

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# *Birth Place Research Quality (ResQu) Index*

| | Item | Scoring rubric | Score |
|---|---|---|---|
| A | **Quality of design** | | |
| 1 | **Includes clear statement of research question/objective** | 0=no<br>1=yes | |
| 2 | **Defines and describes each birth setting clearly (e.g. provider, facilities, location)** | 0=not defined or described<br>1=minimal definition<br>2=definition only in terms of provider<br>4=comprehensive definition of each birth setting | |
| 3 | **Indicates type of study design** | 0=study design unclear<br>1=single retrospective cohort<br>2=single prospective cohort<br>3=case control study OR<br>3=comparative retrospective cohort<br>4=comparative prospective cohort<br>5=non-randomised control trial<br>6=RCT | |
| 4 | **Defines key terms (e.g. low risk, PPH, outcome, mortality) consistently, transparently and appropriately (e.g. NICE, ACOG guidelines)** | 0=key terms not defined<br>2=some terms defined<br>3=most terms defined<br>4=all relevant terms defined | |
| 5 | **Indicates ethics approval** | 0=no<br>1=yes (approval cited or reason why no approval) | |
| B | **Definition of sample** | | |
| 6 | **(If relevant) distinguishes between a) planned home births with skilled attendants AND b) free births or unplanned home births** | 0=no<br>6=yes OR<br>6=NA i.e. doesn't include a home birth cohort | |
| 7 | **Includes sample size calculation** | 0=no mention<br>1=refers to sample size calculation<br>2=indicates ideal sample size required for outcomes | |
| 8 | **Uses reliable method of sampling and recruitment for each cohort** | 0=not reliable for any cohort<br>3=reliable for some but not all cohorts<br>6=reliable for all cohorts | |
| C | **Measurement of outcomes** | | |
| 9 | **Outcome data from reliable source e.g. medical records, registration data** | 0=no<br>1=yes | |
| 10 | **Identifies planned birth setting at time in pregnancy that is appropriate to selected outcome measures** | 0=planned birth setting not identified<br>1=retrospectively defined based on actual birth setting<br>2=retrospectively defined with planned setting clear<br>3=retrospectively determined at onset of active labour<br>3=planned setting prospectively-defined at a time appropriate to study type and measured outcomes | |
| 11 | **Provider type (for birth) is indicated, measured and adjusted for in analysis** | 0=provider type not indicated or measured<br>1=provider reported<br>2=provider type indicated but not stratified / adjusted for<br>3= analysis stratified by provider type<br>4= provider type adjusted for in analysis OR single provider type across study | |
| 12 | **Uses cohort size with appropriate power for selected outcomes being measured** | 0=not adequate for any outcome<br>1=limited power<br>2=uses composite outcome variable to address power<br>2=adequate power for all outcomes used | |
| 13 | **Uses reliable method to indicate changes of birth setting** | 0=no<br>1=change of birth setting acknowledged<br>2=changes of birth setting indicated clearly and reliably | |

| | Item | Scoring rubric | Score |
|---|---|---|---|
| 14 | **Indicates timing of transfer between birth settings in labour or postpartum period** | 0= not indicated<br>2=reports timing of transfer<br>4=discusses impact/relevance of timing of transfer | |
| 15 | **Applies reliable and appropriate statistical methods to compare outcomes between cohorts** | 0=statistical methods not described<br>2=descriptive statistics only<br>2=comparative statistical methods used inappropriately<br>4=some comparative statistical methods appropriate<br>6=all comparative methods appropriate and reliable | |
| 16 | **Reports and minimises missing data** | 0=not reported<br>1=reports missing data<br>2=missing data excluded from denominator<br>3=missing data <5% OR missing data imputed<br>4=assesses differences between results from participants with missing and non-missing data OR no missing data | |
| D | **Comparability of cohorts** | | |
| 17 | **Uses cohorts with comparable obstetric and socio demographic characteristics** | 0=no comparison group<br>1=cohorts differ in terms of risk<br>3=cohorts comparable by risk, but vary by socio-demographic characteristics<br>4=comparable socio demographic and risk profile<br>6=cohort characteristics are matched | |
| 18 | **Retains women in original birth place cohort for analysis (intention to treat)** | 0=no<br>6=yes | |
| 19 | **Provides consistent inclusion criteria** | 0=no inclusion criteria<br>3=vague criteria (e.g. undefined 'low risk', 'normal')<br>6=appropriate, consistently-defined criteria all cohorts | |
| 20 | **Controls for confounders including socio-demographic and health profile** | 0=no<br>2=acknowledges confounders, but not in data analysis<br>2=only accounts for one confounder e.g. parity<br>2=controls for undefined confounders<br>4=controls for multiple confounders in analysis OR<br>4=uses matched data effectively OR<br>4=RCT | |
| E | **Accuracy of interpretation and reporting** | | |
| 21 | **Presents results of statistical comparisons clearly and effectively** | 0=no comparison between cohorts presented<br>2=presentation of comparisons confusing or limited<br>4=clear presentation of comparison between cohorts e.g. AOR, ARR, RR with appropriate CIs | |
| 22 | **Bases discussion and conclusions on reported data** | 0=no<br>3=partly<br>6=all conclusions based on reported data | |
| 23 | **Addresses impact of size of cohorts for each outcome measured** | 0=no<br>2=yes OR 2=NA i.e. all cohorts of sufficient size | |
| 24 | **Addresses impact of incomplete data** | 0=missing data not reported<br>0=missing data >5% but not addressed in limitations<br>2=missing data >5% and impact addressed<br>2=missing data <5% | |
| 25 | **Addresses impact of retrospective data** | 0=no<br>2=yes OR NA i.e. not retrospective data | |
| 26 | **Addresses effect of level of service integration between home, birth centre and hospital** | 0=no<br>2=acknowledges effect of limited integration<br>4=accounts for effects of limited integration OR<br>4=well integrated system | |
| 27 | **Addresses impact of local/regional standards, policies and protocols** | 0=no<br>2=yes OR 2=NA i.e. local protocols have no negative impact | |

***Supplementary Table 2: Summary of all studies included in systematic review (N=28), including statistical methods and summary of results for outcomes relevant to the systematic review***

| | First author. Publicat-ion date. Country | Study design | Source of data. Year/s (if avail) | Population – eligibility criteria | Inter-vention – Place of birth | Compar-ator – Place of birth | Outcome measures | Statistical analysis | Summary of results (outcomes relevant to current review highlighted) | ResQu rating |
|---|---|---|---|---|---|---|---|---|---|---|
| **Abbreviations included at foot of table** | | | | | | | | | | |
| 1 | Bernitz 2011 Norway (1) | RCT. Women random-ised at labour onset to 3 birth units | Hospital perinatal data input by MW. 2004? – 2010 | 1111 low-risk pregnancies. AMU eligibility: healthy mother <BMI 32, <10 cigarettes pd, no prev complicated deliveries or uterine surgery, term cephalic singleton, spontaneous onset of labour. | MW led AMU N=412 | Normal birth unit (NU) N=417. Special birth unit (SU) N=282. | Operative birth, augmentation, pain relief, PPH, sphincter injuries, transfer, Apgar5 <7, metabolic acidosis, NICU adm, acupuncture | Diffs between 3 units compared by chi-square compared to AMU. RR with 95% CI | NS difference between 3 units for operative births, **PPH, sphincter injuries, transfer to NICU** | High |
| 2 | Birthplace in England Collabor-ative 2011. England (2) | Prospec-tive cohort study | Data collection forms. 2008 – 2010 | 64,538 women with singleton, term, booked pregnancy, no planned CS or unplanned HB. Low-risk as per NICE guideline. Additional analysis of women without complicating conditions at onset of labour. N=57,127 | Planned home (HB) N=16,840 AMU N=16,710 FMU N=11,282 | Obstetric Unit (OU) N=19,706 | Composite PO = perinatal mortality + major intrapartum morbidity (defined). Secondary outcomes: interventions during labour, transfer, 'normal birth' (SVB without IOL; general, epidural or spinal anaesthesia; episiotomy | Logistic regression to calculate ORs, AORs and 95% CIs for each outcome. Comparison to OU as reference. | **Primary outcome (PO)**:<br>*All low risk women*:<br>4.2/1000 HB vs 3.5/1000 FMU vs 3.6/1000 AMU vs 4.4/1000 OU (all NS).<br>*All women with no complicating conditions*:<br>4.0/1000 HB vs 3.2/1000 FMU vs 3.4/1000 AMU vs 3.1/1000 OU<br>NS for all except HB.<br>**Mode of birth:**<br>SVB signif higher OR in HB, AMU, FMU<br>CS and vacuum birth signif lower OR in HB, AMU, FMU. Forceps signif lower in HB, FMU.<br>Normal birth signif higher OR in HB, FMU and AMU<br>NS difference in **perineal trauma**.<br>NS difference in blood transfusion for HB and AMU. | High |
| 3 | Blix 2012 Norway (3) | Retro-spective cohort study | HB cohort: MW | 17,941 low-risk pregnancies – singleton, term, spontaneous onset of | Planned HB N=1631 | Planned hospital birth N=16,310 | POs: intrapartum intervention and complications. PPH >500mL. | Comparisons by BP use ORs and AORs with 95% CI for outcomes. All | OU signif higher odds of **instrumental birth:**<br>*Nullips:* 5.7% HB vs 14.8% OU<br>*Multips*: 0.6% HB vs 2.0% OU<br>OU signif higher odds of **3rd/4th degree tear**: | High |

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| | | | patient files<br>OU cohort: birth registry data.<br>1990 – 2007 | labour, no medical or obstetric complications, no prev CS. | | | Secondary outcomes: perinatal and neonatal death rates | analysis stratified by parity. Sample too small for statistical comparison re mortality rates. | *Nullips:* 1.1% HB vs 5.0% OU<br>*Multips*: 0.4% HB vs 1.4% OU<br>OU signif higher **PPH** odds for multips:<br>*Multips*: 1.9% HB vs 6.6% OU<br>NS results for CS, or for nullips for PPH. | |
| 4 | Bolten 2016 Nether-lands (DELIVER study) (4) | Prospec-tive cohort study | National Perinatal Database + parti-cipant questionn aire at 6/52 post-partum 2009 – 2011 | 3495 women with low-risk pregnancies in MW care at onset of labour (risk defined elsewhere). Intended either HB or OU birth. | Home birth N=2050. | MW led OU birth N=1445 | POs: SVB, obstetric interventions and perineal outcomes, PPH.<br>Secondary outcomes: birth position, pain management, transfer, duration | Stratified by parity.<br>Univariable logistic regression, with multivariable regression multilevel analyses to account for clustering. AOR with 95% CIs | OU signif lower odds of **SVB**:<br>*Nullips:* 75.0% HB vs 69.5% OU<br>*Multips*: 98.5% HB vs 96.6% OU<br>OU signif lower odds of **intact perineum** for multips: 48.7% HB vs 39.2% OU<br>OU signif lower odds of **3rd/4th degree tear** for nullips: 5.3% HB vs 3.2% OU<br>NS diffs in PPH, CS or instrumental births | High |
| 5 | Burns 2012 UK (England, Scotland and Northern Ireland) (5) | Prospec-tive cohort study | Data collection form complete d by MW during labour and birth.<br>2000 – 2008 | 8924 women "low risk" as per RCOG water immersion joint statement. | Water immersio n in a birth pool in AMU N=2100. Combined FMU/HB (=commu nity) N=2694. | Water immersion in a birth pool in OU N=4130 | Maternal: mode of birth, 3rd stage, duration, perineal trauma, IP events, transfer, PPH.<br>Neonatal: Apgars, shoulder dystocia, infection, resuscitation, NICU admission, mortality, cord snap, readmission | Continuous data: mean, median, SD, range, t-tests. Categorical data: chi-squared test. Results stratified by parity. | **SVB** rates higher in community for nullips: 88.9% FMU/HB vs 79% AMU vs 79.2% OU.<br>**Perineal trauma** lower in community for nullips:<br>1.9% FMU/HB vs 4.3% AMU vs 3.1% OU.<br><br>No significant difference in interventions or outcomes across birth settings for parous women or newborns. | High |
| 6 | Byrne 2000 Australia | RCT | Case notes and quest- | 201 women with normal uncomplicated | Birth centre AMU. | Hospital delivery suite | Transfers, satisfaction, analgesia, | Parametric and non-parametric tests on normally | NS differences in **CS rate or perineal outcomes.** | High |

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| | (6) | | ionnaires complete d by women 1993 – 1995 | pregnancy, booking in <30/40. | N=100 | N=101 | intervention, costs, duration, FHR monitoring, blood loss, Apgars, NICU admission, BF | and non-normally distributed data. RR with 95% CI. | NS differences in **infant outcomes**, including NICU admission. | |
| 7 | Davis 2011 New Zealand (7) | Comp-arative descript-tive study | Perinatal admini-strative database (Mid-wifery Maternity Provider Org). 2006 - 2007 | 16210 women with low risk pregnancies – exclusions described | Primary Unit (PU, like FMU) N=2877 | Planned place of birth – home N=1830, secondary hospital (SU) N=7380, and tertiary hospital (TU) N=4123 | Mode of birth, augmentation of labour, ARM, pain relief, episiotomy, perineal trauma (not defined), blood loss, Apgars, NICU admission | RR and adjusted RR, compared to PU as reference. | **Mode of birth:**<br>Vacuum birth signif higher risk in hospitals:<br>1.1% HB vs 1.18% PU vs 4.8% SU vs 7.4% TU<br>Forceps signif higher risk in hospitals:<br>0.9% HB vs 0.9% PU vs 2.2% SU vs 4.9% TU<br>Emergency CS signif higher risk in hospitals:<br>2.6% HB vs 32% PU vs 8.5% SU vs 14.9% TU<br>**Perineal trauma** lower risk in HB, higher risk in SU, NS in TU:<br>OR: 0.74 HB vs 1 PU (ref) vs 0.83 SU<br>**NICU admission** higher risk in hospitals:<br>OR: 1 PU vs 1.40 SU vs 1.78 TU | High |
| 8 | Davis 2012 New Zealand (8) | Retro-spective cohort study | NZ College of Midwives database 2006 – 2007 | 16,210 women with low risk pregnancies – eligibility defined | Planned PU birth N=2877 | Planned HB N=1830 Secondary unit (SU) N=7308 Tertiary unit (TU) N=4123 | PPH $\geq$ 1000mL | Multinomial logistic regression controlling for several factors. Comparisons indicated with crude and adjusted RRs (95% CI) | **PPH** lower risk in HB and higher in hospital units, but other differences NS<br>1.0% HB vs 1.1% PU vs 1.3% SU vs 1.6% TU | High |
| 9 | de Jonge, 2013 Nether-lands (9) | Linked cohort study | Admin databases (National Perinatal Register databases and the | 146,752 women with low risk pregnancies – eligibility described. | Planned HB N=92,333 | Planned OU birth N=54,419. | PO: Severe acute maternal morbidity: ICU admission + uterine rupture + eclampsia + HELLP + blood transfusion of 4+ packed cells. Secondary | Multivariable logistic regression, OR, AOR, relative risk reduction, sensitivity analyses. | **Severe acute maternal morbidity**:<br>1.5/1000 HB vs 2.7/1000 OU<br>NS difference except for multips (signif lower in HB).<br>**PPH**:<br>29.2/1000 HB vs 39.9/1000 OU<br>NS difference except for multips (signif lower in HB). | High |

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| | | | LEMMoN study) 2004 - 2006 | | | | outcomes: PPH ≥ 1000mL, manual removal placenta | Stratified by parity. | | |
| 10 | de Jonge 2015 Nether-lands (10) | Nation-wide retro-spective cohort study | National registratio n data. Linked from three datasets. 2000 – 2009 | 743,070 women with low risk pregnancies in midwife-led care - eligibility described. | Planned HB N=466,11 2 | Planned hospital birth (including AMU) N=276,958 | Intrapartum and neonatal death, Apgar scores, and admission to NICU within 28 days of birth | Crude and adjusted odds ratios. Stratified by parity. | **Intrapartum and neonatal death** 0-28 days:<br>*Nullips:*<br>1.02/1000 HB vs 1.09/1000 OU (NS)<br>*Multips:*<br>0.59/1000 HB vs 0.58/1000 OU (NS)<br>**Admission to NICU** 0-28 days:<br>*Nullips:*<br>3.41/1000 HB vs 3.61/1000 OU (NS)<br>*Multips:*<br>1.36/1000 HB vs 1.95/1000 OU (signif higher in OU) | High |
| 11 | Dixon 2014 New Zealand (11) | Retro-spective cohort (aim to replicate BPiE in NZ) | NZ College Midwives Clinical Outcomes Research Data. 2006 – 2010 | 61,072 women defined as low-risk using BPiE criteria (singleton, term, cephalic pregnancy, no elective CS, unplanned HB, confounding medical or obstetric risks, BMI < 35, registered with MW) | Planned HB with MW N=4921 Primary unit (PU) N=10,158 | Hospital birth in either secondary (N=29,027) or tertiary unit (N=16,966) | Transfer rates; Apgar <7 at 5 mins; perinatal mortality (data include congenital abnormalities and deaths before labour); NICU admission. | Z tests and chi-squared. | **Perinatal mortality**:<br>2/1000 HB vs 1.9/1000 PU vs 3/1000 SU vs 3/1000 TU, p=0.14 (NS)<br>**NICU admission** higher in hospital births**:**<br>1.8% HB vs 2.2% PU vs 3.1% SU vs 3.8% TU<br>P<0.0001 | Mod-erate |
| 12 | Eide 2009 Norway (12) | Prospec-tive obser-vational cohort study | Hospital records, collected by project staff. 2001 – 2002 | 453 *nulliparous* women with low-risk pregnancies who met the criteria for attending Midwifery led ward (MLW) at the onset of labour | MLW N=252 | Convention al delivery ward (CDW) N=201 | Birth positions, labour duration, PPH, Apgars, perineal trauma. Interventions: mode of delivery, analgesia, episiotomy. | Chi-squared/ Fisher's exact test, unadjusted and adjusted odds ratios | NS differences in **mode of birth, perineal status, PPH and transfer to NICU** | High |

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| 13 | Gaudineau 2012 France (13) | Retro-spective case-control study | Medical records. 2005 – 2008 | 1206 women with low risk pregnancies. Exclusion criteria described. | Home-like birth centre (BC) N=316 | Traditional labour ward (TLW) N=890 | Mode of delivery, perineal trauma, PPH (≥500mL), BF initiation, analgesia, adverse neonatal outcomes (including neonatal death), transfers. | Chi-squared test, Fisher's exact test or ANOVA. T-test or Wilcoxon test for comparison of continuous variables. Adjusted ORs – but unclear presentation (Table 2). | **Mode of birth** significantly different though AOR results unclear.<br>SVB: 88.6% BC vs 82.8% TLW<br>Instrumental birth: 8.9% BC vs 11.9% TLW<br>CS: 2.5% BC vs 5.3% TLW<br>**Perineal outcomes** significantly different though AOR unclear.<br>Intact perineum: 32.8% BC vs 26.1% TLW<br>3rd or 4th degree lesions: 0% BC vs 0.6% TLW.<br>NS differences in **PPH.**<br>No **neonatal deaths** in either cohort. | Mod-erate |
| 14 | Halfdans-dottir 2015 Iceland (14) | Retro-spective cohort study – matched. Two app-roaches (1) natural prospec-tive (ITT) (2) perfect guideline - low-risk | Clinical notes, birth register data base. 2005 – 2009 | (1) 1228 all HB + matched hospital births (incl some known contraindications) Directorate of Health guidelines (2) 1112 women with low risk pregnancies – no contraindications (not described). | Planned home birth (1) N=307 (2) N=278. | Matched planned hospital birth (including AMU) (1) N=921 (2) N=834. | Operative birth, oxytocin augmentation, epidural analgesia, PPH, anal sphincter injury, NICU admission, Apgars | ITT for all home births and their matched hospital births and only low risk home births and their matches were analysed. Used t-tests, Fisher's exact and chi-squared; regression analysis; adjusted ORs with 95% CI. Stratified by parity. | Using approach (1):<br>NS differences in **operative births, PPH ≥1000mL, anal sphincter injury or NICU admission.**<br>Significant difference in **PPH ≥ 500mL:** 12.9% HB vs 19.2% OU<br>Using approach (2):<br>Same conclusions re differences as (1), including signif difference in **PPH ≥ 500mL**.<br>No **infant mortality** in either group. | High |
| 15 | Hiraizumi 2013 Japan (15) | Retro-spective cohort study | Data source unclear - ?medical records. 2007 – 2011 | 508 women with low risk pregnancies (exclusion criteria described) | Planned HB under MW-led care N=168 | Planned hospital birth under MW (N=123) or obst-etric care | Labour 24/24+, augmentation, mode of birth, perineal trauma, PPH 1000+ mL, maternal fever, Apgars, neonatal asphyxia, transfer | Continuous variables compared with t-tests; categorical with chi-squared test. ORs with 95% CI. | NS differences in **mode of birth, perineal trauma or PPH** | Mod-erate |

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| | | | | | | (N=217). All MW births in tatami rooms | | | | |
| 16 | Homer 2000 Australia (16) | Retro-spective cohort study | Medical records. 1995. | 734 women with low-risk singleton, term pregnancies, vertex presentation, in spontaneous labour, free of medical or obstetrical complications | Birth centre N=367 | Hospital labour ward N=367 | Transfer, mode of birth, perineal trauma, neonatal outcomes, EFM. | Continuous variables compared with t-tests; categorical with chi-squared statistic. | **Mode of birth**<br>Normal vaginal birth: 86.1% BC vs 82.3% OU<br>Instrumental birth: 10.4% BC vs 13.4% OU<br>CS: 3.5% BC vs 4.3% OU (all NS)<br>**Perineal status:**<br>Intact perineum: 36% BC vs 27% OU (NS)<br>NS differences in **infant outcomes**. | Mod-erate |
| 17 | Homer 2014 Australia (17) | Retro-spective popu-lation-based cohort study | Linked administr ative and health data. 2000 – 2008 | 258,161 women with low risk pregnancies – exclusions described. Additional analysis for 235,611 women without complications (defined) at start of labour<br>Supplementary data obtained for stillbirth and early neonatal death separately. | Home birth (N=742) and birth centre (N=14,483 ) | Hospital labour ward N=242,936 | PO: primary neonatal outcome (see BPiE Collaboration), stillbirth + NND, transfer, mode of birth, perineal trauma, oxytocin augmentation, general anaesthesia, 'normal labour and birth' (defined). | Continuous data analysed with t-test and ANOVA. Chi-squared analysis for contingency data. Logistic regression. ORs and AORs. Secondary analysis on women without complications at start of labour. Results stratified by parity. | **Primary composite neonatal outcome**:<br>7.1/1000 HB vs 5.3/1000 BC vs 5.8/1000 OU<br>Only significantly lower for multip women in BC (incl those without complications). Other groups NS difference in neonatal outcome.<br>**Stillbirth and early neonatal death:**<br>NS difference – but limited power.<br>**Mode of birth:** Significant differences<br>SVB**:** 97.4% HB vs 86% BC vs 73.9% OU<br>CS: 3.3% HB vs 4.8% BC vs 10.6% OU<br>Normal labour and birth:<br>90.9% HB vs 69.2% BC vs 44% OU (similar rates for women without complications)<br>**3rd/4th degree tear:** NS difference | High |
| 18 | Laws 2010 Australia (18) | Retro-spective popu-lation-based study | National Perinatal Data collection. 2001 – 2005 | 822,955 women included in most analysis.<br>Smaller sample of low-risk pregnancies – eligibility described. N=498,023 | Intended BC birth at the onset of labour N=22,222 | Intended OU birth at the onset of labour N=800,733<br>Low-risk group: N=475,791 | Perinatal mortality, obstetric complications, mode of birth, episiotomy, severe perineal trauma, gestational age, birthweight, Apgar, | Descriptive analysis, chi-square test for comparative data: logistic regression to calculate aOR of perinatal death (only for all OU | P**erinatal deaths:** NS differences<br>*Nullips:*<br>1.5/1000 BC vs 1.9/1000 low risk term OU<br>*Multips:*<br>1.1/1000 BC vs 1.5/1000 low risk term OU<br>**Admission to NICU/SCN**: NS differences<br>*Nullips:*<br>8.2% BC vs 10.0% low risk term OU | Mod-erate |

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| | | | | | | | resuscitation, SCN/NICU | cohort – not low risk); Poisson distribution to compare perinatal outcomes. Results stratified by parity. | *Multips:*<br>3.9% BC vs 6.9% low risk term OU<br>Signif differences in **mode of birth:**<br>SVB: 85.1% BC vs 66.9% low risk term OU<br>Instrumental vaginal birth: 7.6% BC vs11.0% low risk term OU<br>CS: 7.1% BC vs 22.1% low risk term OU<br>**Perineal trauma s**ignif higher in BC**:**<br>3rd/4th degree tear: 2.1% BC vs 1.7% low risk term OU | |
| 19 | Miller 2012 New Zealand (19) | Retro-spective matched case control study | Question-naire to 13 MW practising in hospitals and HB. 2006 – 2007 | 225 *nulliparous* women with low risk pregnancies. Singleton, spontaneous term labour. No risk factors because all still in primary care | Intending HB at outset of labour N=109 | Intending birth in hospital with same MW as HB group N=116 | IP interventions; type of birth, perineal status, transfer, 3rd stage, PPH >500ml, Apgar, birthweight | Group differences using t-test and non-parametric tests (chi-square, Mann-Whitney U, Fisher exact) | Signif difference in **mode of birth** (p<.001)<br>SVB: 95.4% HB vs 79.3% OU<br>CS: 2.8% HB vs 9.5% OU<br>NS difference in **perineal outcomes**:<br>Intact perineum: 33.0% HB vs 42.2% OU<br>3rd degree team: 18% HB vs 0% OU<br>Signif difference in **PPH** (p=.017):<br>2.7% HB vs 12.0% OU | Mod-erate |
| 20 | Nove 2012 UK (20) | Observa-tional study | Secondary analysis of maternity records. 1998 – 2000 | 273,872 women. Exclude high risk pregnancies (NICE), BBA, pre-term birth, elective CS, unattended HB and medical inductions | Planned HB at end of pregnancy N=5998 | Planned birth in one of 15 hospitals N=267,874 | PPH >1000ml | Binary logistic regression, excluding covariates that might influence outcomes, and blur the impact of BP. | Signif difference in **PPH**:<br>0.38% HB vs 1.04% OU<br>(AOR 2.7[1.7-3.8]) | High |
| 21 | Overgaard 2011 Denmark (21)<br><br>For results by parity see Chris-tensen 2017 | Cohort study with matched control. | Patient records and patient administr ation system data. | 1678 women with low risk pregnancies according to NICE guidelines + healthy multips if previous pregnancy and birth were uncomplicated regardless of age and BMI. OU women with | Intended birth in 2 x FMU in communit y hospitals with ICU but no OU. | Births in 1 x large specialised hospital and 1 x provincial hospital with OU. N=839 | PO: Apgar5 <7 and CS. Secondary: Apgars, asphyxia, NICU, neonatal and maternal readmission, perineal status, analgesia, type of birth, water tub, | McNemar test for paired binary data. Wilcoxon signed rank test for paired continuous data. Ordinal data dichotomised. RR with 95% CI. | Signif difference in **mode of birth**:<br>CS: 2.3% FMU vs 4.0% OU<br>SVB: 94.9% FMU vs 89.5% OU<br>Instrumental vaginal birth:<br>3.0% FMU vs 7.8% OU<br>**PPH > 1000mL:** NS difference<br>1.3% FMU vs 1.7% OU<br>Variation in **perineal outcomes**<br>Signif difference in intact perineum: | High |

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| | (22) | | 2004 – 2008. | low risk pregnancies matched prospectively to each FMU woman on 9 key factors. | N=839 | | fetal heart, dystocia, PPH. | | 61.3% FMU vs 55.5% OU<br>NS difference in 3rd or 4th degree tear:<br>2.3% FMU vs 2.9% OU<br>**Perinatal outcomes**: NS differences | |
| 22 | Overgaard 2012 Denmark (23) | Cohort study with matched control. | Secondary analysis of study data from 2004 – 2008. Same data as Overgaard et al 2011. | 1678 women with low risk pregnancies, defined by NICE guidelines. Matched prospectively by obstetric/socio-economic factors. Education used as proxy for social position to test impact of social disadvantage on birth outcomes.<br>*[Women without post-secondary education N=460]* | Intended birth in 2 x FMU in communit y hospitals with ICU but no OU.<br>N=839<br>*[Women without post-secondary education N=230]* | Births in 1 x large specialised hospital and 1 x provincial hospital with OU.<br>N=839<br>*[Women without post-secondary education N=230]* | Composite optimal birth outcome (uncomplicated SVB with good maternal and fetal outcomes) Apgars, SVB, CS, NICU admission, readmission, augmentation, perineal status, epidural, water birth, position. | Conditional logistic regression grouped on matched pairs, looking at overall effect of BP, and education-induced subgroups. ORs with 95% CI. Results stratified by education. | Signif difference in **optimal birth outcome**:<br>*No post-secondary education:*<br>83.5% FMU vs 67.8% OU<br>*Post-secondary education*:<br>83.7% FMU vs 71.3% OU<br>NS differences in other **perinatal outcomes**.<br>Some signif difference in **perineal status**:<br>*Post-secondary education:*<br>Intact perineum: 58.3% FMU vs 52.9% OU<br>Some signif difference in **instrumental vaginal birth** (x education)<br>*Post-secondary education:*<br>3.3% FMU vs 8.2% OU<br>NS difference in other maternal outcomes by educational sub-group. | High |
| 23 | Pang 2002 USA (24) | Retro-spective popu-lation-based cohort study | Birth registry data, linked with death records. 1989 – 1996 | Singleton birth 34/40+ with no recorded pregnancy-related complications (defined) N=16,726 women.<br>Secondary analysis used infants 2500g+ or 37/40+ N=16,253. | HB after 34/40 with health professional as attendant or certifier (not 'planned HB') N=5854; or | Hospital birth N=10,593. Secondary analysis N=10,347 | Neonatal death, post-neonatal death, Apgar5 <4, PPH (not defined), prolonged labour, respiratory distress. | RR for each outcome, using Cochran Mantel-Haenszel method, taking account of confounders | *Raw data only available for larger cohort (≥ 34/40 gestation) not low-risk cohort*.<br>**Neonatal death**: Signif more likely in HB<br>0.35% HB vs 0.17% OU<br>**Post-neonatal death**: NS difference<br>0.24% HB vs 0.25% OU<br>**PPH**: SIgnif higher risk for HB<br>1.24% HB vs 0.85% OU<br><br>*For births ≥ 37/40 or ≥2500g ARRs reported*:<br>**Neonatal death**:<br>Higher risk in HB (ARR 2.09[1.09-3.97])<br>**Post-neonatal death**: NS difference<br>**PPH**: | Low |

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| | | | | | attempted HB transfer-red to hospital N=279. Secondary analysis N=6052 | | | | Higher risk in HB (ARR 1.52[1.12-2.05]) | |
| 24 | Prelec 2014 Slovenia (25) | Prospec-tive observ-ational case-control study | Data from women at Ljubljana Maternity Hospital. May – August 2013 | All low risk *nulliparous,* singleton term pregnancies, normal heart beat, cephalic presentation, spontaneous labour. NICE guidelines. N=497. | MW-managed births in MLU, (promotes physiologic birth and minimises intervention). N=154 | OU births N=343 | PO: CS rate. Secondary: EFM, augmentation, SVB, PPH≥ 500mL, perineal status, transfusion, manual removal of placenta. Neonatal: resuscitation, Apgar <6, NICU, BF, birthweight. | Categorical data – chi-square. Continuous data – t-test and Mann-Whitney test. | **CS:** Signif more likely in OU<br>1.9% MLU vs 13.4% OU, p<0.001<br>**Assisted vaginal birth**: Signif more likely in OU<br>0.6% MLU vs 4.7% OU, p<0.001<br>**SVB with no perineal trauma**:<br>64.9% MLU vs 41.4% OU, p<0.001<br>**3rd/4th degree laceration:**<br>0.6% MLU vs 1.5% OU, NS<br>**PPH**: 1.3% MLU vs 5.5% OU, NS<br><br>NS differences for **neonatal outcomes** | Mod-erate |
| 25 | Ryan 2005 Australia (26) | Retro-spective cohort study | Hospital computer records. 1995 - 1996 | 3683 women. BC eligibility for all study participants. | Planned BC birth N=720 | Planned hospital labour ward (LW) N=2963 | Maternal: type of labour and birth; analgesia; perineal status; blood loss; length of labour; BF.<br>Infant: perinatal death; low Apgar; birthweight; resuscitation; BF | Categorical variables: chi-squared test and Yate's continuity correction. Continuous data: t-test. Relative risk. | **Neonatal death**:<br>0/720 BC vs 3/2963 LW, ?significance<br>**Perinatal mortality:**<br>1.4/1000 BC vs 3/1000 LW, ?significance<br>**SCN admission:** Signif lower from BC<br>5.7% BC vs 9.9% LW<br>**Mode of birth:** Signif differences<br>SVB: 88.3% BC vs 78.8% LW<br>Instrumental: 8.3% BC vs 12.5% LW<br>CS: 3.3% BC vs 8.7% LW<br>**Intact perineum:** NS difference | Low |
| 26 | Thornton 2016 USA | Retro-spective cohort | Secondary analysis of data from | 11,303 women attending BC for antenatal care, who | FMU birth centers N=8776 | Hospital birth (but after | PO: Type of birth. Secondary: PPH, BF, low Apgar, | Comparison by chi-squared tests, | **CS**: Signif lower odds in BC (both methods) 4.14% BC vs 4.99% OU | High |

| | First author. Publicat-ion date. Country | Study design | Source of data. Year/s (if avail) | Population – eligibility criteria | Inter-vention – Place of birth | Compar-ator – Place of birth | Outcome measures | Statistical analysis | Summary of results (outcomes relevant to current review highlighted) | ResQu rating |
|---|---|---|---|---|---|---|---|---|---|---|
| | (27) | study using data from prospect-ive study | American Assn of Birth Centers. 2006 – 2011 | chose hospital or BC birth. Strict exclusion criteria (described) to ensure that differences were associated with BP. | | antenatal care from MW in BC) N=2527 | composite of severe newborn outcomes | logistic and linear regression. Used two methods (1) multivariable logistic regression; (2) propensity score modelling to control for confounders. | (Did not distinguish between SVB and instrumental births) **PPH:** 6.18% BC vs 4.63% OU, NS **Neonatal composite outcome**: NS difference | |
| 27 | Van der Kooy 2011 Nether-lands (28) | Popu-lation-based cohort - 2 methods: 1) natural prospectiv e (ITT) 2) perfect guideline | Nether-lands Perinatal Registry data. 2000 – 2007 | 679,952 women with low risk pregnancies in MW care – singleton, spontaneous birth, BMI <30, no history of PPH Method 2) further excludes <37/40 or >41/40, prolonged ROM or intrauterine death at unknown time. N=602,331 | Planned HB with MW 1) N=402,91 2 2) N=363,56 8 | Planned hospital birth 1) N=219,105 2) N=190,098 OR unknown intended BP 1) N=57,935 2) N=48,665 | Combined intrapartum death, neonatal death up to 24/24, neonatal death from 1-7 days. | Compares characteristics from 2 methods (t-test). ORs and aORs. Multivariable logistic regression to measure risk by intended BP. | **Intrapartum + early neonatal mortality**: 0.15% HB vs 0.18% OU, crude RR 0.88[0.71 – 0.91]. After adjustment for maternal factors, relationship is reversed, but NS difference. In some sub-groups, higher risk for HB, i.e. small for gestational age, congenital abnormality and low Apgar scores. | High |
| 28 | Wiegerinck, 2015 Nether-lands (29) | Retro-spective cohort study | Linked admin data: National Perinatal Register + hospital and MW records. 2005 – 2008 | 83,289 women with singleton pregnancies 37/40+, planned vaginal birth without congenital abnormality or fetal death, at all risk levels. Supplementary data obtained on women with low-risk | Primary care (MW-led care with low risk) planned HB N=23,323 | Secondary care (obstet-rician-led care with low risk) planned OU birth N=10,631 PLUS primary care | PO: Perinatal mortality Secondary outcomes: maternal interventions, mode of birth, analgesia, perineal trauma, PPH, third stage complications, admission to NICU, Apgars | $X^2$, RR with 95% CI, students' t-test, comparing primary and secondary care, i.e. not by BP. Supplementary analysis contains raw values, not RR by BP. | **Stillbirth + neonatal death (<28 days):** 0.77/1000 HB vs 0.41/1000 OU **Mode of birth** SVB: 91.2% HB vs 84.7% OU CS: 1.7% HB vs 4.8% OU Instrumental: 7.2% HB vs 10.5% OU **PPH**: 3.3% HB vs 5.4% OU **Perineal trauma (3rd and 4th degree rupture):** 2.3% HB vs 2.7% OU | Mod-erate |

| | First author. Publicat-ion date. Country | Study design | Source of data. Year/s (if avail) | Population – eligibility criteria | Inter-vention – Place of birth | Compar-ator – Place of birth | Outcome measures | Statistical analysis | Summary of results (outcomes relevant to current review highlighted) | ResQu rating |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | pregnancies (defined) N=57,385. NB Risk factors not well recorded in secondary care. | | planned OU birth N=18,675. Total planned OU N=29,306 | | | | |

***Abbreviations:***
AMU=Alongside Midwifery Unit; ANOVA=analysis of variance; AOR=adjusted odds ratio; ARR=adjusted relative risk; BBA=birth before arrival (at hospital); BC=birth centre; BF=breastfeeding; BMI=Body Mass Index; BP=birth place; BPiE=Birthplace in England (Collaboration Group); CDW=conventional delivery ward; CI=confidence interval; CLU=consultant led unit; CS=Caesarean section; EFM=electronic fetal monitoring; FMU=Freestanding (stand-alone) Midwifery Unit; HB=home birth; HELLP = haemolysis, elevated liver enzymes, low platelet count; IOL=induction of labour; ITT=intention to treat; LW=labour ward; mL=millilitres; MLU=Midwifery Led Unit; MLW=Midwife Led Ward; MW=midwife; N=number in sample; NB=nota bene; NICU=Neonatal Intensive Care Unit; NICE=National Institute for Health and Care Excellence; NL=Netherlands; NND=neonatal death; NS=not significant; NU=normal unit; NZ=New Zealand; OR=odds ratio; OU=hospital (obstetric unit); PO=primary outcome; PPH=postpartum haemorrhage; PPV=positive pressure ventilation; PU=primary unit; RCOG=Royal College of Obstetricians and Gynaecologists; RCT=randomised controlled trial; ResQu=Research Quality Index (Vedam et al 2017); RR=Relative risk; SCN=special care nursery; SD=standard deviation; signif=significant; SU=special/secondary unit; SVB=spontaneous vaginal birth; TLW=traditional labour ward; TU=tertiary unit

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## *Supplementary Table S3 - Sample data extraction form*

| **META ANALYSIS: Title** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Home Birth** | | **Birth Centre** | | | **Obstetric Unit** | | **Congenital abnormalities** | **Notes** |
| **Author, year** | **Definition** | **n of events** | **N in sample** | **BC type** | **n of events** | **N in sample** | **n of events** | **N in sample** | | |
| Study A, 2000 | 1 | | | AMU | | | | | Included | |
| Study B, 2005 | 2 | | | FMU | | | | | Excluded | |
| Study C, 2010 | 3 | | | AMU | | | | | Not stated | |
| etc | | | | | | | | | | |

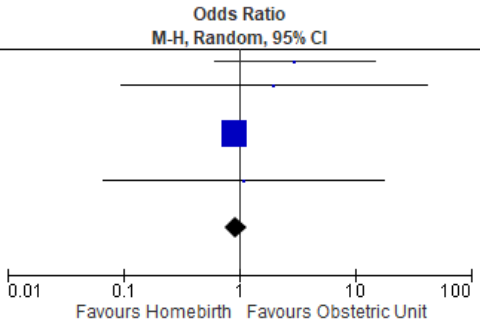
*Definitions*
1 = xxx
2 = yyy
3 = zzz

# *Supplementary Figures - Forest Plots for Meta-analysis*

## 1. Fig S1: Stillbirth HB vs OU

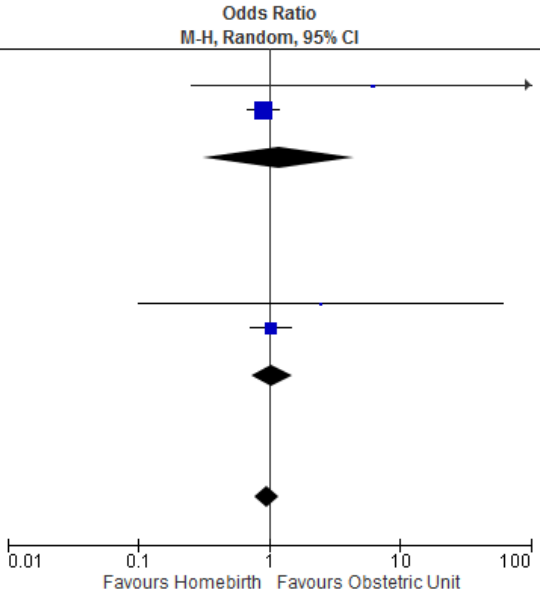
| Study or Subgroup | Homebirth Events | Homebirth Total | Obstetric Unit Events | Obstetric Unit Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Birthplace Collaboration 2011 | 6 | 15538 | 2 | 15676 | 1.8% | 3.03 [0.61, 15.00] |
| Blix 2012 | 0 | 1631 | 2 | 16310 | 0.5% | 2.00 [0.10, 41.66] |
| Davis 2011 | 0 | 1830 | 0 | 11503 | | Not estimable |
| de Jonge 2014 | 200 | 466041 | 130 | 276908 | 97.0% | 0.91 [0.73, 1.14] |
| Halfdansdottir 2015 | 0 | 307 | 0 | 921 | | Not estimable |
| Homer 2014 | 0 | 688 | 146 | 221056 | 0.6% | 1.10 [0.07, 17.61] |
| **Total (95% CI)** | | **486035** | | **542374** | **100.0%** | **0.94 [0.76, 1.17]** |
| Total events | 206 | | 280 | | | |

Heterogeneity: Tau² = 0.00; Chi² = 2.36, df = 3 (P = 0.50); I² = 0%
Test for overall effect: Z = 0.56 (P = 0.57)

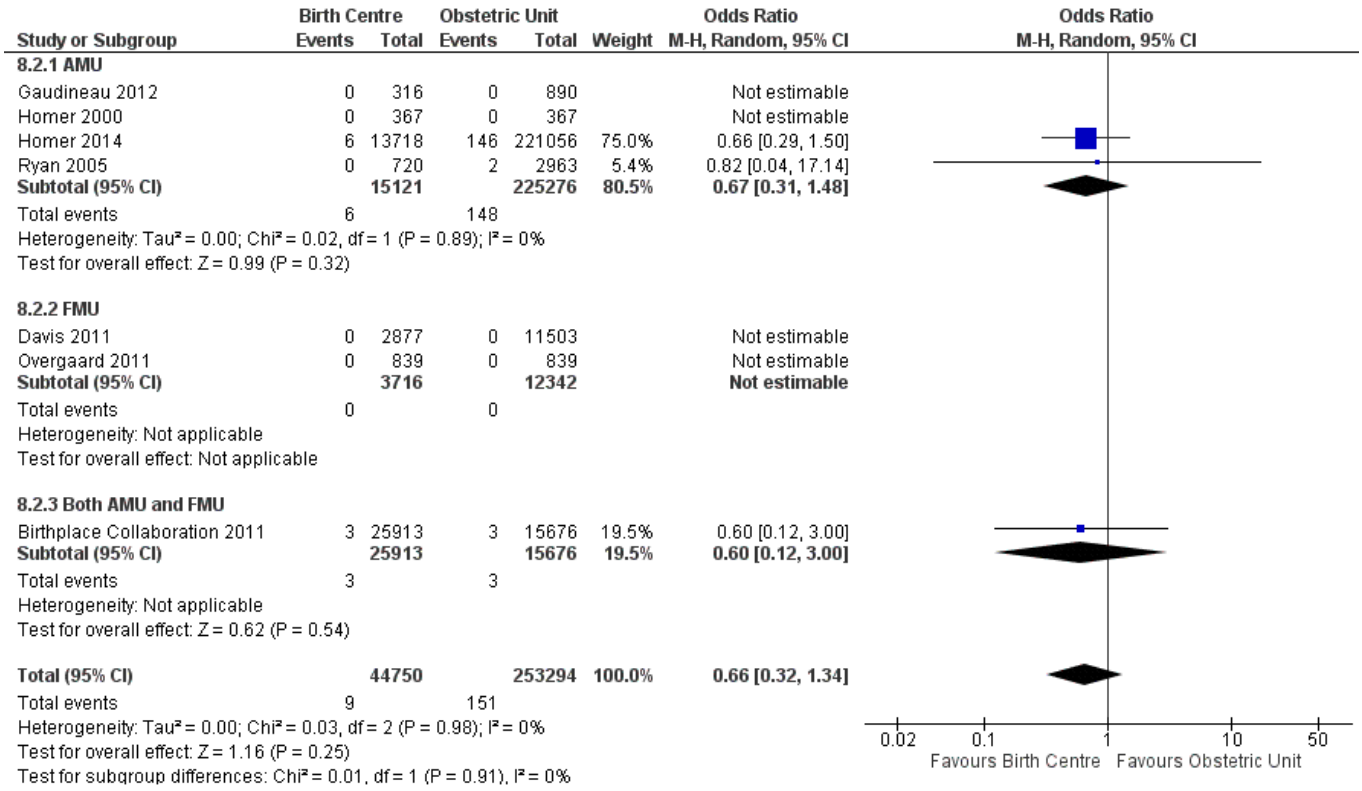



## Fig S1a: Stillbirth HB vs OU – by parity

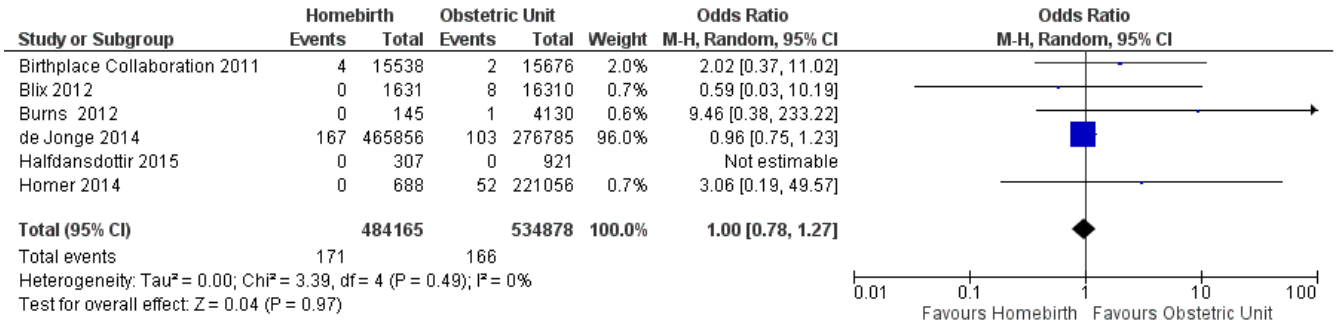
| Study or Subgroup | Homebirth Events | Homebirth Total | Obstetric Unit Events | Obstetric Unit Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| **8.5.1 Nulliparous** | | | | | | |
| Blix 2012 | 0 | 369 | 1 | 6913 | 0.5% | 6.24 [0.25, 153.34] |
| de Jonge 2014 | 113 | 198515 | 86 | 137168 | 62.0% | 0.91 [0.69, 1.20] |
| Halfdansdottir 2015 | 0 | 64 | 0 | 192 | | Not estimable |
| **Subtotal (95% CI)** | | **198948** | | **144273** | **62.4%** | **1.20 [0.32, 4.51]** |
| Total events | 113 | | 87 | | | |
| Heterogeneity: Tau² = 0.51; Chi² = 1.38, df = 1 (P = 0.24); I² = 28% | | | | | | |
| Test for overall effect: Z = 0.27 (P = 0.79) | | | | | | |
| **8.5.2 Multiparous** | | | | | | |
| Blix 2012 | 0 | 1262 | 1 | 9397 | 0.5% | 2.48 [0.10, 60.93] |
| de Jonge 2014 | 87 | 267526 | 44 | 139740 | 37.1% | 1.03 [0.72, 1.48] |
| Halfdansdottir 2015 | 0 | 243 | 0 | 729 | | Not estimable |
| **Subtotal (95% CI)** | | **269031** | | **149866** | **37.6%** | **1.04 [0.73, 1.50]** |
| Total events | 87 | | 45 | | | |
| Heterogeneity: Tau² = 0.00; Chi² = 0.28, df = 1 (P = 0.59); I² = 0% | | | | | | |
| Test for overall effect: Z = 0.24 (P = 0.81) | | | | | | |
| **Total (95% CI)** | | **467979** | | **294139** | **100.0%** | **0.97 [0.77, 1.20]** |
| Total events | 200 | | 132 | | | |
| Heterogeneity: Tau² = 0.00; Chi² = 1.96, df = 3 (P = 0.58); I² = 0% | | | | | | |
| Test for overall effect: Z = 0.31 (P = 0.76) | | | | | | |
| Test for subgroup differences: Chi² = 0.04, df = 1 (P = 0.85), I² = 0% | | | | | | |



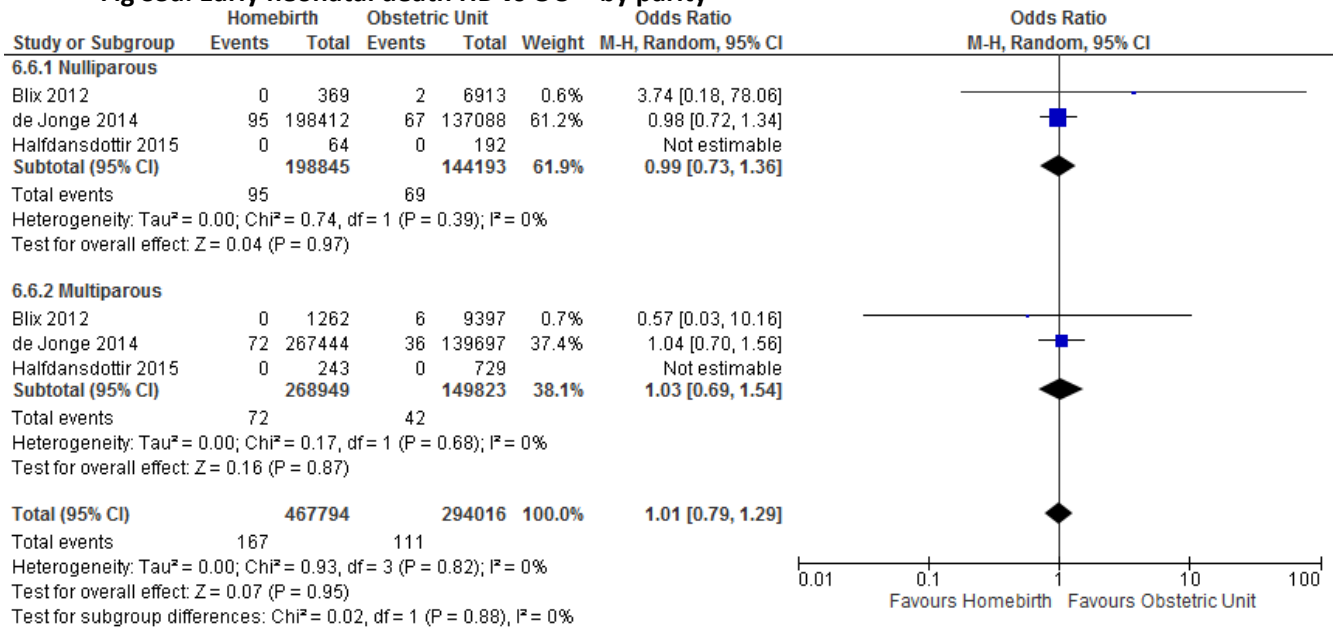
## 2. Fig S2: Stillbirth BC vs OU



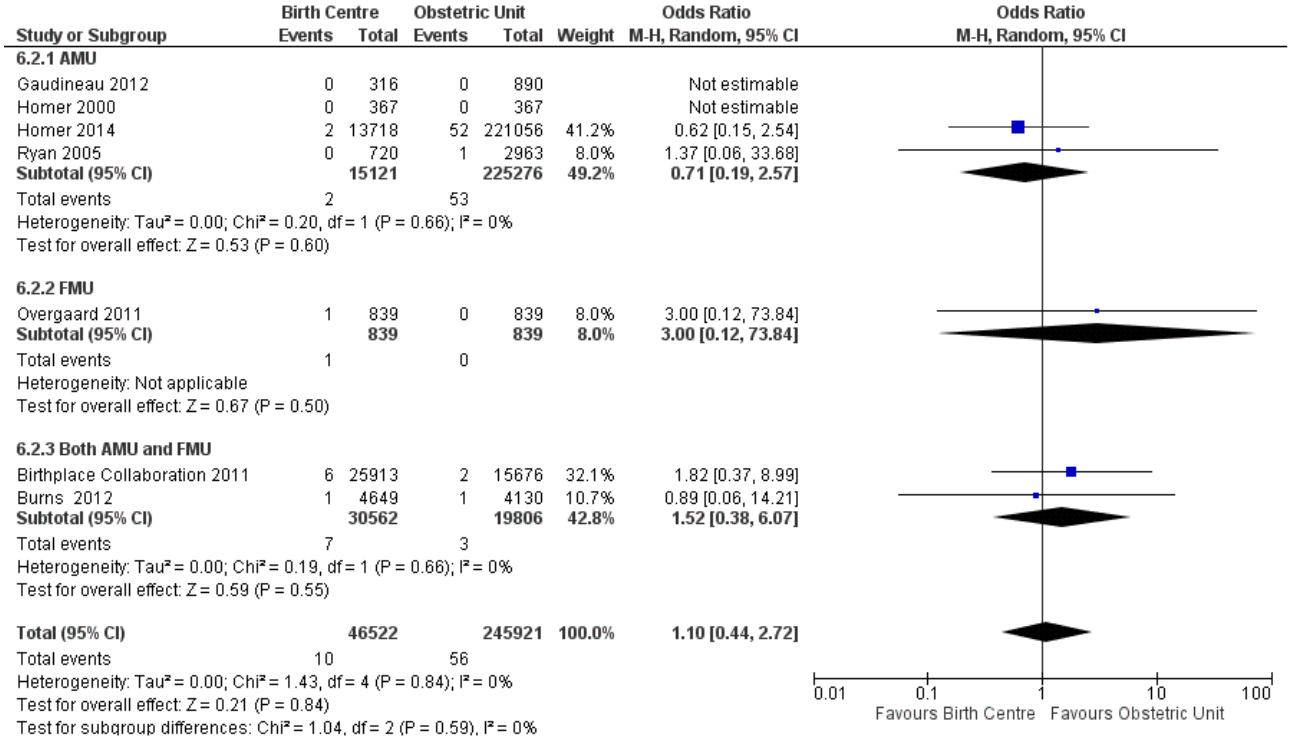
## 3. Fig S3: Early neonatal death HB vs OU



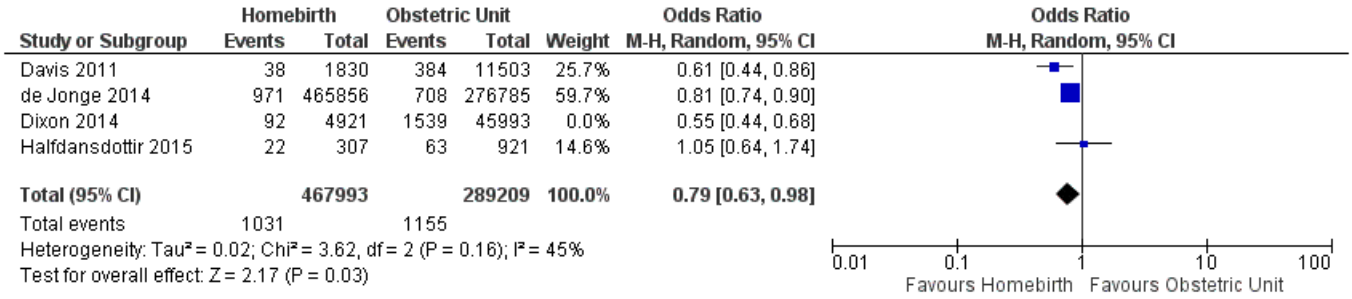

## Fig S3a: Early neonatal death HB vs OU – by parity



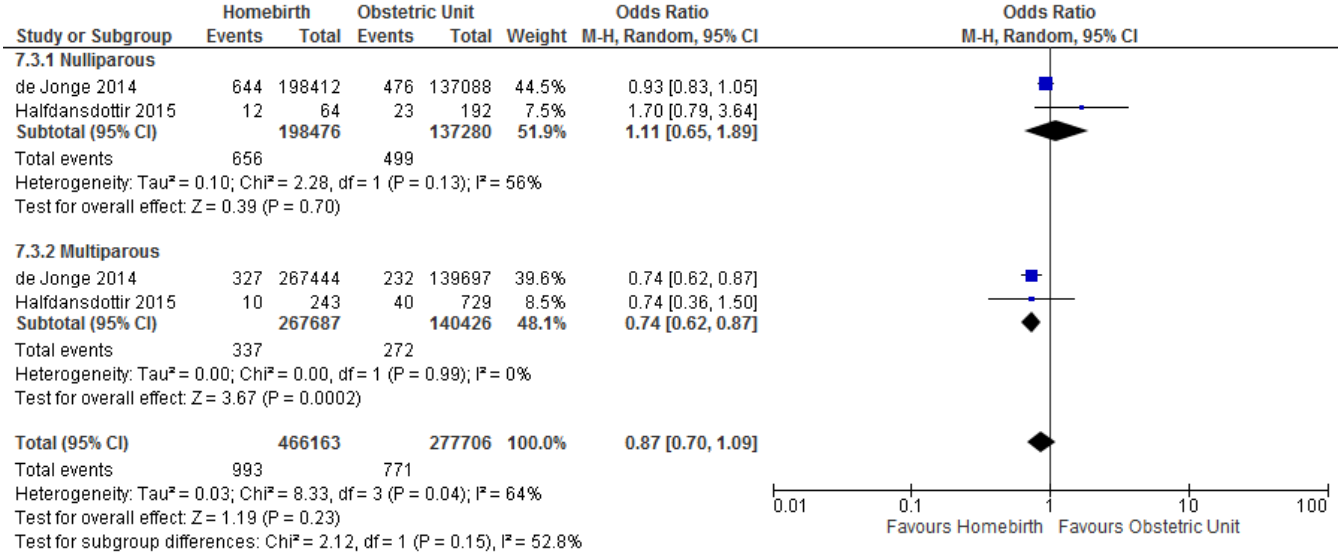

## Fig S4: Early neonatal death BC vs OU



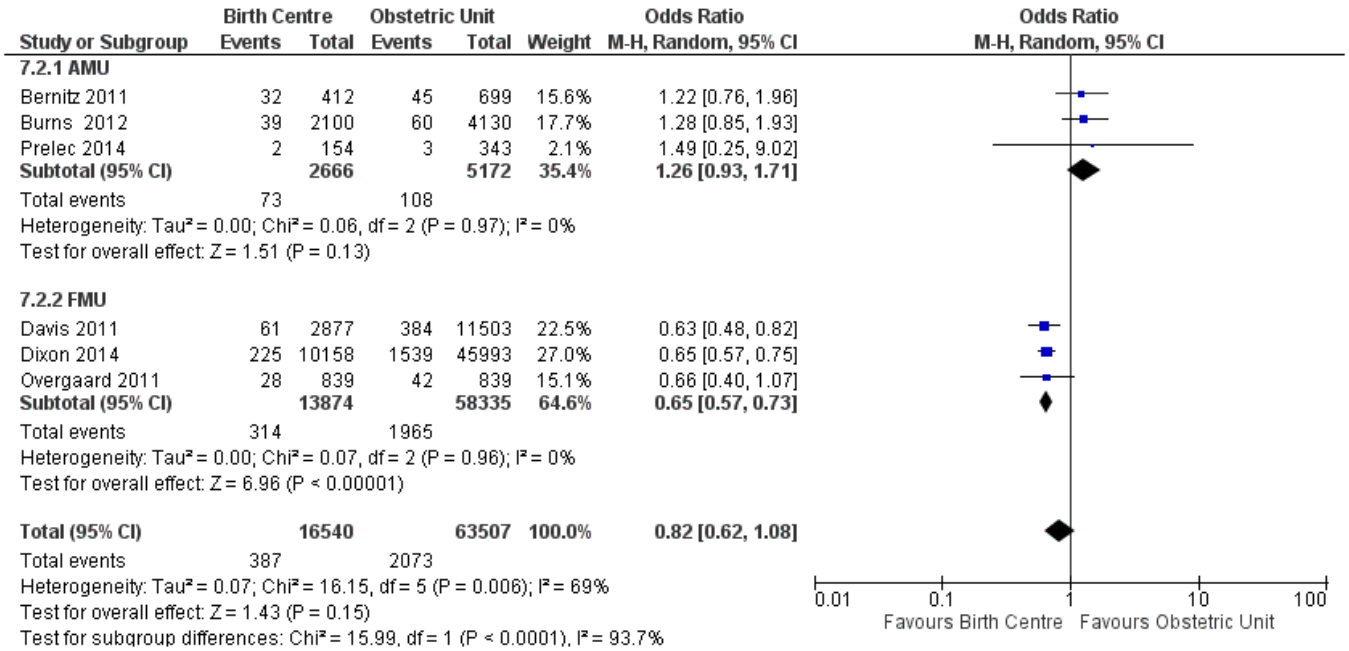
## 5. Fig S5: NICU admission HB vs OU



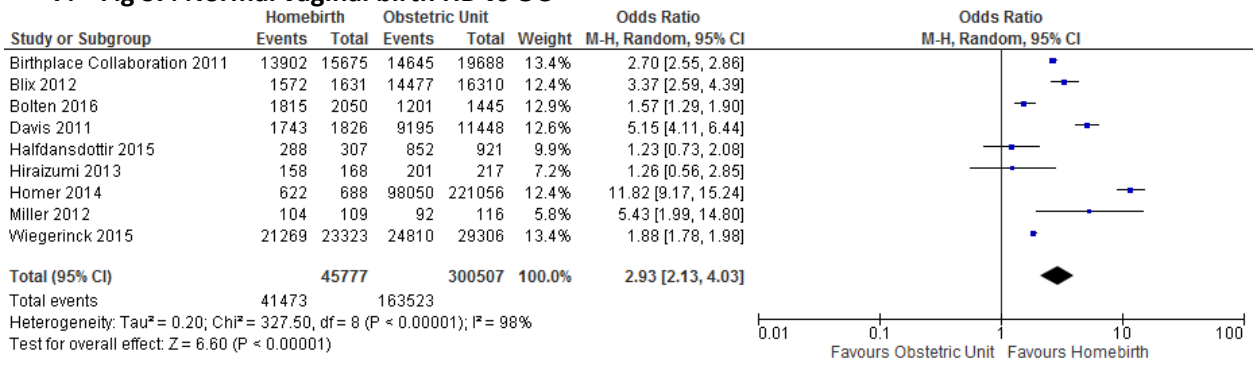

### Fig S5a: NICU admission HB vs OU – by parity




## 6. Fig S6: NICU admission BC vs OU



## 7. Fig S7: Normal vaginal birth HB vs OU

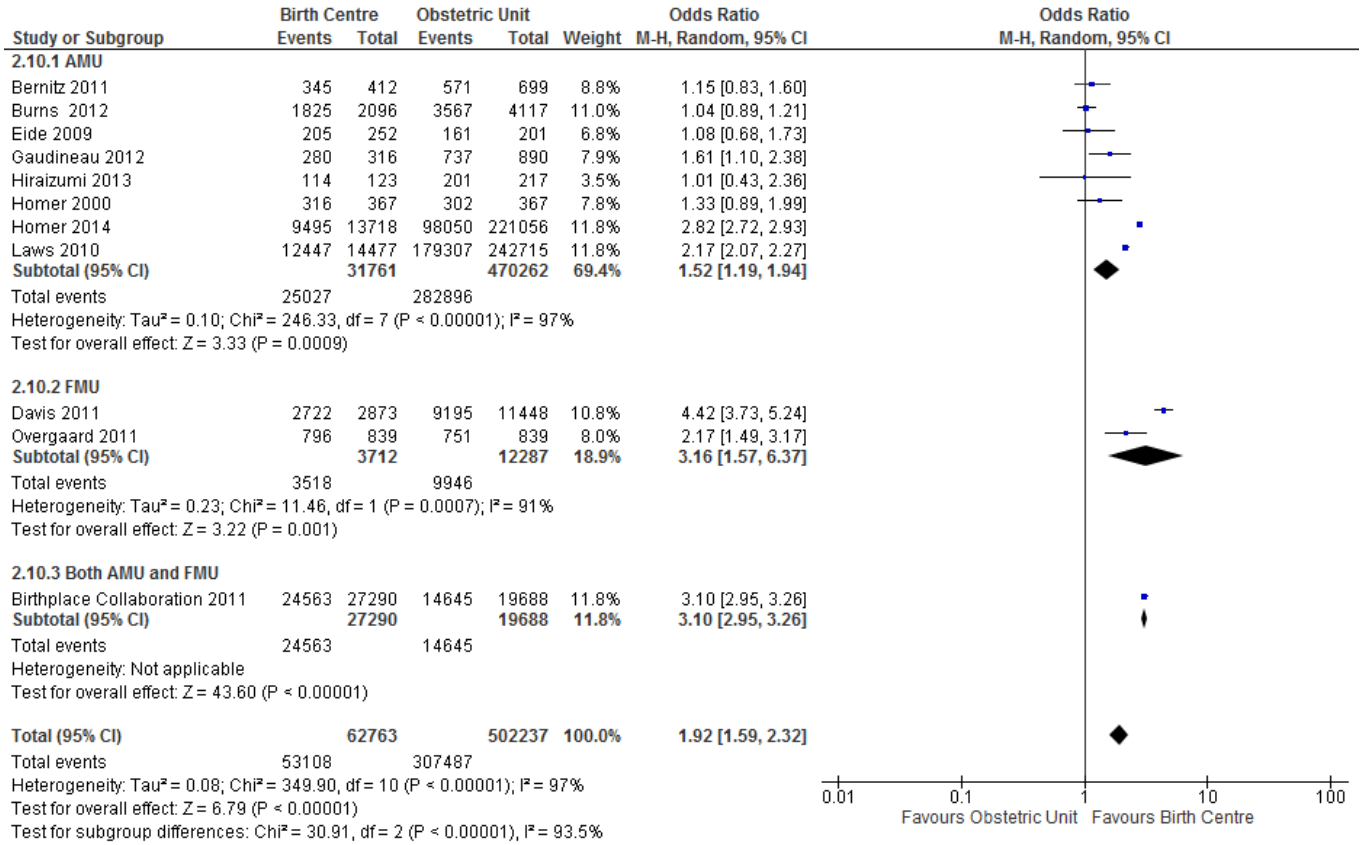


| Study or Subgroup | Homebirth Events | Total | Obstetric Unit Events | Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Birthplace Collaboration 2011 | 13902 | 15675 | 14645 | 19688 | 13.4% | 2.70 [2.55, 2.86] |
| Blix 2012 | 1572 | 1631 | 14477 | 16310 | 12.4% | 3.37 [2.59, 4.39] |
| Bolten 2016 | 1815 | 2050 | 1201 | 1445 | 12.9% | 1.57 [1.29, 1.90] |
| Davis 2011 | 1743 | 1826 | 9195 | 11448 | 12.6% | 5.15 [4.11, 6.44] |
| Halfdansdottir 2015 | 288 | 307 | 852 | 921 | 9.9% | 1.23 [0.73, 2.08] |
| Hiraizumi 2013 | 158 | 168 | 201 | 217 | 7.2% | 1.26 [0.56, 2.85] |
| Homer 2014 | 622 | 688 | 98050 | 221056 | 12.4% | 11.82 [9.17, 15.24] |
| Miller 2012 | 104 | 109 | 92 | 116 | 5.8% | 5.43 [1.99, 14.80] |
| Wiegerinck 2015 | 21269 | 23323 | 24810 | 29306 | 13.4% | 1.88 [1.78, 1.98] |
| **Total (95% CI)** | | **45777** | | **300507** | **100.0%** | **2.93 [2.13, 4.03]** |
| Total events | 41473 | | 163523 | | | |

Heterogeneity: Tau² = 0.20; Chi² = 327.50, df = 8 (P < 0.00001); I² = 98%
Test for overall effect: Z = 6.60 (P < 0.00001)

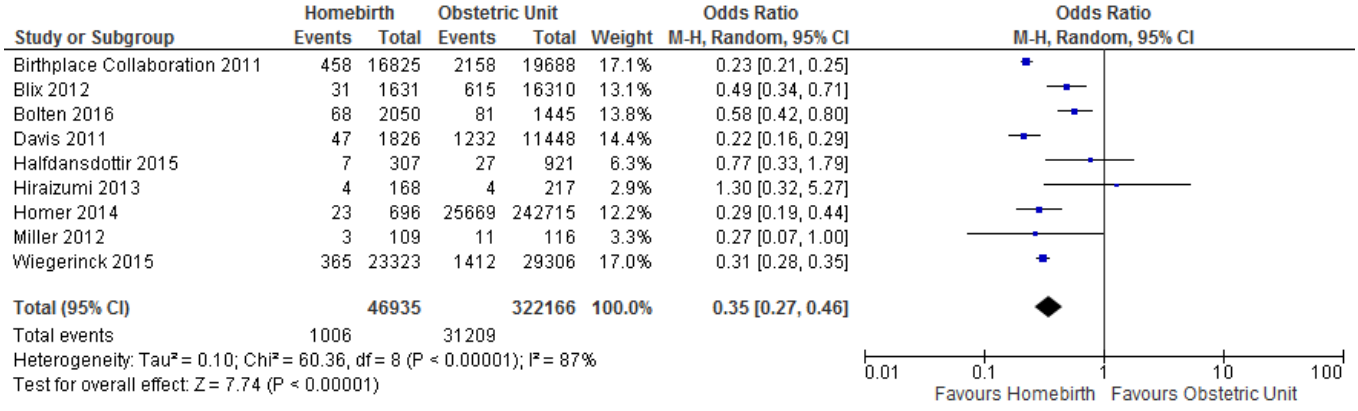


## 8. Fig S8: Normal vaginal birth BC vs OU

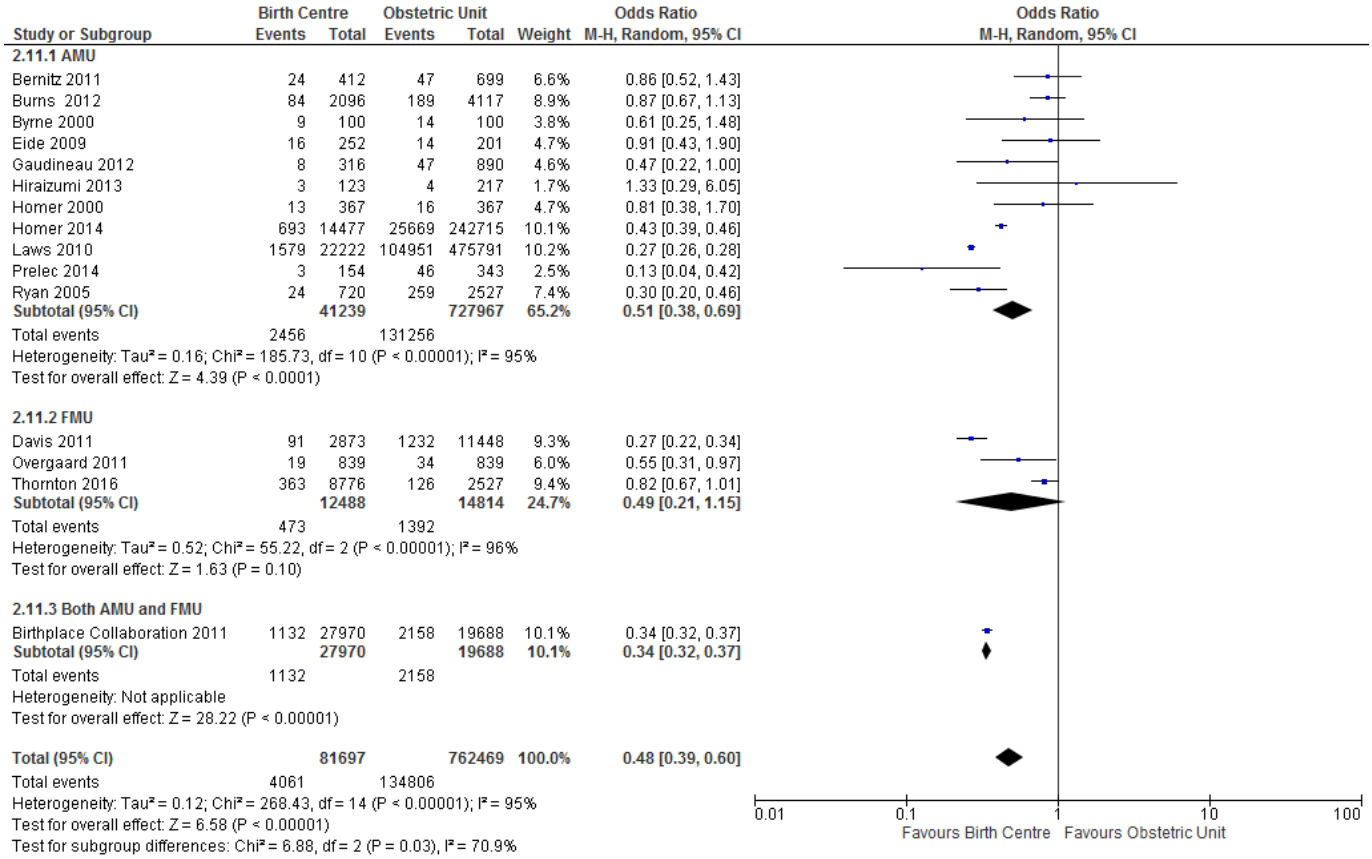


| Study or Subgroup | Birth Centre Events | Total | Obstetric Unit Events | Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| **2.10.1 AMU** | | | | | | |
| Bernitz 2011 | 345 | 412 | 571 | 699 | 8.8% | 1.15 [0.83, 1.60] |
| Burns 2012 | 1825 | 2096 | 3567 | 4117 | 11.0% | 1.04 [0.89, 1.21] |
| Eide 2009 | 205 | 252 | 161 | 201 | 6.8% | 1.08 [0.68, 1.73] |
| Gaudineau 2012 | 280 | 316 | 737 | 890 | 7.9% | 1.61 [1.10, 2.38] |
| Hiraizumi 2013 | 114 | 123 | 201 | 217 | 3.5% | 1.01 [0.43, 2.36] |
| Homer 2000 | 316 | 367 | 302 | 367 | 7.8% | 1.33 [0.89, 1.99] |
| Homer 2014 | 9495 | 13718 | 98050 | 221056 | 11.8% | 2.82 [2.72, 2.93] |
| Laws 2010 | 12447 | 14477 | 179307 | 242715 | 11.8% | 2.17 [2.07, 2.27] |
| **Subtotal (95% CI)** | | **31761** | | **470262** | **69.4%** | **1.52 [1.19, 1.94]** |
| Total events | 25027 | | 282896 | | | |
| Heterogeneity: Tau² = 0.10; Chi² = 246.33, df = 7 (P < 0.00001); I² = 97% | | | | | | |
| Test for overall effect: Z = 3.33 (P = 0.0009) | | | | | | |
| **2.10.2 FMU** | | | | | | |
| Davis 2011 | 2722 | 2873 | 9195 | 11448 | 10.8% | 4.42 [3.73, 5.24] |
| Overgaard 2011 | 796 | 839 | 751 | 839 | 8.0% | 2.17 [1.49, 3.17] |
| **Subtotal (95% CI)** | | **3712** | | **12287** | **18.9%** | **3.16 [1.57, 6.37]** |
| Total events | 3518 | | 9946 | | | |
| Heterogeneity: Tau² = 0.23; Chi² = 11.46, df = 1 (P = 0.0007); I² = 91% | | | | | | |
| Test for overall effect: Z = 3.22 (P = 0.001) | | | | | | |
| **2.10.3 Both AMU and FMU** | | | | | | |
| Birthplace Collaboration 2011 | 24563 | 27290 | 14645 | 19688 | 11.8% | 3.10 [2.95, 3.26] |
| **Subtotal (95% CI)** | | **27290** | | **19688** | **11.8%** | **3.10 [2.95, 3.26]** |
| Total events | 24563 | | 14645 | | | |
| Heterogeneity: Not applicable | | | | | | |
| Test for overall effect: Z = 43.60 (P < 0.00001) | | | | | | |
| **Total (95% CI)** | | **62763** | | **502237** | **100.0%** | **1.92 [1.59, 2.32]** |
| Total events | 53108 | | 307487 | | | |
| Heterogeneity: Tau² = 0.08; Chi² = 349.90, df = 10 (P < 0.00001); I² = 97% | | | | | | |
| Test for overall effect: Z = 6.79 (P < 0.00001) | | | | | | |
| Test for subgroup differences: Chi² = 30.91, df = 2 (P < 0.00001), I² = 93.5% | | | | | | |

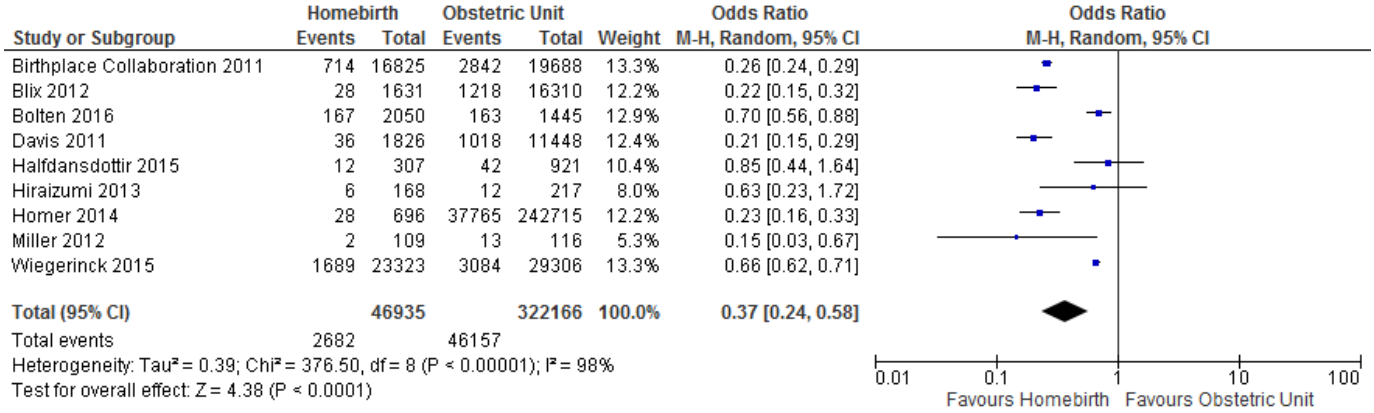
## 9. Fig S9: Caesarean section HB vs OU



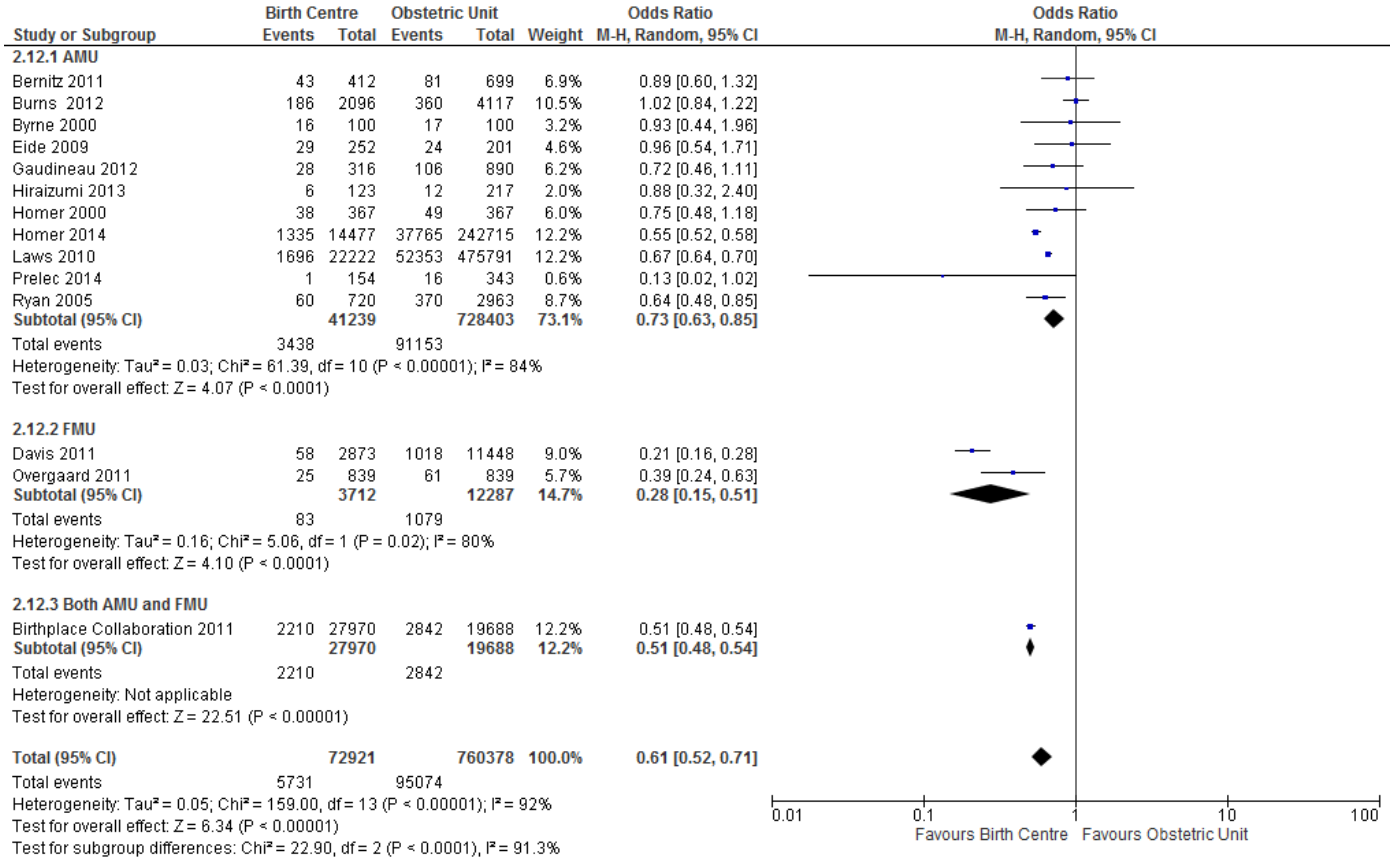

## 10. Fig S10: Caesarean section BC vs OU



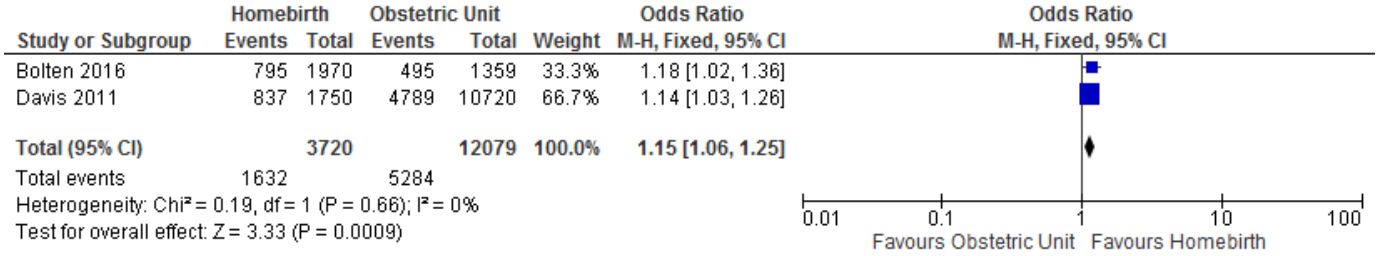
## 11. Fig S11: Instrumental vaginal birth HB vs OU



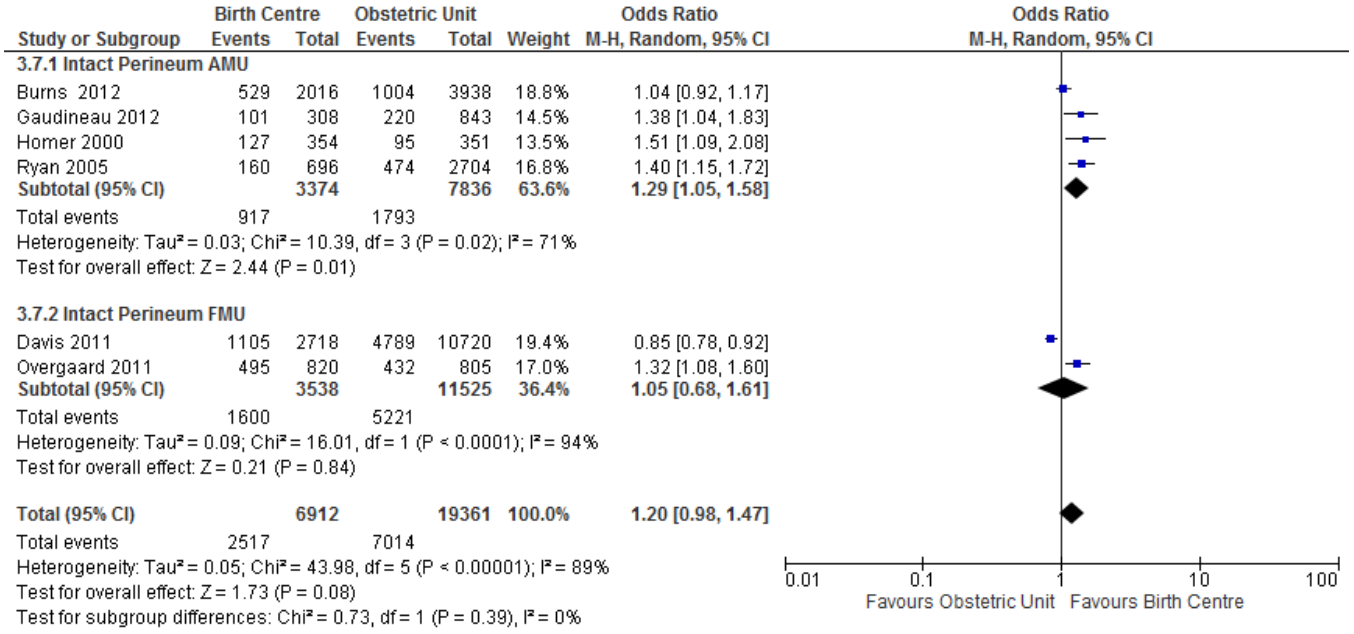

## 12. Fig S12: Instrumental vaginal birth BC vs OU



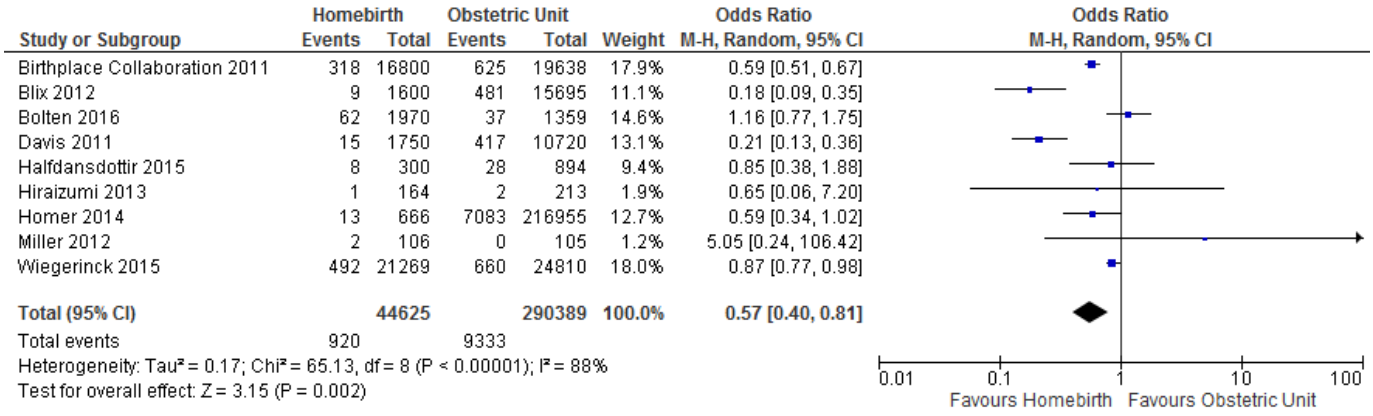
## 13. Fig S13: Intact perineum HB vs OU



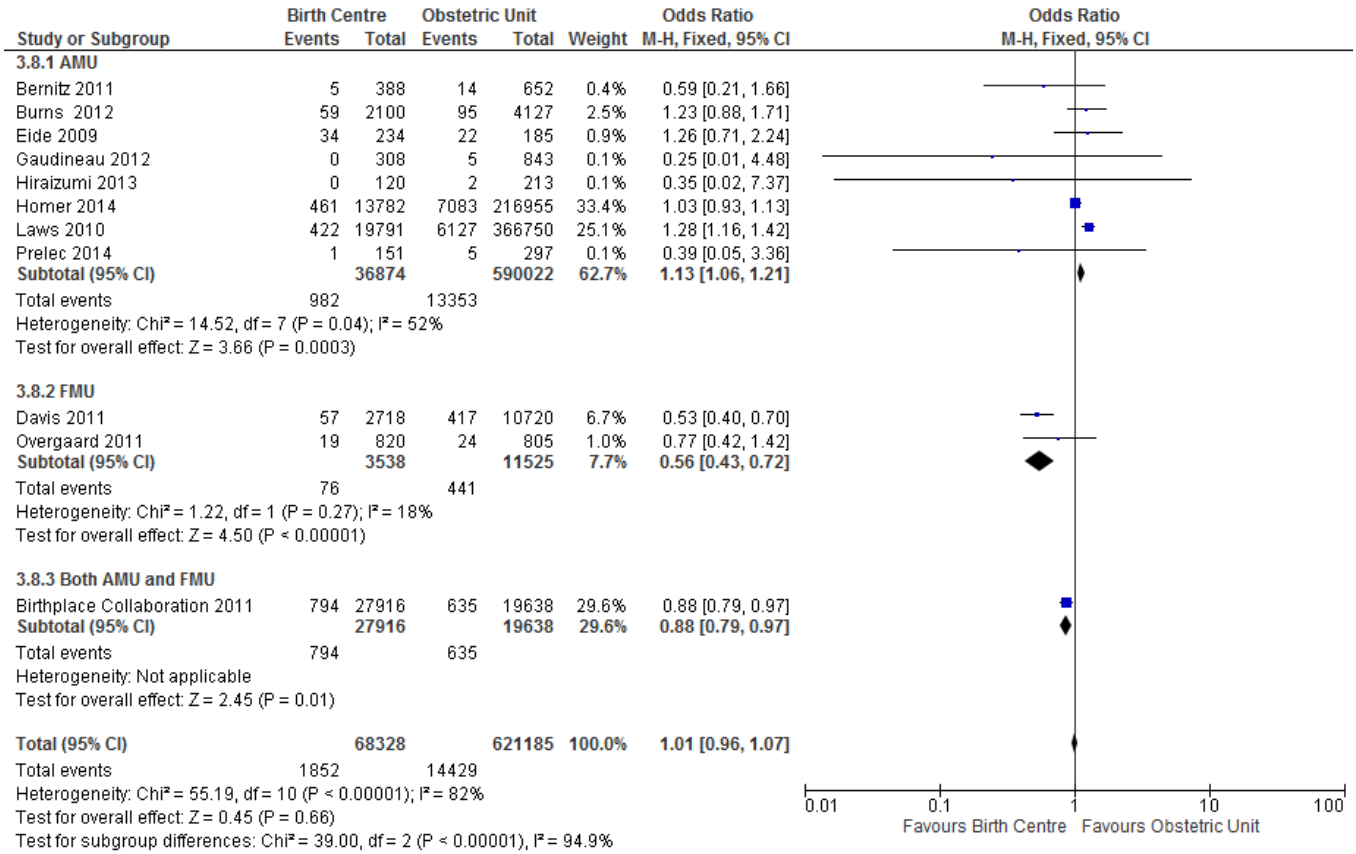

## 14. Fig S14: Intact perineum BC vs OU



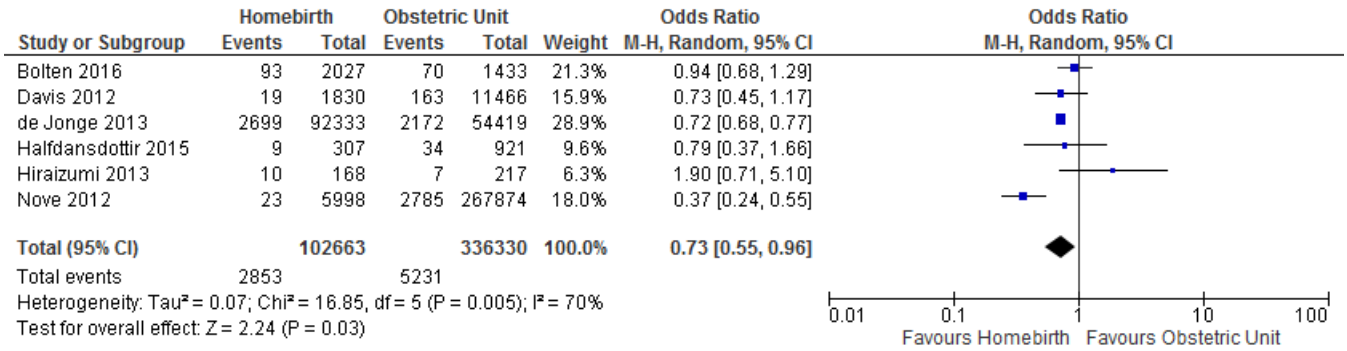
## 15. Fig S15: Severe perineal trauma HB vs OU



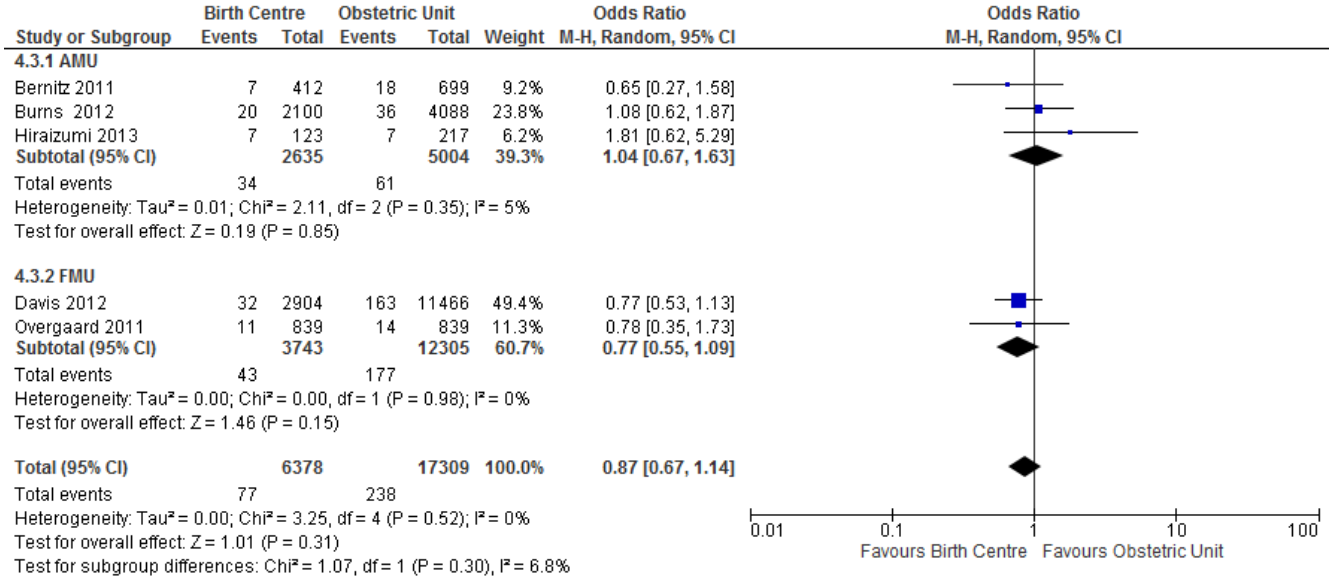

## 16. Fig S16: Severe perineal trauma BC vs OU



## 17. Fig S17: Postpartum haemorrhage (>1000mL) HB vs OU




## 18. Fig S18: Postpartum haemorrhage (>1000mL) BC vs OU



Appendix B

1. Ethics Approval HNELHD
2. Participant Information Sheet – Time and motion data collection Homebirth
3. Participant Consent Form – Homebirth
4. Participant Information Sheet – Time and motion data collection Birth Centre and/or Birth Unit
5. Participant Information Sheet – Focus Group Discussion
6. Participant Consent Form – Focus Group
7. Participant Information Sheet – Interview
8. Participant Consent Form – Interview
9. Home Birth Resource Survey
10. Hospital birth unit/birth centre data collection sheet

Professor Caroline Homer
Professor of Midwifery, Director CMCFH
Centre for Midwifery, Child and Family Health (CMCFH)
University of Technology
City Campus
PO Box 123
Sydney NSW 2077

5 March 2014

Dear Professor Homer,

**NSW Population & Health Services Research Ethics Committee**

**AU RED Reference: HREC/14/CIPHS/15**

**Cancer Institute NSW reference number: 2014/02/515**

**Project Title: Birthplace in Australia: A Population-Based Cohort Study**

Thank you for your application submitted to the NSW Population & Health Services Research Ethics Committee for single ethical and scientific review. The Committee reviewed your documentation at its meeting held on 20 February 2014 and I am pleased to inform you that full ethical approval has been granted.

The Committee commends you for embarking on such an ambitious study. The committee notes that interpreting the outcomes of this study may be challenging due to the potential unmeasured factors influencing the choice of place of birth.

***National Statement 1.1 Research Merit and Integrity***

- The Committee requested you clarify the Health Economics expertise in the investigator team.

The following documents were reviewed during the Committee's deliberation of the study:

- NSW National Ethics Application Form, v2, submission code AU/1/6E86115, dated 30 January 2014
- CHeReL Application for Data
- Study Protocol, Version 3, dated 23 October 2013
- Data Custodian Sign off Form, NSW Admitted Patient Data Collection, dated 9 December 2013
- Data Custodian Sign off Form, NSW RBDM deaths, ABS deaths, dated 6 November 2013
- Data Custodian Sign off Form, NSW Perinatal Data Collection, dated 29 November 2013
- CHeReL Letter of feasibility, dated 25 October 2013
- NSW Privacy Form
- Dear Applicant Letter

The Ethics Committee granted a waiver of the usual requirement for the consent of the individual to the use of their health information in a research project, in line with the State Privacy Commissioner's Guidelines for Research and the Health Records and Information Privacy Act 2002 (NSW)

The NSW Population & Health Services Research Ethics Committee has been accredited by the NSW Ministry of Health to provide single ethical and scientific review of research proposals conducted within the NSW public health system.

The Committee is a joint initiative of the Cancer Institute NSW and NSW Ministry of Health. The Committee has been constituted and operates in accordance with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research (2007)* and relevant legislation and guidelines.

Please note that ethical approval is valid for **5 years**, conditional on the following:

- Principal investigators will immediately report anything which might warrant a review of ethical approval of the research, including unforeseen events that might affect continued ethical acceptability.
- Proposed amendments to the research proposal or conduct of the research which may affect the ethical acceptability of the research are to be provided to the NSW Population & Health Services Research Ethics Committee for review.
- The NSW Population & Health Services Research Ethics Committee will be notified giving reasons, if the research is discontinued before the expected date of completion.
- The Principal Investigator will provide an annual progress report to the NSW Population & Health Services Research Ethics Committee and at the completion of the study.

You are reminded that this letter constitutes *'ethical approval'* only. This research project must not commence at a site until separate authorisation from the Chief Executive or delegate of that site has been obtained. It is your responsibility to forward a copy of this letter together with any approved documents as enumerated above, to all site investigators for submission to the site's Research Governance Officer. Where relevant, copies will also need to be provided to the CHeReL and the data custodian.

For further information about the NSW Population & Health Services Research Ethics Committee, please refer to our website www.cancerinstitute.org.au/research.

Should you have any queries about the ethical review of your research proposal, please contact me on 02 8374 5615 or email ethics@cancerinstitute.org.au.

The NSW Population & Health Services Research Ethics Committee wishes you well in your research endeavours.

Yours sincerely,

Production Note:
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prior to publication.

Samantha Dawes
Administration Support Officer
Cancer Institute NSW


28 February 2017

Professor Caroline Homer
Professor of Midwifery
Director of the Centre of Midwifery
Child and Family Health
University of Technology Sydney
PO Box 123
Broadway NSW 2007

Dear Professor Homer

**Re: Costing the Place of Birth in New South Wales: New knowledge to support maternity service reform (16/11/16/5.01)**

**HNEHREC Reference No: 16/11/16/5.01**
**NSW HREC Reference No: LNR/16/HNE/505**
**NSW SSA Reference No: LNRSSA/16/506**

Thank you for submitting the above study for single ethical review for a multi-centre study. This project was considered to be eligible to be reviewed as Low and Negligible risk research, and so was reviewed at an Executive Meeting of the Hunter New England Human Research Ethics Committee on **24 February 2017.** This Human Research Ethics Committee is constituted and operates in accordance with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research (2007)* (National Statement) and the *CPMP/ICH Note for Guidance on Good Clinical Practice*. Further, this Committee has been accredited by the NSW Department of Health as a lead HREC under the model for single ethical and scientific review. The Committee's Terms of Reference are available from the Hunter New England Local Health District website.

I am pleased to advise, the Hunter New England Human Research Ethics Committee has determined that the above protocol meets the requirements of the *National Statement on Ethical Conduct in Human Research* and, following acceptance of the requested clarifications and revised Protocol, participant information sheets, consent forms and home birth resource data collection by Dr Nicole Gerrand Manager, Research Ethics & Governance, under delegated authority from the Committee, grants ethical approval of the above project.

The *National Statement on Ethical Conduct in Human Research (2007),* to which the Committee is obliged to adhere, include the requirement that the Committee monitors the research protocols it has approved. Ethics Approval will be ongoing subject to the following conditions:

- A report on the progress of the above protocol is to be submitted at 12 monthly intervals, or, 2 months after the proposed closure date of the project, if this date is less than 12 months. A proforma for the annual report will be sent. Your review date is **February 2018.**

**Hunter New England Research Ethics & Governance Office**
Locked Bag No 1
New Lambton NSW 2305
Telephone: (02) 49214950
Email: HNELHD-HREC@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/ethics/Pages/Research-Ethics-and-Governance-Unit.aspx

- All variations or amendments to this protocol must be forwarded to, and approved by, the Hunter New England Human Research Ethics Committee prior to their implementation.
- A final report must be submitted at the completion of the above protocol, that is, after data analysis has been completed and a final report compiled.
- The Principal Investigator will immediately report anything which might warrant review of ethical approval of the project in the specified format, including:
  - Notify the reviewing HREC of any adverse events that have a material impact on the conduct of the research in accordance with the NHMRC Position Statement: *Monitoring and reporting of safety for clinical trials involving therapeutic products May 2009* https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e112_nhmrc_position_statement_monitoring_reporting_safety_clinical_trials.pdf
  - Unforeseen events that might affect continued ethical acceptability of the project.
- If for some reason the above protocol does not commence (for example it does not receive funding); is suspended or discontinued, please inform Dr Nicole Gerrand as soon as possible.

The following documentation has been reviewed and approved by the Hunter New England Human Research Ethics Committee:

| Document | Version | Date |
|---|---|---|
| LNR Ethics Application [Locked Code AU/6/BBD8214] | | |
| Protocol | 2 | 27 January 2017 |
| Participant Information Sheet – Focus Group Discussion | 1 | 21 December 2016 |
| Participant Consent Form – Focus Group | 1 | 27 January 2017 |
| Participant Information Sheet – Time and motion data collection Birth Centre and/or Birth Unit | 1 | 21 December 2016 |
| Participant Information Sheet – Time and motion data collection Homebirth | 1 | 21 December 2016 |
| Participant Consent Form - Homebirth | 1 | 27 January 2017 |
| Participant Information Sheet – Interview | 1 | 21 December 2106 |
| Participant Consent Form – Interview | 1 | 27 January 2017 |
| Home Birth Resource Survey | - | undated |

Approval has been granted for this study to take place at the following sites:

- **Belmont Birthing Centre**
- **John Hunter Hospital**

**You are reminded that this letter constitutes ethical approval only. You must not commence this research project at a site until separate authorisation from the Chief Executive or delegate of that site has been obtained.**

A copy of this letter must be forwarded to all site investigators for submission to the relevant Research Governance Officer.

Should you have any concerns or questions about your research, please contact Dr Gerrand as per the details at the bottom of the page. The Hunter New England Human Research Ethics Committee wishes you every success in your research.

**Hunter New England Research Ethics & Governance Office**
Locked Bag No 1
New Lambton NSW 2305
Telephone: (02) 49214950
Email: HNELHD-HREC@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/ethics/Pages/Research-Ethics-and-Governance-Unit.aspx

Please quote **16/11/16/5.01** in all correspondence.

The Hunter New England Human Research Ethics Committee wishes you every success in your research.

Yours faithfully

For: Ms M Hunter
Chair
Hunter New England Human Research Ethics Committee

**Hunter New England Research Ethics & Governance Office**
Locked Bag No 1
New Lambton NSW 2305
Telephone: (02) 49214950
Email: HNELHD-HREC@hnehealth.nsw.gov.au
http://www.hnehealth.nsw.gov.au/ethics/Pages/Research-Ethics-and-Governance-Unit.aspx

**THE UNIVERSITY OF TECHNOLOGY SYDNEY**

# Costing the place of birth in New South Wales: New knowledge to support maternity service reform

## INFORMATION FOR PARTICIPANTS- Time and motion data collection Homebirth

## Introduction

Maternity services are the third most common specialist service in public hospitals and therefore use considerable resources including workforce, goods and services. In Australia, over 300,000 babies are born each year with more than 99% of births occurring in hospital (public or private) or in a birth centre, either within or alongside a hospital. Less than 1% of mothers give birth at home.

Following the National Review of Maternity Services by the Department of Health and Aging in 2009, the National Maternity Services Plan was released in 2011 with priorities for the following five years. One of these was to "increase access for Australian women and their family members to local maternity care by expanding the range of models of care" going on to state that "continuing to provide a range of maternity care options, including homebirth, is a priority." Access to birth centres and homebirth are integral to "expanding the range of models of care". Despite this recommendation, there has been very little expansion in birth setting options. One reason given for this is a perceived increase in the cost of providing these services in a publicly funded model; however these services have never been costed on a state-wide scale.

Evidence and policy indicates that access to birth centres and homebirth should be expanded for healthy women (those without obstetric or medical risk factors) as there are benefits for women, babies and staff. *However, relative costs of providing care in these alternative settings is not known and there is a perception that birth centres and homebirth are more expensive to implement.*

This is an NHMRC funded project (APP1103015).

You are invited to take part in a research study into the cost of place of birth in New South Wales. The objective of this stage of the study is to identify the staff time and resources required to provide care in a public hospital labour ward, birth centre or at home in a publicly-funded homebirth program.

## What is the research about?

This research will estimate the cost of giving birth at home, in a birth centre or in a hospital labour ward from the perspective of the health service.

This phase of the study will collect information on the staff time and resources required to provide care in a birth centre or at home in a publicly-funded homebirth program.

## Where is the research being done?

The study is being conducted within John Hunter Hospital by

1. Vanessa Scarf, RM, PhD Candidate, University of Technology Sydney
2. Caroline Homer, Professor of Midwifery, University of Technology Sydney
3. Rosalie Viney, Professor of Health Economics, Centre for Health Economics Research and Evaluation (CHERE)
4. Maralyn Foureur, Professor of Midwifery, University of Technology Sydney
5. David Sibbritt, Professor of Epidemiology, University of Technology Sydney
6. Hannah Dahlen, Professor of Midwifery, Western Sydney University
7. Charlene Thornton, Research Fellow, Western Sydney University
8. Mandy Hunter, Clinical Midwifery Consultant, John Hunter Hospital

as part of an NHMRC Funded project.

## Who can participate in the research?

We are seeking midwives who work with women who plan to give birth in a birth centre or at home. You have been selected as you are a midwife who works in these birth settings.

## What Choice do you have?

Participation in this study is entirely voluntary. You do not have to take part in it. If you do take part, you can withdraw at any time without having to give a reason. Whatever your decision, please be assured that it will not affect your work status or employment.

## What would you be asked to do if you agree to participate?

If you agree to participate in this study, you will be asked to sign the Participant Consent Form. You will then be asked to complete one data collection form for the next five women you work with in a home setting (prospective) and the last five homebirths you have attended (retrospective), including transfer to higher level care. We ask that you complete the data collection form at the time of labour (or as close as possible). This data collection form will collect information regarding the time you spent and the resources you used during the antenatal period and in labour with each woman you attend in labour.

## What are the risks and benefits of participating?

### Risks

There are very few, if any risks. We will not be collecting any identifiable information about you or the women you work with. We ask that you provide the initials and date of birth of the baby for research verification purposes only. Identification of the hospital (in the event of a transfer) is for research purposes only; the only detail of interest is the level of hospital service and whether it is situated in a rural or metropolitan area of New South Wales. No identifying information will be kept about you. It is foreseeable that you will need to plan to set time aside to complete the survey either during the birth or as close to the birth as possible.

## Benefits

While we intend that this research study furthers knowledge of health service provision and may improve the choice for women and their families in the future, it may not be of direct benefit to you.

## Will the study cost you anything?

Participation in this study will not cost you anything.

## How will your privacy be protected?

All the information collected from you for the study will be treated confidentially, and only the researchers named above will have access to it. The study results may be presented at a conference or in a scientific publication, but individual participants will not be identifiable in such a presentation. Any identifiable information collected will be used for verification purposes only. All information will be accessed, used and stored in accordance with Commonwealth Privacy Laws and the NSW Health Records and Information Privacy Act 2002.

If you choose to withdraw from the study, the data collected by you will be retained unless you declare it to be false or misleading. Because the data you collect is about a third party, your withdrawal from the data collection process will be accepted and no further involvement will be required.

## Further Information

When you have read this information, Vanessa Scarf will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact her on 02 9514 4572 or vanessa.scarf@uts.edu.au.

Data collected at this stage of the study will be kept for the duration of the study and up to seven years following the date of completion. Following this time, the data will be disposed of securely either by permanently deleting it from the secure file server (electronic) or in a confidential waste bin (paper).

You may also be invited to participate in a focus group discussion or interview regarding the data collected.

This information statement is for you to keep.

Thank you for taking the time to read this information sheet. Please consider this invitation to be involved in the data collection phase of the Costing the Place of Birth in New South Wales Study.

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prior to publication.

Production Note:
Signature removed
prior to publication.

**Complaints about this research**

This research has been approved by the Hunter New England Human Research Ethics Committee of Hunter New England Local Health District, Reference 16/11/16/5.01. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to Dr Nicole Gerrand, Manager, Research Ethics and Governance Unit, Hunter New England Human Research Ethics Committee, Hunter New England Local Health District, Locked Bag 1, New Lambton NSW 2305, telephone (02) 49214950, email Hnehrec@hnehealth.nsw.gov.au

The conduct of this study at the John Hunter Hospital and Belmont Birth Centre has been authorised by Hunter New England Local Health District. Any person with concerns or complaints about the conduct of this study may also contact Dr Nicole Gerrand, Manager Research Ethics & Governance Unit on 4921 4950 and quote reference number LNRSSA/16/HNE/506.

**THE UNIVERSITY OF TECHNOLOGY SYDNEY**

## Costing the place of birth in New South Wales: New knowledge to support maternity service reform

### PARTICIPANT CONSENT FORM – Homebirth

I, .....[name] of

……..... [address]

have read and understand that the study will be conducted as described in the Information Statement, a copy of which I have retained.

I have been made aware of the procedures involved in the study, including any known or expected inconvenience, risk, discomfort or potential side effect and of their implications as far as they are currently known by the researchers.

I agree to participate in this study and understand that I can withdraw at any time without providing a reason.

I understand that my personal information will remain confidential to the researchers.

I have had the opportunity to have questions answered to my satisfaction.

I hereby agree to participate in this research study.

**NAME:** _____

**SIGNATURE:** _____

**DATE:** _____

**Declaration by person conducting the consent process**

I, the undersigned, have fully explained this research to the patient named above.

**NAME:** _____

**SIGNATURE:** _____

**DATE:** _____

**THE UNIVERSITY OF TECHNOLOGY SYDNEY**

# Costing the place of birth in New South Wales: New knowledge to support maternity service reform

## INFORMATION FOR PARTICIPANTS- Time and motion data collection Birth Centre and/or Birth Unit

### Introduction

Maternity services are the third most common specialist service in public hospitals and therefore use considerable resources including workforce, goods and services. In Australia, over 300,000 babies are born each year with more than 99% of births occurring in hospital (public or private) or in a birth centre, either within or alongside a hospital. Less than 1% of mothers give birth at home.

Following the National Review of Maternity Services by the Department of Health and Aging in 2009, the National Maternity Services Plan was released in 2011 with priorities for the following five years. One of these was to "increase access for Australian women and their family members to local maternity care by expanding the range of models of care" going on to state that "continuing to provide a range of maternity care options, including homebirth, is a priority." Access to birth centres and homebirth are integral to "expanding the range of models of care". Despite this recommendation, there has been very little expansion in birth setting options. One reason given for this is a perceived increase in the cost of providing these services in a publicly funded model; however these services have never been costed on a state-wide scale.

Evidence and policy indicates that access to birth centres and homebirth should be expanded for healthy women (those without obstetric or medical risk factors) as there are benefits for women, babies and staff. *However, relative costs of providing care in these alternative settings is not known and there is a perception that birth centres and homebirth are more expensive to implement.*

This is an NHMRC funded project (APP1103015).

You are invited to take part in a research study into the cost of place of birth in New South Wales. The objective of this stage of the study is to identify the staff time and resources required to provide care in a public hospital labour ward, birth centre or at home in a publicly-funded homebirth program.

### What is the research about?

This research will estimate the cost of giving birth at home, in a birth centre or in a hospital birth unit from the perspective of the health service.

This phase of the study will collect information on the staff time and resources required to provide care in a birth centre or birth unit at John Hunter Hospital through observational data collection.

## Where is the research being done?

The study is being conducted within John Hunter Hospital by

1. Vanessa Scarf, RM, PhD Candidate, University of Technology Sydney
2. Caroline Homer, Professor of Midwifery, University of Technology Sydney
3. Rosalie Viney, Professor of Health Economics, Centre for Health Economics Research and Evaluation (CHERE)
4. Maralyn Foureur, Professor of Midwifery, University of Technology Sydney
5. David Sibbritt, Professor of Epidemiology, University of Technology Sydney
6. Hannah Dahlen, Professor of Midwifery, Western Sydney University
7. Charlene Thornton, Research Fellow, Western Sydney University
8. Mandy Hunter, Clinical Midwifery Consultant, John Hunter Hospital

as part of an NHMRC Funded project.

## How will the observational data be collected?

Data will be collected on women attending birth centre and hospital care through real-time observations: a researcher will be placed in the setting (birth centre or hospital birth unit) and time and motion data collection will be carried out as described below:

- Labour care will be observed by a research assistant positioned in the delivery suite (but not inside the room)
- Observational data will consist of time spent with the labouring women (midwife and doctor), number of staff attending the women, equipment used and procedures performed and length of stay in the birth unit
- Observations will be carried out in the birth centre and the hospital birth unit
- A specifically developed data collection sheet will be drafted for this purpose

## What are the risks and benefits of participating?

### Risks

There are very few, if any risks. We will not be collecting any identifiable information about you or the women you work with. We ask that you provide the initials and date of birth of the baby for research verification purposes only. Identification of the hospital (in the event of a transfer) is for research purposes only; the only detail of interest is the level of hospital service and whether it is situated in a rural or metropolitan area of New South Wales. No identifying information will be kept about you. It is foreseeable that you will need to plan to set time aside to complete the survey either during the birth or as close to the birth as possible.

### Benefits

While we intend that this research study furthers knowledge of health service provision and may improve the choice for women and their families in the future, it may not be of direct benefit to you.

## Will the study cost you anything?

Participation in this study will not cost you anything.

## How will your privacy be protected?

All the information collected from you for the study will be treated confidentially, and only the researchers named above will have access to it. The study results may be presented at a conference or in a scientific publication, but individual participants will not be identifiable in such a presentation. Any identifiable information collected will be used for verification purposes only. All information will be accessed, used and stored in accordance with Commonwealth Privacy Laws and the NSW Health Records and Information Privacy Act 2002.

If you choose to withdraw from the study, the data collected by you will be retained unless you declare it to be false or misleading. Because the data you collect is about a third party, your withdrawal from the data collection process will be accepted and no further involvement will be required.

## Further Information

When you have read this information, Vanessa Scarf will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact her on 02 9514 4572 or vanessa.scarf@uts.edu.au.

Data collected at this stage of the study will be kept for the duration of the study and up to seven years following the date of completion. Following this time, the data will be disposed of securely either by permanently deleting it from the secure file server (electronic) or in a confidential waste bin (paper).

You may also be invited to participate in a focus group discussion or interview regarding the data collected.

This information statement is for you to keep.

Thank you for taking the time to read this information sheet. Please consider this invitation to be involved in the data collection phase of the Costing the Place of Birth in New South Wales Study.

Production Note:
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**Professor Caroline Homer**

Production Note:
Signature removed prior to publication.

**Vanessa Scarf (PhD Candidate)**

**Complaints about this research**

This research has been approved by the Hunter New England Human Research Ethics Committee of Hunter New England Local Health District, Reference 16/11/16/5.01
Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the

researcher, or, if an independent person is preferred, to Dr Nicole Gerrand, Manager, Research Ethics and Governance Unit, Hunter New England Human Research Ethics Committee, Hunter New England Local Health District, Locked Bag 1, New Lambton NSW 2305, telephone (02) 49214950, email Hnehrec@hnehealth.nsw.gov.au

The conduct of this study at the John Hunter Hospital and Belmont Birth Centre has been authorised by Hunter New England Local Health District. Any person with concerns or complaints about the conduct of this study may also contact Dr Nicole Gerrand, Manager Research Ethics & Governance Unit on 4921 4950 and quote reference number [insert SSA reference number]"

**THE UNIVERSITY OF TECHNOLOGY SYDNEY**

# Costing the place of birth in New South Wales: New knowledge to support maternity service reform

## INFORMATION FOR PARTICIPANTS- Focus Group discussion

## Introduction

Maternity services are the third most common specialist service in public hospitals and therefore use considerable resources including workforce, goods and services. In Australia, over 300,000 babies are born each year with more than 99% of births occurring in hospital (public or private) or in a birth centre, either within or alongside a hospital. Less than 1% of mothers give birth at home.

Following the National Review of Maternity Services by the Department of Health and Aging in 2009, the National Maternity Services Plan was released in 2011 with priorities for the following five years. One of these was to "increase access for Australian women and their family members to local maternity care by expanding the range of models of care" going on to state that "continuing to provide a range of maternity care options, including homebirth, is a priority." Access to birth centres and homebirth are integral to "expanding the range of models of care". Despite this recommendation, there has been very little expansion in birth setting options. One reason given for this is a perceived increase in the cost of providing these services in a publicly funded model; however these services have never been costed on a state-wide scale.

Evidence and policy indicates that access to birth centres and homebirth should be expanded for healthy women (those without obstetric or medical risk factors) as there are benefits for women, babies and staff. *However, relative costs of providing care in these alternative settings is not known and there is a perception that birth centres and homebirth are more expensive to implement.*

This is an NHMRC funded project (APP1103015).

You are invited to take part in a research study into the cost of place of birth in New South Wales. The objective of this stage of the study is to identify the staff time and resources required to provide care in a public hospital labour ward, birth centre or at home in a publicly-funded homebirth program.

## What is the research about?

This research will estimate the cost of giving birth at home, in a birth centre or in a hospital labour ward from the perspective of the health service.

This phase of the study will collect information on the staff time and resources required to provide care in a birth centre or at home in a publicly-funded homebirth program.

## Where is the research being done?

The study is being conducted within John Hunter Hospital by

1. Vanessa Scarf, RM, PhD Candidate, University of Technology Sydney
2. Caroline Homer, Professor of Midwifery, University of Technology Sydney
3. Rosalie Viney, Professor of Health Economics, Centre for Health Economics Research and Evaluation (CHERE)
4. Maralyn Foureur, Professor of Midwifery, University of Technology Sydney
5. David Sibbritt, Professor of Epidemiology, University of Technology Sydney
6. Hannah Dahlen, Professor of Midwifery, Western Sydney University
7. Charlene Thornton, Research Fellow, Western Sydney University
8. Mandy Hunter, Clinical Midwifery Consultant, John Hunter Hospital

as part of an NHMRC Funded project.

## Who can participate in the research?

We are seeking midwives who work with women who plan to give birth in a birth centre or at home. You have been selected as you are a midwife who works in these birth settings.

## What Choice do you have?

Participation in this study is entirely voluntary. You do not have to take part in it. If you do take part, you can withdraw at any time without having to give a reason. Whatever your decision, please be assured that it will not affect your work status or employment.

## What would you be asked to do if you agree to participate?

If you agree to participate in this study, you will be asked to sign the Participant Consent Form. You will then be asked to attend a focus group discussion regarding the data collected relating to the time and resources used to provide birthing services to women in a in a hospital labour ward, a birth centre or at home in a publicly-funded homebirth service.

## What are the risks and benefits of participating?

### Risks

There are very few, if any risks. We will not be collecting any identifiable information about you or the women you work with, however we will need to identify you during the focus group in the event that there needs to be clarification during the analysis of the transcript. Your name will be de-identified. Every effort will be made to set a time that is convenient to you to attend the focus group, however we may ask you to consider attending outside work time.

## Benefits

While we intend that this research study furthers knowledge of health service provision and may improve the choice for women and their families in the future, it may not be of direct benefit to you.

## Will the study cost you anything?

Participation in this study will not cost you anything.

## How will your privacy be protected?

All the information collected from you for the study will be treated confidentially, and only the researchers named above will have access to it. The study results may be presented at a conference or in a scientific publication, but individual participants will not be identifiable in such a presentation. Any identifiable information collected will be used for verification purposes only. All information will be accessed, used and stored in accordance with Commonwealth Privacy Laws and the NSW Health Records and Information Privacy Act 2002.

## Withdrawal

If you choose to withdraw from the study, the data collected by you will be retained unless you declare it to be false or misleading. Your withdrawal from the data collection process will be accepted and no further involvement will be required.

## Further Information

When you have read this information, Vanessa Scarf will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact her on 02 9514 4572 or vanessa.scarf@uts.edu.au.

## Data Retention

Data collected at this stage of the study will be kept for the duration of the study and up to seven years following the date of completion. Following this time, the data will be disposed of securely either by permanently deleting it from the secure file server (electronic) or in a confidential waste bin (paper).

This information statement is for you to keep.

Thank you for taking the time to read this information sheet. Please consider this invitation to be involved in the data collection phase of the Costing the Place of Birth in New South Wales Study.

Production Note:
Signature removed
prior to publication.

**Professor Caroline Homer**

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Signature removed
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**Vanessa Scarf (PhD Candidate)**

## Complaints about this research

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## THE UNIVERSITY OF TECHNOLOGY SYDNEY

### Costing the place of birth in New South Wales: New knowledge to support maternity service reform

### PARTICIPANT CONSENT FORM – Focus Group

I, .....[name] of

……..... [address]

have read and understand that the study will be conducted as described in the Information Statement, a copy of which I have retained.

I have been made aware of the procedures involved in the study, including any known or expected inconvenience, risk, discomfort or potential side effect and of their implications as far as they are currently known by the researchers.

I understand that the focus group will be recorded, and I agree to this.

I agree to participate in this study and understand that I can withdraw at any time without providing a reason.

I understand that my personal information will remain confidential to the researchers.

I have had the opportunity to have questions answered to my satisfaction.

I hereby agree to participate in this research study.

**NAME:** _____

**SIGNATURE:** _____

**DATE:** _____

**Declaration by person conducting the consent process**

I, the undersigned, have fully explained this research to the patient named above.

**NAME:** _____

**SIGNATURE:** _____

**DATE:** _____

# THE UNIVERSITY OF TECHNOLOGY SYDNEY

## Costing the place of birth in New South Wales: New knowledge to support maternity service reform

## INFORMATION FOR PARTICIPANTS- Interview

### Introduction

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Evidence and policy indicates that access to birth centres and homebirth should be expanded for healthy women (those without obstetric or medical risk factors) as there are benefits for women, babies and staff. *However, relative costs of providing care in these alternative settings is not known and there is a perception that birth centres and homebirth are more expensive to implement.*

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7. Charlene Thornton, Research Fellow, Western Sydney University
8. Mandy Hunter, Clinical Midwifery Consultant, John Hunter Hospital

as part of an NHMRC Funded project.

## Who can participate in the research?

We are seeking managers and clinical midwifery consultants who work in health facilities which offer settings for birth other than a standard labour ward. You have been selected as you are a manager/CMC who works in a facility such as this.

## What Choice do you have?

Participation in this study is entirely voluntary. You do not have to take part in it. If you do take part, you can withdraw at any time without having to give a reason. Whatever your decision, please be assured that it will not affect your work status or employment.

## What would you be asked to do if you agree to participate?

If you agree to participate in this study, you will be asked to sign the Participant Consent Form. You will then be asked to attend an interview with Vanessa Scarf regarding the operational, resource use and cost considerations associated with providing birthing services to women in different birth settings.

## What are the risks and benefits of participating?

### Risks

There are very few, if any risks. We will not be collecting any identifiable information about you or the staff you work with. The interview will be recorded and your name will be de-identified. You can ask for the recording to be stopped and edited at any time during the interview. You will have the opportunity to review and make corrections of the transcript of the interview as necessary on request.

## Benefits

While we intend that this research study furthers knowledge of health service provision and may improve the choice for women and their families in the future, it may not be of direct benefit to you.

## Will the study cost you anything?

Participation in this study will not cost you anything.

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Production Note:
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**Professor Caroline Homer**

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**Vanessa Scarf (PhD Candidate)**

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**THE UNIVERSITY OF TECHNOLOGY SYDNEY**

## Costing the place of birth in New South Wales: New knowledge to support maternity service reform

### PARTICIPANT CONSENT FORM – Interview

I, .....[name] of

……..... [address]

have read and understand that the study will be conducted as described in the Information Statement, a copy of which I have retained.

I have been made aware of the procedures involved in the study, including any known or expected inconvenience, risk, discomfort or potential side effect and of their implications as far as they are currently known by the researchers.

I understand that the interview will be recorded, and I agree to this.

I agree to participate in this study and understand that I can withdraw at any time without providing a reason.

I understand that my personal information will remain confidential to the researchers.

I have had the opportunity to have questions answered to my satisfaction.

I hereby agree to participate in this research study.

**NAME:** _____

**SIGNATURE:** _____

**DATE:** _____

**Declaration by person conducting the consent process**

I, the undersigned, have fully explained this research to the patient named above.

**NAME:** _____

**SIGNATURE:** _____

**DATE:** _____

*Woman's initials _____ *Baby's DOB _____

## Home Birth Resource Survey

The aim of this data collection is to estimate the cost of providing care to women who choose a home birth. This survey will be distributed to Privately Practising and Publicly Funded Midwives.

**Antenatal:**

1. How many antenatal consultations did you have with this woman? _____
2. What was the average duration of these visits (mins)? _____
3. How many of these consultations were attended a) in the woman's home? _____
   b) in your clinic? _____
4. How far did you travel to attend each antenatal visit with this woman? _____ Mins

**Labour Care:**

5. What contact did you have with this woman regarding her labour but prior to attending her at home for the duration of the labour?
   - Phone Y/ N Number of calls _____
   - Home visit Y / N Duration _____
6. How long did you attend this home birth? _____Hrs/Mins
7. Did a second midwife attend this home birth? Y / N For how long? _____
8. How far did you travel to attend this home birth? _____Mins
9. How far did the second midwife travel to this birth (if applicable)? _____ Mins
10. Please indicate in the **table below** the equipment you took to and used at this home birth

| **Equipment** | **Used at this birth (number)** |
|---|---|
| Delivery Set (list contents): | |
| | |
| Cord clamp/s | |
| Scissors | |
| Suture set | |
| Suture material | |
| Local anaesthetic | |
| Syringes | |
| Needles | |
| Cannula | |
| IV giving set | |
| "Blueys" | |
| Pads | |
| Swabs | |
| Syntocinon | |
| Syntometrine/ ergot | |
| Birth pool / liner / pump | |
| Oxygen cylinder | |
| Sterile water for injection | |
| Konakion | |
| Indwelling catheter | |
| | |
| | |

12. Was this woman transferred to hospital? Y / N
13. If so, how did she and her family travel to the hospital?_____
14. How long did you stay at the hospital? _____Hrs/Mins
15. How far did you travel home from the hospital? _____ mins
16. How much time was spent on administration/paperwork tasks for this woman? _____Hrs

* For research verification purposes only.

| ID: | | | | | Date: | | Time: | | Parity: | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MW1 | MW2 | MW3 | MW4 | O&G Res | O&G Reg | O&G Cons | O&G Unknown | MO Neo | MO Anaes | NICU nurse | Neo Nurse Practitioner | | |
| 00:00 | | | | | | | | | | | | | | |
| 01:00 | | | | | | | | | | | | | | |
| 02:00 | | | | | | | | | | | | | | |
| 03:00 | | | | | | | | | | | | | | |
| 04:00 | | | | | | | | | | | | | | |
| 05:00 | | | | | | | | | | | | | | |
| 06:00 | | | | | | | | | | | | | | |
| 07:00 | | | | | | | | | | | | | | |
| 08:00 | | | | | | | | | | | | | | |
| 09:00 | | | | | | | | | | | | | | |
| 10:00 | | | | | | | | | | | | | | |
| 11:00 | | | | | | | | | | | | | | |
| 12:00 | | | | | | | | | | | | | | |
| 13:00 | | | | | | | | | | | | | | |
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| 19:00 | | | | | | | | | | | | | | |
| 20:00 | | | | | | | | | | | | | | |
| 21:00 | | | | | | | | | | | | | | |
| 22:00 | | | | | | | | | | | | | | |
| 23:00 | | | | | | | | | | | | | | |

Mark time in 15 minute sections. Please mark the time of birth with an X and continue to log midwifery time. Please mark the time of TF to home/PN ward with a TFH or TFW.

# Equipment

| Equipment | Number | Equipment | Number | Equipment | Number |
|---|---|---|---|---|---|
| **MIXED** | | **PAIN MANAGEMENT** | | **NEONATAL RESUS** | |
| AMNIHOOK | | EPIDURAL | | NEOPUFF MASK | |
| “BLUEYS” | | IBUPROFEN TABS. | | NEOPUFF TUBING | |
| BLOOD COLLECTION TUBE | | IMI ANALGESIA (vials) | | PULSE OXIMETER PROBE | |
| FETAL SCALP ELECTRODE | | $N_2O + O_2$ | | SUCTION CATHETER | |
| IDC (REGULAR) | | PARACETAMOL SUPP. | | SUCTION TUBING | |
| IDC (HOURLY BAG) | | PARACETAMOL TABS. | | | |
| KY LUBRICANT GEL (sachets) | | STERILE WATER FOR INJECTION (10mL) | | | |
| NEEDLES | | | | **PPH/3rd STAGE** | |
| NON-STERILE GLOVES (pairs) | | | | CARBOPROST (vials) | |
| PADS (5 per pack) | | **BIRTH** | | ERGOMETRINE (vials) | |
| SYRINGES | | CORD CLAMPS | | MISOPROSTOL (suppository tabs) | |
| SWABS | | DELIVERY INSTRUMENTS | | SPONGE-HOLDING FORCEPS | |
| VOMIT BAGS | | DELIVERY SET | | SYNTOCINON (vials) | |
| | | EPISIOTOMY SCISSORS | | SYNTOMETRINE (vials) | |
| | | SCISSORS | | | |
| **IV THERAPY** | | SPONGES (5 per pack) | | | |
| CANNULA | | STERILE GLOVES (pairs) | | **SUTURING** | |
| IV GIVING SET | | | | CHLORHEXIDINE 500mL | |
| IV ANTIBIOTICS (vials) | | | | INDOCID SUPPOSITORIES | |
| IV FLUID (bags) | | **INSTRUMENTAL BIRTH** | | LOCAL ANAESTHETIC (vials) | |
| NORMAL SALINE 10mL | | VACUUM EXTRACTOR | | PERI ICE PACKS | |
| | | NEVILLE BARNES FORCEPS | | SUTURE MATERIAL (packets) | |
| | | FORCEPS - OTHER | | SUTURE SET | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## Staffing and activity – Date:

| | MW Staff rostered on | Women present in labour (spont., IOL) | Other women present (antenatal, postnatal, TOP etc.) |
|---|---|---|---|
| **Morning shift** | | | |
| **Evening shift** | | | |
| **Night shift** | | | |

## Background medical/pregnancy information:

| | |
|---|---|
| **Medical Issues:** | |
| **Previous Pregnancies:** | |
| **Current Pregnancy:** | |
| **Other issues:** | |

## Discharge information:

| | Date | Time |
|---|---|---|
| **Mother discharge** | | |
| **Baby discharge** | | |