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Complete List of Authors:	Homer, Caroline; UTS, Faculty of Health; Burnet Institute, Maternal and Child Health Program Cheah, Seong; University of Technology Sydney Faculty of Health, Centre for Midwifery, Child and Family Health Rossiter, Christine ; University of Technology Sydney, Dahlen, Hannah; University of Western Sydney, School of Nursing and Midwifery Ellwood, David; Griffith University, School of Medicine Foureur, Maralyn; UTS, Health Forster, Della; La Trobe University, Judith Lumley Centre; Royal Women's Hospital, Maternity Services McLachlan, HL; La Trobe University, Judith Lumley Centre; La Trobe University, School of Nursing and Midwifery Oats, Jeremy; University of Melbourne Institute, Melbourne School of Population and Global Health Sibbritt, David; University of Technology Sydney, Faculty of Health Thornton , Charlene ; Flinders University Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Scarf, Vanessa; University of Technology Sydney, Centre for Midwifery, Child and Family Health
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Homer, Caroline SE
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia
Maternal and Child Health Program, Burnet Institute, Melbourne, Australia

Cheah, Seong
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Rossiter, Christine
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

Dahlen, Hannah G
School of Nursing and Midwifery, University of Western Sydney, Sydney, Australia

Ellwood, David
School of Medicine, Griffith University, Queensland, Australia

Foureur, Maralyn
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

Forster, Della
Judith Lumley Centre; Royal Women's Hospital, Maternity Services, La Trobe University, Melbourne, Australia

McLachlan, Helen L
Judith Lumley Centre; Royal Women's Hospital, Maternity Services, La Trobe University, Melbourne, Australia

Oats, Jeremy
Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia

Sibbritt, David
Faculty of Health, University of Technology Sydney, Australia

Thornton, Charlene
Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Flinders University, Adelaide, Australia

Scarf, Vanessa
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

Corresponding author
Professor Caroline Homer AO
Burnet Institute
85 Commercial Road, Melbourne, 3000 Victoria
T +613 8506 2454
M +61 418 466 974
E caroline.homer@burnet.edu.au

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ABSTRACT

Objective – To compare perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, in hospital labour wards, birth centres or at home.

Design – A population-based retrospective design, linking and analysing routinely collected electronic data about women and their infants. Analysis comprised chi-square tests and binary logistic regression for categorical data, yielding adjusted odds ratios. Continuous data were analysed using ANOVA.

Setting – All eight Australian states and territories.

Participants – Women with low-risk pregnancies who gave birth between 2000 and 2012 to a singleton baby in cephalic presentation at between 37 and 41 completed weeks' gestation. Of the 1 251 420 births, 1 171 703 (93.6%) were planned in hospital labour wards or birth suites, 71 505 (5.7%) in birth centres and 8212 (0.7%) at home.

Main outcome measures – Mode of birth, interventions and procedures during labour and birth, maternal complications, admission to special care/high dependency or intensive care units (mother or infant) and perinatal mortality (intrapartum stillbirth and neonatal death).

Results – Compared with planned hospital births, the odds of normal labour and birth were over twice as high in planned birth centre births (AOR 2.72; 99% CI 2.63-2.81) and nearly six times as high in planned home births (AOR 5.91; 99% CI 5.15-6.78). There were no statistically significant differences in the proportion of intrapartum stillbirths, early or late neonatal deaths between the three planned places of birth.

Conclusions – This is the first Australia-wide study to examine outcomes by planned place of birth. It demonstrates that for low-risk healthy women in Australia, planned births in birth centres or at home are associated with positive maternal outcomes. There were no significant differences in the perinatal mortality rate, although the absolute numbers of deaths were very small.

ARTICLE SUMMARY

Strengths and limitations of this study

- This retrospective study reveals the first Australia-wide evidence on the relative safety of planned birth in hospital, a birth centre and at home.
- It analyses linked data on the outcomes for low-risk women and their infants in all eight Australian states and territories.
- Careful data screening eliminated most causes of obstetric complexity, resulting in three cohorts with equivalent levels of risk.
- Inconsistency between state-based datasets limited the number of confounding variables available for analysis.
- Insufficient data on changes in planned birth place prior to labour hampered identification of intrapartum transfers and analysis of the relationship between intended and actual place of birth.

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Competing interest statement

We have read and understood *BMJ* policy on declaration of interests and declare that we have no competing interests.

Acknowledgements

We acknowledge and thank the data custodians in each state and territory and the data linkage units who assisted with data collection at each jurisdictional level.

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) (university reference number: 2012000167) and from data custodians in each state and territory. The details are provided in a Supplementary File.

Author contribution

CSEH as the lead investigator was responsible for the overall leadership of the study including the initial conception and design, grant application, ethical approval processes, leading the project, drafting the manuscript and finalising the paper.

SLC was the data analyst responsible for merging the datasets from each jurisdiction, refining the datasets, developing the analysis codes and processes and conducting the statistical analysis and has provided final approval of this version.

CR worked with the data analyst to support data analysis and interpretation as well as taking a key role in supporting the drafting of the manuscript and has provided final approval of this version.

HGD was involved in the initial design of the study, played a key role in developing the study questions and data analytic processes, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DAE was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

MJF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

HMc was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

JO was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DS was involved in the initial design of the study, played a key role in developing the study questions and analytic processes and providing expert statistical planning and review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

CT played a key role in developing the study questions and analytic plan, assisted with planning the data set merging and cleaning of the data and providing expert epidemiological review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

VS was the project coordinator responsible for the ethical approval processes, took a key role in coordinating the acquisition of the data from the different states and territories as well as a lead role in planning and undertaking the analysis and interpretation, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

Reporting statement

The STROBE Statement for a cohort study is included as a Supplementary File.

Consent

Individual consent by participants was deemed to not be required due to the population-based de-identified form of the data released to the researchers.

Data sharing statement

The data that support the findings of this study are not available. It was a condition of the agreement between the data linkage units and the researchers that the dataset remain confidential. We are not permitted to make any part of the linked data available to any party outside those named on the research team who have been granted access.

INTRODUCTION

In Australia, most births occur in hospitals (97.5% in 2015), with some variation by the different states and territories (for example, 91% in the Australian Capital Territory to 99% in Victoria).[1] Women with uncomplicated pregnancies planning hospital births in the public health system receive antenatal care from hospital-based midwives and doctors, sometimes within continuity of care models, and often in partnership with local general practitioners. Hospital midwives attend their labour and birth, with medical involvement as required or in line with local protocols. In the private health system, women receive antenatal care from private obstetricians or midwives employed by obstetricians. Hospital midwives attend their labour and birth; the obstetrician attends the birth.[2,3] There are some differences across Australia in the way care is provided, the local guidelines and the choices available to women.

While most births take place in hospital labour wards or birth suites, a small proportion (1.8% nationally) take place in midwife-run birth centres.[1] Australian birth centres are typically co-located with hospitals (alongside midwifery units) although a small number of stand-alone birth centres exist.[4] Less than 0.3% of Australian births take place at home, ranging from 0.1% of births in New South Wales to 0.6% in the Northern Territory.[1,5] Most planned home births are attended by midwives working in private practice, some of whom also attend women in birth centres and hospitals. A small number of hospitals and birth centres offer home births through the public health system.[6] An evaluation of the outcomes of publicly funded models showed that the rate of stillbirth and early neonatal mortality was low, at 1.7 per 1000 births. However, the sample size did not have sufficient power to generate a conclusion about safety.[7]

We recently conducted a systematic review to examine maternal and perinatal outcomes associated with planned place of birth for women with low-risk pregnancies in high-income countries.[8] The 28 studies from 13 countries investigated several outcomes using mostly observational methods. Meta-analysis of data from high-quality studies where intended birth place was identified at labour onset demonstrated that women who planned hospital births had significantly higher rates of perineal trauma and instrumental/caesarean birth than those who planned other birth places. Overall, there was no significant difference in

the odds of intrapartum stillbirth according to place of birth (compared with planned hospital births, planned homebirth: OR=0.94; 95% CI: 0.76-1.17; planned birth centre OR=0.66; 95% CI: 0.32-1.34) or in early neonatal deaths (planned home birth OR=1.00; 95% CI: 0.78-1.27; planned birth centre 1.08; 95% CI: 0.42-2.78).

Previous Australian state-based studies into place of birth identified differing outcomes. For example, a study of births in NSW (accounting for around 30.9% of Australian births)[9] found that women without pregnancy complications who planned a home or birth centre birth had significantly higher proportions of normal birth than those planning hospital births (home 97.4% vs birth centre 86.0% vs hospital 73.9%). The study detected no significant difference in neonatal mortality although the overall sample size (n= 258 161, including only 742 planned home births), was insufficient to test reliably for differences by birth place for these relatively rare outcomes. Another study in South Australia (SA) (297 192 planned hospital births and 1141 [0.38%] planned home births) found lower intervention rates and equivalent perinatal death rates in home births compared to hospital births. However, the odds of an intrapartum fetal death were significantly higher among planned home births (two deaths in the planned home birth group; AOR 7.42; 95% CI: 1.53–35.87). This study also included some women with obstetric risk factors in the home birth group including twins.[10] Large-scale studies in other countries have used larger data sets, generating greater statistical power[11-14] and mostly showing similar perinatal outcomes between births planned at home and in hospitals (and birth centres where these exist) with some differences for nulliparous women.

Data from Australian birth centres indicate lower rates of maternal morbidity,[15] intervention, preterm birth and low birthweight compared with hospital births for women with similar low-risk profiles.[16] One study identified no significant differences by birth place in perinatal mortality[16] and another reported lower perinatal mortality in birth centre births, although based on actual rather than intended birth place.[17] A smaller hospital-based study found no significant difference in caesarean section rates between birth centre and labour ward for women with low-risk pregnancies.[18] Two other birth centre studies reported higher rates of spontaneous vaginal birth and lower rates of adverse infant outcomes (neonatal intensive care unit [NICU] admission, low birthweight) compared to hospital births.[19,20]

Place of birth continues to be controversial in Australia. To generate evidence to assist policy makers, health practitioners, and pregnant women and their families to make informed decisions about place of birth, we undertook a national study combining data from all eight Australian jurisdictions to examine the outcomes for women with low-risk pregnancies related to three different birth settings. This is the first national study on the comparative safety of different planned birth settings in Australia.

Aim

The study aimed to compare the perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, hospital labour wards, birth centres or at home.

METHODS

Study design

The study used a population-based retrospective design, linking and analysing routinely collected electronic data from multiple sources about births between 2000 and 2012 to women with low-risk pregnancies. We compared outcomes from three cohorts comprising women who were as comparable as possible given the available data. In Australia, homebirth and birth centre options are mostly restricted to women who meet low-risk criteria. We therefore endeavoured to ensure that the hospital cohort shared the same characteristics, clinically if not demographically and applied the same filters on all three cohorts to increase the similarity between groups.

The study was approved by a university Human Research Ethics Committee (HREC). HRECs in each state and territory also approved access to anonymised linked data (see Supplementary File 1). Patients and the public were not involved in the design or conduct of the study.

Data sources

All eight Australian states and territories compile electronic perinatal datasets with items on maternal characteristics, labour, birth, and perinatal outcomes in the immediate postpartum period. However, to eliminate women with complicating conditions from the

sample and to examine deaths and major morbidity requiring hospitalisation beyond the perinatal period, we examined additional data sources on deaths and hospital admissions nine months before and twelve months following birth. This study used linked anonymous data on all available mothers and infants from the following sources:

- *Perinatal Data Collection* (PDC) – maternal and infant data on all live births and stillbirths from 20 weeks' gestation or >400g birth weight;
- *Admitted Patient Data Collection* (APDC) – services provided to all individuals admitted to public and private hospitals, using the International Classification of Diseases – Australian modifications (ICD-10-AM)[21] for clinical data;
- *Registry of Births, Deaths and Marriages* (RBDM) – all registered births and deaths;
- *Australian Bureau of Statistics* (ABS) – data on deaths including primary cause of death (only for NSW and Queensland).

It was not possible to obtain data from all sources for all states and territories for the full study period due to differences in data collection systems. Table footnotes indicate the scope of data for each variable. In addition, not all states and territories provided data on maternal mortality.

Definitions

We defined *low-risk pregnancy* as a singleton fetus in cephalic presentation between 37 and 41 completed weeks' gestation and free of known and recorded complications. Exclusions are detailed in Box 1.

< Insert Box 1 here >

Planned place of birth incorporates three possible locations: home, birth centre, and hospital. *Homebirths* are instances where women intend to give birth outside a formal health facility, usually their own home, and receive care from a registered midwife, funded through either the public or private health system or self-funded. *Birth centres* provide a home-like birth setting and are run by midwives. They can be located within a hospital campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the main hospital service for access to interventions such as epidural analgesia or caesarean

section. *Hospital births* take place in the labour ward or birth suite (terms vary across the country) of either a public or private hospital, staffed by midwives and doctors.

The timing of the decision about birth setting is critical within the birthplace literature. While women choose a birth location early in their pregnancy, clinical factors may preclude them from achieving this intention. If they develop complications, they may no longer be eligible to give birth in a birth centre or at home. These women are excluded from comparisons of outcome by birth setting if they transfer to hospital care prior to labour. Ideally, researchers should identify planned place of birth at labour onset, to ensure that all participants have a similar level of clinical complexity. All Australian data collections record intended place of birth, but the majority did not indicate intention at labour onset. Therefore, the current study analyses data on planned place of birth identified at an undetermined time in the pregnancy, as close to labour as we were able to identify. The screening process eliminated women with many of the risk factors that would have prompted antenatal transfer from a birth centre or homebirth.

Maternal outcomes include mode of birth, interventions and procedures during labour and birth (episiotomy, epidural or spinal analgesia, oxytocin augmentation), intact perineum (no tears or episiotomy), maternal complications, and admission to a high dependency or intensive care unit.

Mode of birth includes caesarean section, forceps birth, vacuum extraction, and normal vaginal birth (non-instrumental). More specifically, *normal labour and birth* is defined as spontaneous labour, cephalic presentation, without epidural, spinal or general anaesthesia, forceps, vacuum extraction or episiotomy. Measures of *maternal complications* were severe perineal trauma (3rd or 4th degree tear), postpartum haemorrhage (PPH) requiring a transfusion, admission to intensive care or high dependency unit for more than 48 hours and hospital readmission within 28 days. *Perinatal outcomes* include intrapartum stillbirth, early neonatal death (0-7 days), late neonatal death (8-28 days), admission to special care or neonatal intensive care unit (NICU) for more than 48 hours and readmission to hospital within 28 days. We also stratified combined perinatal mortality data by parity. Other specific definitions are included in relevant tables.

Data linkage

Independent data linkage units (DLU) in each state matched information from the four data sources (where available), using probabilistic linkage techniques.[22,23] This generated de-identified health records linking information from multiple datasets about the same individuals. This process yields the best available data on maternal and infant health status. However, it is not infallible and has estimated false positive and false negative rates of 0.5% each.[24]

Cross-jurisdictional data linkage was not possible, as independent DLUs had diverging protocols for maintaining patient privacy. We therefore applied to the individual data custodians for access to the linked data, through the six DLUs (data linkage for the Australian Capital Territory and the Northern Territory is provided by NSW and SA units respectively). Data were combined on relevant variables, where comparable, into a national dataset. Box 2 provides details on the datasets.

< Insert Box 2 here >

Data cleaning, screening and cohort selection

Because the data collections were developed separately in each state and territory (except ABS collections), they had different characteristics and components. In particular, several PDC and APDC variables differed in name and type by jurisdiction. Even within the same state, some variable definitions changed over the study period, with items merged or split into multiple variables over time. The researchers scrutinised definitions to ensure accurate matching between variables with different names and attributes into a standardised dataset.

Our broad request to state DLUs specified data on women with singleton pregnancies and a cephalic presentation at 37 to 41 completed weeks' gestation. Datasets arrived in different formats and met our low-risk criteria to varying extents. We then applied more specific inclusion and exclusion criteria (Box 1) to generate the low-risk sample.

Data analysis

Data were converted to SPSS Version 24, then grouped according to women's planned place of birth for intention to treat analysis. Descriptive statistics were generated and reported using percentages (or incidence per 1000 births for postpartum complications and perinatal outcomes). Categorical variables were initially compared using chi-square tests, followed by odds ratios from binary logistic regression adjusted for maternal age, maternal country of birth (Australia or elsewhere), gestational age and parity (adjusted odds ratio=AOR). For simplicity, percentages were computed for incidence of events at each birth setting instead of examining the corresponding sphericities and specificities of the data. Unfortunately, state and territory-based data collections have inconsistent variables on other potential demographic factors such as maternal education, socioeconomic status or body mass index, limiting the variables available for controlling the analysis. We also present analysis stratified by parity for normal labour and birth (Table 2) and perinatal mortality (Table 5). For continuous data such as maternal age and gestation week, we used univariate general linear model for analysis of variance (ANOVA) to examine the differences between the means.

No imputation was made to missing data. All calculations in regression and rates were computed based on non-missing data. Wherever necessary, sizes of missing data (not stated/inadequately described) on related variables were reported. The analysis reports 99% confidence intervals. Statistical significance level was set at $p<0.01$. Ethics approval requirements prevented us reporting cell sizes of less than five to maintain confidentiality.

RESULTS

Demographic characteristics

The sample comprised 1 251 420 births to women with full-term, singleton pregnancies without complications between 2000 and 2012. Of these, 1 171 703 (93.6%) births were planned in hospital labour wards (referred to as 'hospital' births), 71 505 (5.7%) in a birth centre and 8212 (0.7%) at home.

Women planning to give birth in hospital labour wards were more likely to be younger, nulliparous, of a shorter gestation (less than 40 weeks) or Australian-born than those planning birth centre or home births (Table 1).

<Insert Table 1 here>

Mode of birth, intervention and analgesia by planned place of birth

Planned birth at home or in a birth centre was associated with normal labour and birth more often than planned hospital birth. Women planning a birth centre birth were almost three times as likely (AOR 2.72, 99% CI 2.63-2.81) and women planning a home birth were almost six times as likely (AOR 5.91, 99% CI 5.15-6.78) to have a normal birth (Table 2). The odds for nulliparous and multiparous women were similar.

<Insert Table 2 here>

Conversely, women planning hospital births were more likely to experience interventions in birth. Compared with planned hospital births, births planned in other settings had significantly lower odds of: vacuum extraction (birth centre AOR 0.42; 99% CI 0.40-0.44 and homebirth AOR 0.18; 99% CI 0.14-0.24), forceps (birth centre AOR 0.54; 99% CI 0.50-0.58 and homebirth AOR 0.21; 99% CI 0.14-0.31) and intrapartum caesarean section (birth centre AOR 0.45; 99% CI 0.43-0.48 and homebirth AOR 0.29; 99% CI 0.24-0.35).

Women who planned a birth centre or home birth were significantly more likely to have an intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-0.73) and more likely in planned birth centre births (AOR 1.17; 53% CI 1.09-1.25). The odds of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI 0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births.

The odds of other interventions such as oxytocin augmentation and epidural or spinal analgesia were lower in planned birth centre or home births (Table 3).

<Insert Table 3 here>

Postpartum complications

Women who planned to give birth in a birth centre were less likely to have a PPH requiring a blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78). There was no significant difference in the odds for women who planned a home birth (AOR 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the absolute number of admissions is small (Table 4). There were no significant differences between the groups in the odds of readmission to hospital within a month.

<Insert Table 4 here>

Perinatal outcomes by planned place of birth

There were no significant differences in the odds of intrapartum stillbirth, or early or late neonatal deaths between the three planned places of birth. Combined data on stillbirth during labour, early and late neonatal death indicate that women planning a home birth were no more likely to experience perinatal mortality than those planning a hospital birth (AOR 1.55; 99% CI 0.65-3.69), although the absolute number of deaths was very small (9/8182). Similarly, there was no significant difference for women planning a birth centre birth (AOR 0.84; 99% CI 0.60-1.19). When women were stratified by parity, there were no significant differences between any of the groups in the odds of perinatal mortality.

Women who planned a birth centre birth were more likely to have their baby admitted to the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women who planned hospital births. This trend was not seen in planned home births (AOR 0.63; 99% CI 0.39-1.01). There were no significant differences between the three groups in the odds of readmission of the baby to hospital within 28 days (Table 5).

<Insert Table 5 here>

DISCUSSION

This study, the first in Australia, has examined maternal and perinatal outcomes nationally by planned place of birth including all eight states and territories. Our study has

demonstrated results consistent with several international studies of planned place of birth.[11,12,14] Normal births were more likely for women who planned birth in birth centres or at home than in a hospital. Women who planned to give birth at home were older than women planning hospital or birth centre births, but despite this, had consistently lower rates of intervention.

The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live births compared with 0.4 in planned birth centre births and 1.1 in planned home births, although the absolute risks were very small with low numbers of deaths overall. These differences by place of birth were neither statistically significant for all women nor for cohorts stratified by parity. However, the differences are more marked in nulliparous women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned homebirth). Given the small number of deaths in the planned homebirth group (n=9) this may be a chance finding over a long period of time (13 years). However, it is similar the combined perinatal outcome in the Birthplace in England study[11], although that study did find statistically significant higher odds of perinatal mortality among nulliparous women planning home births. This highlights the need to explain the risks to women in absolute terms, as this is likely to be more helpful in assisting decision-making.

There were two negative findings in relation to birth centre outcomes, firstly, a significantly higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned hospital births. Another Australian study[16] and one in New Zealand also found higher rates of perineal trauma in birth centres.[25] However, other research found no significant differences in perineal outcomes for example in studies in Norway,[26,27] Denmark,[28] Australia[29] or England.[30] The higher rate of severe perineal trauma may be related to the use of birth stools, more common in Australian birth centres but less frequently in hospitals or at home. Birth stools have been linked to higher rates of severe perineal trauma compared with other birth positions or waterbirth.[31] The higher rates of trauma could be due to better case ascertainment or lower rates of episiotomy.

The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other

research, which either found higher rates associated with planned hospital births[16,25] or else no statistically significant differences in NICU admission rates from birth centres and hospital births.[26,28,32] The admissions to the NICU or SCN in the current study are low in absolute terms (1 per 100 for birth centre births) but higher than planned hospital births. This requires ongoing examination to determine possible reasons and ways to reduce the rate.

The study findings are important especially in light of evidence that shows associations between intervention in labour and birth, and long-term maternal and newborn health. For example, a recent population-based study showed that caesarean section is associated with an increased risk of infections, eczema, and metabolic disorders in children aged five years, compared with spontaneous vaginal births, especially for emergency caesarean sections.[33]

Strengths and limitations

This study is the first to comprehensively examine maternal and perinatal outcomes from three birth settings across Australia. It used a population-based sample consisting of women with low-risk pregnancies. The large sample size was sufficient to detect differences between the three groups, although the numbers of homebirth nationally, even over this time period, were comparatively small (i.e. 8212 only 0.7% of the total low-risk sample).

Low-risk pregnancies were defined consistently across all three cohorts in the dataset. However, merging linked data from multiple jurisdictions created several challenges and potential shortcomings, including missing responses, inconsistent variable definitions and limited data from some states. For example, Queensland's data collection only covered 2007-2012, resulting in under-representation: 9.6% of the combined sample, compared with 20.4% of Australian births in 2012.[34] Although we eliminated unintended home births among women intending hospital or birth centre births (births before arrival), the home birth data do not always record whether or not a qualified health professional attended. Within the constraints of the data available, we have only included births attended by a health professional. Moreover, different states recorded birthplace intentions at different times. Although this means that intended birth place is not always recorded at onset of labour, the scrupulous process of data cleaning and categorising eliminated most women with risk factors which would have rendered them ineligible for birth centre or home births.

Thus, the recorded birthplace intention was as close as possible to that at labour onset. Some data items were collected inconsistently across the jurisdictions, for example, transfer from home to hospital after the onset of labour. This was either because the data item did not exist or because it only recorded 'transfer', which could have been at any time during pregnancy. Therefore, we were unable to report on intrapartum transfer rates.

Inconsistencies in the data from different jurisdictions also affected the data analysis. The regression analysis incorporated very few potential confounders, limited to those for which consistent data were available nation-wide (i.e. maternal age, gestational age, parity and whether born in Australia or not). Socio-economic status is also inconsistently collected across the country, as is maternal BMI and education, so we were unable to adjust for these factors. Although this introduced some risk of selection bias, the process of identifying women with low-risk pregnancies increased the comparability of the cohorts in terms of clinical factors.

CONCLUSION

This study provides evidence on the safety of births planned in hospital, birth centre and at home across all states and territories in Australia by comparing cohorts of women with low-risk pregnancies. Inconsistencies between state-based datasets as described limited the number of variables available for analysis. However, for healthy women with low-risk pregnancies, planned birth centre births resulted in high rates of normal labour and birth, low rates of most maternal complications, and comparable perinatal mortality outcomes. Women planning home birth also had similarly positive maternal outcomes with no statistically significant differences in the rate of perinatal mortality or NICU admission. In absolute terms, the numbers of deaths were small, although the rate of perinatal mortality was higher among nulliparous women who planned homebirths than their multiparous counterparts.

Box 1: Exclusion criteria

Women were excluded if the baby was:

- Born before arrival for a planned birth at hospital or birth centre;
- Diagnosed antenatally with a congenital abnormality (all ICD-10-AM Q codes)

Women were also excluded if they had:

- Received no antenatal care;
- A previous caesarean section;
- A breech presentation;
- Labour induced for any reason;
- An elective caesarean section (pre-labour);
- Pre-existing (essential) and/or pregnancy-related hypertension;
- Pre-existing or gestational diabetes;
- Prolonged rupture of membranes;
- Antepartum haemorrhage or any other relevant pregnancy complications
- ICD-10-AM Diagnosis
    - O10 Pre-existing hypertension complicating pregnancy, childbirth and the puerperium
    - O11 Pre-eclampsia superimposed on chronic hypertension
    - O13 Gestational [pregnancy-induced] hypertension
    - O14 Pre-eclampsia
    - O15 Eclampsia
    - O24 Diabetes mellitus in pregnancy
    - O30 Multiple gestation
    - O31.2 Continuing pregnancy after intrauterine death of one fetus or more
    - O36.4 Maternal care for intrauterine death
    - O42 Premature rupture of membranes
    - O46 Antepartum haemorrhage
    - O75.5 Delayed delivery after artificial rupture of membranes
    - O75.7 Vaginal delivery following previous caesarean section
    - P95 Fetal death of unspecified cause

Box 2: Proportion of births included in sample, by state and territory

State or Territory	NSW	QLD	VIC	SA	WA	TAS	ACT	NT	Total
Years of data provided	2000-2012	2007-2012	2000-2012	2000-2012	2000-2012	2005-2012	2000-2012	2000-2012	
Number of births which met low-risk criteria for this study	507 017	114 245	370 356	69 356	130 848	19 915	23 484	16 199	1 251 420
Proportion of total study sample	40.5%	9.1%	29.6%	5.5%	10.5%	1.6%	1.9%	1.3%	100%

Key to the states and territories: NSW - New South Wales; Qld - Queensland, VIC – Victoria; SA – South Australia; WA – Western Australia; TAS – Tasmania; ACT – Australian Capital Territory; NT – Northern Territory

Table 1: Demographic characteristics by planned place of birth

	Hospital	Birth Centre	Home
All women	**1 171 703 (93.6%)**	**71 505 (5.7%)**	**8212 (0.7%)**
Maternal age (years) - mean (sd)	29.0 (5.6)	29.8 (5.3)	31.8 (5.0)
Maternal age (years)			
<20	61 451 (5.2%)	2044 (2.9%)	71 (0.9%)
20-24	200 386 (17.1%)	10 116 (14.1%)	548 (6.7%)
25-29	348 785 (29.8%)	21 579 (30.2%)	2047 (24.9%)
30-34	365 022 (31.2%)	23 949 (33.5%)	3058 (37.2%)
35-39	167 803 (14.3%)	11 931 (16.7%)	1997 (24.3%)
≥40	28 177 (2.4%)	1886 (2.6%)	474 (5.8%)
Missing	79 (0.0%)	0 (0.0%)	17 (0.2%)
Previous pregnancies (≥20weeks)			
0	494 019 (42.2%)	28 891 (40.4%)	2295 (27.9%)
1	376 047 (32.1%)	25 079 (35.1%)	2745 (33.4%)
2	174 873 (14.9%)	11 364 (15.9%)	1688 (20.6%)
≥3	126 111 (10.8%)	6153 (8.6%)	1456 (17.7%)
Not stated	653 (0.1%)	18 (0.0%)	28 (0.3%)
Gestation* - mean (sd)	39.5 (1.0)	39.6 (1.0)	39.8 (1.0)
Gestation*			
37	54 825 (4.7%)	2403 (3.4%)	209 (2.5%)
38	155 764 (13.3%)	7470 (10.4%)	724 (8.8%)
39	323 179 (27.6%)	18 278 (25.6%)	1666 (20.3%)
40	481 665 (41.1%)	29 289 (41.0%)	3779 (46.0%)
41	156 270 (13.3%)	14 065 (19.7%)	1834 (22.3%)
Maternal country of birth			
Australia	889 550 (75.9%)	56 201 (78.6%)	6822 (83.1%)
Others	276 001 (23.6%)	15 105 (21.1%)	1188 (14.5%)
Inadequately described/not stated	6152 (0.5%)	199 (0.3%)	202 (2.5%)

*Gestation is in completed weeks

Note: Chi-square tests on categorical data within each sub-heading between birth settings yielded statistically significant differences with $p<0.001$ in all categories with no missing or not stated data. GLM revealed significant differences at $p<0.0001$ between means in all pairwise comparisons.

Percentages may not total exactly 100% due to rounding.

Table 3: Mode of birth and intervention rates by planned place of birth

Intervention and planned place of birth	No. events/births	Incidence of events (%)	Unadjusted OR	Adjusted OR [Æ]
Normal vaginal birth	992 118/1 251 420	79.3		
Hospital	920 514/1 171 703	78.6	1	1
Birth Centre	63 790/71 505	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7814/8212	95.2	5.36 (4.69-6.12)	5.91 (5.15-6.78)
Vacuum extraction	88 586/1 251 420	7.1		
Hospital	85 975/1 171 703	7.3	1	1
Birth Centre	2503/71 505	3.5	0.46 (0.43-0.48)	0.42 (0.40-0.44)
Home	108/8212	1.3	0.17 (0.13-0.22)	0.18 (0.14-0.24)
Forceps birth	56 332/1 251 420	4.5		
Hospital	54 451/1 171 703	4.6	1	1
Birth Centre	1820/71 505	2.5	0.54 (0.50-0.57)	0.54 (0.50-0.58)
Home	61/8212	0.7	0.15 (0.11-0.21)	0.21 (0.14-0.31)
Intrapartum caesarean section	94 303/1 251 420	7.5		
Hospital	91 238/1 171 703	7.8	1	1
Birth Centre	2871/71 505	4.0	0.50 (0.47-0.52)	0.45 (0.43-0.48)

Table 2: Normal labour and birth[†] by planned place of birth and parity[^^]

Planned place of birth	No. events[†]/births	Incidence of events (%)	Unadjusted OR	Adjusted OR [Æ]
All women	991 534/1 250 721	79.3		
Hospital	919 974/1 171 050	78.6	1	1
Birth Centre	63 773/71 487	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7787/8184	95.1	5.35 (4.69-6.11)	5.91 (5.15-6.78)
Nulliparous women	322 640/525 205	61.4		
Hospital	298 243/494 019	60.4	1	1
Birth Centre	22 401/28 891	77.5	2.27 (2.18-2.35)	2.60 (2.50-2.70)
Home	1996/2295	87.0	4.38 (3.73-5.14)	5.99 (5.09-7.04)
Multiparous women	668 894/725 516	92.2		
Hospital	621 731/677 031	91.8	1	1
Birth Centre	41 372/42 596	97.1	3.01 (2.79-3.24)	3.27 (3.03-3.53)
Home	5791/5889	98.3	5.26 (4.04-6.83)	5.86 (4.50-7.62)

[Æ] Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.

[†] Normal labour and birth – spontaneous labour, no epidural or spinal, general anaesthesia, forceps, vacuum extraction or episiotomy.

[^^] Parity refers to previous pregnancies ≥20 weeks.

Cases with missing data were not included in rates or regression calculations

Home	194/8212	2.4	0.29 (0.24-0.35)	0.29 (0.24-0.35)
Mode of birth not stated	20 081/1 251 420	1.6		
Hospital	19 525/1 171 703	1.7	1	1
Birth Centre	521/71 505	0.7	0.43 (0.39-0.49)	0.41 (0.36-0.46)
Home	35/8212	0.4	0.25 (0.16-0.39)	0.26 (0.17-0.41)
Intact perineum*	382 570/1 251 420	30.6		
Hospital	355 689/1 171 703	30.4	1	1
Birth Centre	22 949/71 505	32.1	1.08 (1.06-1.11)	1.16 (1.14-1.19)
Home	3932/8212	47.9	2.11 (1.99-2.23)	2.07 (1.95-2.20)
3rd or 4th degree perineal trauma¥*	23 165/1 157 117*	2.0		
Hospital	21 454/1 080 465	2.0	1	1
Birth Centre	1641/68 634	2.4	1.21 (1.13-1.29)	1.17 (1.09-1.25)
Home	70/8018	0.9	0.43 (0.32-0.59)	0.53 (0.39-0.73)
Episiotomy*	193 171/1 157 117*	16.7		
Hospital	187 276/1 080 465	17.3	1	1
Birth Centre	5688/68 634	8.3	0.43(0.42-0.45)	0.37(0.36-0.39)
Home	207/8018	2.6	0.13(0.11-0.15)	0.13(0.10-0.15)
Oxytocin augmentation	199 302/1 251 420	15.9		
Hospital	193 229/1 171 703	16.5	1	1
Birth Centre	5790/71 505	8.1	0.45 (0.43-0.46)	0.41 (0.40-0.43)
Home	283/8212	3.4	0.18 (0.15-0.21)	0.19 (0.16-0.22)

Epidural or spinal analgesia for labour	166 746/1 251 420	13.3		
Hospital	161 796/1 171 703	13.8	1	1
Birth Centre	4675/71 505	6.5	0.44 (0.42-0.45)	0.41 (0.39-0.43)
Home	275/8212	3.3	0.22 (0.18-0.25)	0.22 (0.19-0.26)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.

* Denominator = excluded caesarean section

¥ Included episiotomy extensions

Cases with missing data were not included in rates or regression calculations. No imputation was implemented to avoid data contamination. However, noises from data was unavoidably retained. Variables on mode of birth and intervention are as defined by each state or territory.

Table 4: Postpartum complications by planned place of birth

Complication and planned place of birth	No. events/births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Postpartum haemorrhage with blood transfusion	6518/1 251 420	5.2		
Hospital	6230/1 171 703	5.3	1	1
Birth Centre	244/71 505	3.4	0.64 (0.54-0.76)	0.66 (0.56-0.78)
Home	44/8212	5.4	1.01 (0.68-1.49)	1.08 (0.73-1.60)
Admission at least 48 hrs to intensive care or high dependency unit∞	2602/707 221*	3.7		
Hospital	2521/654 960	3.8	1	1
Birth Centre	74/47 266	1.6	0.41 (0.30-0.55)	0.42 (0.31-0.56)
Home	7/4995	1.4	0.36 (0.14-0.96)	0.41 (0.15-1.08)
Readmission to hospital (within 28 days)	917/864 865**	1.1		
Hospital	843/804 667	1.0	1	1
Birth Centre	68/54 522	1.2	1.19 (0.86-1.65)	1.18 (0.85-1.64)
Home	6/5676	1.1	1.01 (0.35-2.90)	1.08 (0.38-3.12)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.

* Excluded QLD, VIC, NT, ACT, TAS

∞ Intensive care and high dependency units provided additional care – these were defined by each state and territory

** Excluded VIC, NT

Cases with missing data were not included in rates or regression calculations

Table 5: Perinatal outcomes by planned place of birth and parity^^

Planned place of birth	No. events/births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Stillbirth during labour, early and late neonatal death				
All women^	921/1 250 721^	0.7		
Hospital	880/1 171 050	0.8	1	1
Birth Centre	32/71 487	0.4	0.60 (0.37-0.95)	0.84 (0.60-1.19)
Home	9/8182	1.1	1.46 (0.62-3.47)	1.55 (0.65-3.69)
Nulliparous women	425/525 205	0.8		
Hospital	406/494 019	0.8	1	1
Birth Centre	15/28 891	0.5	0.63 (0.32-1.24)	0.65 (0.33-1.27)
Home	4/2295	1.7	2.12 (0.58-7.75)	2.12 (0.58-7.82)
Multiparous women	496/725 516	0.7		
Hospital	474/677 031	0.7	1	1
Birth Centre	17/42 596	0.4	0.57 (0.30-1.08)	0.65 (0.34-1.23)
Home	5/5889	0.8	1.21 (0.38-3.86)	1.29 (0.40-4.14)
Stillbirth during labour				
All women	399/1 251 420	0.32		
Hospital	378/1 171 703	0.32	1	1
Birth Centre	17/71 505	0.24	0.74 (0.39-1.40)	0.78 (0.41-1.48)
Home	4/8212	0.49	1.51 (0.41-5.51)	1.56 (0.42-5.71)
Early neonatal death[1]				
All women	240/881 064**	0.27		
Hospital	221/819 963	0.27	1	1
Birth Centre	14/55 312	0.25	0.94 (0.46-1.91)	0.94 (0.46-1.92)
Home	5/5789	0.86	3.21 (1.00-10.28)	3.18 (0.98-10.30)
Late neonatal death[2]				
All women	95/881 064*	0.11		
Hospital	94/819 963	0.11	1	1
Birth Centre	1/55 312	0.02	0.16 (0.01-2.10)	0.19 (0.01-2.50)
Home	0/5789	0.00	na	na
Admission to SCN and/or NICU >48hrs (all babies)[3]	7500/881 064*	8.51		
Hospital	6908/819 963	8.42	1	1
Birth Centre	562/55 312	10.16	1.21 (1.08-1.35)	1.24 (1.10-1.39)
Home	30/5789	5.18	0.61 (0.38-0.98)	0.63 (0.39-1.01)
Readmission to hospital within 28 days[4]				
All babies	37 569/1 251 420	30.02		
Hospital	35 413/1 171 703	30.22	1	1
Birth Centre	1967/71 505	27.51	0.91 (0.85-0.96)	0.95 (0.90-1.01)
Home	189/8212	23.02	0.76 (0.63-0.91)	0.83 (0.68-1.00)

[1] Early neonatal death: death of a liveborn infant occurring within 7 completed days from the time of birth.

[2] Late neonatal death: death of a liveborn infant occurring after 7 completed days but before 29 completed days.

[3] NICU and SCN were combined due to complexities in the data to separate them out for all states and territories, except the Northern Territory where there was only SCN available and for South Australia where only NICU was available.

[4] For home births, this is defined as admission to hospital following birth within 28 days.

^ Denominator excluded missing parity information. The denominator in the first section of this table has 699 records with missing data for parity. Because this part of the data analysis was stratified by parity, we excluded the women whose parity data were unavailable.

* Excluded VIC.

Æ Logistic regression was undertaken with adjustments occurring for maternal age, country of birth, gestational age, and parity at 99% CI. Any case with missing data was excluded from the regression.

^^ Parity refers to previous pregnancies ≥20 weeks.

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SUPPLEMENTARY FILE 1

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) – University of Technology Sydney, Australia (university reference number: 2012000167). Each state and territory also provided ethical approval.

State or territory	Name of the ethics committee(s)	Number/ID of the approval
Australian Capital Territory	ACT Health HREC	ETH 3.14.061
New South Wales	NSW Population and Health Services HREC	HREC/14/CIPHS/15
Northern Territory	Department of Health of the Northern Territory and the Menzies School of Health Research HREC	HREC 2014-2247
Queensland	Qld Health Office of the HREC	HREC/14/QGC/175
South Australia	South Australian Health HREC	HREC/14/SAH/117
Tasmania	Tasmania Network HREC	Ref No: H0015023
Victoria	Department of Health and Human Services – Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM)	Ref: 14/12
Western Australia	Government of Western Australia, Department of Health HREC	HREC 2014/57

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page no
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8-9
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-11
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11-12
		(*b*) Describe any methods used to examine subgroups and interactions	11-12
		(*c*) Explain how missing data were addressed	12
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12 Table 1
		(b) Give reasons for non-participation at each stage	12
		(c) Consider use of a flow diagram	Table 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	In each table
		(c) Summarise follow-up time (eg, average and total amount)	NA

Outcome data	15*	Report numbers of outcome events or summary measures over time	12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14 Plus tables
		(*b*) Report category boundaries when continuous variables were categorized	Tables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Maternal and perinatal outcomes by planned place of birth in Australia 2000 – 2012: A linked population data study

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Complete List of Authors:	Homer, Caroline; University of Technology Sydney, Centre for Midwifery, Child and Family Health; Burnet Institute, Maternal and Child Health Cheah, Seong; University of Technology Sydney Faculty of Health, Centre for Midwifery, Child and Family Health Rossiter, Chris; University of Technology Sydney, Dahlen, Hannah; University of Western Sydney, School of Nursing and Midwifery Ellwood, David; Griffith University, School of Medicine Foureur, Maralyn; UTS, Health Forster, Della; La Trobe University, Judith Lumley Centre; Royal Women's Hospital, Maternity Services McLachlan, HL; La Trobe University, Judith Lumley Centre; La Trobe University, School of Nursing and Midwifery Oats, Jeremy; University of Melbourne Institute, Melbourne School of Population and Global Health Sibbritt, David; University of Technology Sydney, Faculty of Health Thornton , Charlene ; Flinders University Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Scarf, Vanessa; University of Technology Sydney, Centre for Midwifery, Child and Family Health
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Homer, Caroline SE
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia
Maternal and Child Health Program, Burnet Institute, Melbourne, Australia

Cheah, Seong
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Rossiter, Christine
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

Dahlen, Hannah G
School of Nursing and Midwifery, University of Western Sydney, Sydney, Australia

Ellwood, David
School of Medicine, Griffith University, Queensland, Australia

Foureur, Maralyn
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

Forster, Della
Judith Lumley Centre; Royal Women's Hospital, Maternity Services, La Trobe University, Melbourne, Australia

McLachlan, Helen L
Judith Lumley Centre; La Trobe University, Melbourne, Australia

Oats, Jeremy
Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia

Sibbritt, David
Faculty of Health, University of Technology Sydney, Australia

Thornton, Charlene
Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Flinders University, Adelaide, Australia

Scarf, Vanessa
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

Corresponding author
Professor Caroline Homer AO
University of Technology Sydney, Australia
T +613 8506 2454
M +61 418 466 974
E caroline.homer@uts.edu.au

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ABSTRACT

Objective – To compare perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, in hospital labour wards, birth centres or at home.

Design – A population-based retrospective design, linking and analysing routinely collected electronic data. Analysis comprised chi-square tests and binary logistic regression for categorical data, yielding adjusted odds ratios. Continuous data were analysed using ANOVA.

Setting – All eight Australian states and territories.

Participants – Women with low-risk pregnancies who gave birth between 2000 and 2012 to a singleton baby in cephalic presentation at between 37 and 41 completed weeks' gestation. Of the 1 251 420 births, 1 171 703 (93.6%) were planned in hospital labour wards, 71 505 (5.7%) in birth centres and 8212 (0.7%) at home.

Main outcome measures – Mode of birth, normal labour and birth, interventions and procedures during labour and birth, maternal complications, admission to special care/high dependency or intensive care units (mother or infant) and perinatal mortality (intrapartum stillbirth and neonatal death).

Results – Compared with planned hospital births, the odds of normal labour and birth were over twice as high in planned birth centre births (AOR 2.72; 99% CI 2.63-2.81) and nearly six times as high in planned home births (AOR 5.91; 99% CI 5.15-6.78). There were no statistically significant differences in the proportion of intrapartum stillbirths, early or late neonatal deaths between the three planned places of birth.

Conclusions – This is the first Australia-wide study to examine outcomes by planned place of birth. For low-risk healthy women in Australia, planned births in birth centres or at home are associated with positive maternal outcomes although the number of homebirths was small overall. There were no significant differences in the perinatal mortality rate, although the absolute numbers of deaths were very small.

ARTICLE SUMMARY

Strengths and limitations of this study

- This retrospective study reveals the first Australia-wide evidence on the relative safety of planned birth in hospital, a birth centre and at home.
- It analyses linked data on the outcomes for low-risk women and their infants in all eight Australian states and territories.
- Careful data screening eliminated most causes of obstetric complexity, resulting in three cohorts with equivalent levels of risk.
- Inconsistency between state-based datasets limited the number of confounding variables available for analysis.
- Insufficient data on changes in planned birth place prior to labour hampered identification of intrapartum transfers and analysis of the relationship between intended and actual place of birth.

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Competing interest statement

We have read and understood *BMJ* policy on declaration of interests and declare that we have no competing interests.

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We acknowledge and thank the data custodians in each state and territory and the data linkage units who assisted with data collection at each jurisdictional level.

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) (university reference number: 2012000167) and from data custodians in each state and territory. The details are provided in a Supplementary File.

Author contribution

CSEH as the lead investigator was responsible for the overall leadership of the study including the initial conception and design, grant application, ethical approval processes, leading the project, drafting the manuscript and finalising the paper.

SLC was the data analyst responsible for merging the datasets from each jurisdiction, refining the datasets, developing the analysis codes and processes and conducting the statistical analysis and has provided final approval of this version.

CR worked with the data analyst to support data analysis and interpretation as well as taking a key role in supporting the drafting of the manuscript and has provided final approval of this version.

HGD was involved in the initial design of the study, played a key role in developing the study questions and data analytic processes, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DAE was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

MJF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

HMc was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

JO was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DS was involved in the initial design of the study, played a key role in developing the study questions and analytic processes and providing expert statistical planning and review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

CT played a key role in developing the study questions and analytic plan, assisted with planning the data set merging and cleaning of the data and providing expert epidemiological review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

VS was the project coordinator responsible for the ethical approval processes, took a key role in coordinating the acquisition of the data from the different states and territories as well as a lead role in planning and undertaking the analysis and interpretation, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

Consent

Individual consent by participants was deemed to not be required due to the population-based de-identified form of the data released to the researchers.

Data sharing statement

The data that support the findings of this study are not available. It was a condition of the agreement between the data linkage units and the researchers that the dataset remain confidential. We are not permitted to make any part of the linked data available to any party outside those named on the research team who have been granted access.

INTRODUCTION

In Australia, most births occur in hospitals (97.5% in 2015), with some variation across the eight states and territories (for example, 91% in the Australian Capital Territory to 99% in Victoria).[1] Women with uncomplicated pregnancies (those without medical or obstetric risk factors) and are planning hospital births in the public health system receive antenatal care from hospital-based midwives and doctors, sometimes within continuity of care models, and often in partnership with local general practitioners. Hospital midwives attend their labour and birth, with medical involvement as required or in line with local protocols. In the private health system (where 25% of births take place), women receive antenatal care from private obstetricians or midwives employed by obstetricians. Hospital midwives attend their labour and birth and, the obstetrician attends during the labour and is usually at the birth.[2,3] There are some differences across Australia in the way care is provided, especially the local guidelines and the choices available to women. The availability of different models of care varies across the country.

While most births take place in hospital labour wards or birth suites, a small proportion (1.8% nationally) take place in midwife-run birth centres.[1] These birth centres in Australia are typically co-located with hospitals (similar to alongside midwifery units in other countries) although a small number of stand-alone birth centres exist.[4] Birth centres typically provide midwifery continuity of care to women with uncomplicated pregnancies in a home-like environment and are well integrated into the health system.

Less than 0.3% of Australian births take place at home, ranging from 0.1% of births in New South Wales to 0.6% in the Northern Territory.[1,5] Most planned home births are attended by midwives working in private practice, some of whom also attend women in birth centres and hospitals. The integration of private homebirth services varies across the country. A small number of hospitals and birth centres offer home births through the public health system.[6] An evaluation of the outcomes of publicly funded models showed that the rate of stillbirth and early neonatal mortality was low, at 1.7 per 1000 births. However, the sample size did not have sufficient power to generate a conclusion about safety.[7]

We have conducted a systematic review to examine maternal and perinatal outcomes associated with planned place of birth for women with low-risk pregnancies in high-income

countries.[8] In this analysis of 28 studies from 13 countries, women who planned hospital births had significantly higher rates of perineal trauma and instrumental/caesarean birth than those who planned other birth places. Overall, there was no significant difference in the odds of intrapartum stillbirth according to place of birth (compared with planned hospital births, planned homebirth: OR=0.94; 95% CI: 0.76-1.17; planned birth centre OR=0.66; 95% CI: 0.32-1.34) or in early neonatal deaths (planned home birth OR=1.00; 95% CI: 0.78-1.27; planned birth centre 1.08; 95% CI: 0.42-2.78).

Previous Australian state-based studies into place of birth have showed variation in findings. In New South Wales (the most populous state accounting for around 30.9% of births)[9], women without pregnancy complications who planned a home or birth centre birth had significantly higher proportions of normal birth than those planning hospital births (home 97.4% vs birth centre 86.0% vs hospital 73.9%). There was no significant difference in neonatal mortality although the overall sample size (n= 258 161, including only 742 planned home births), had insufficient power for these relatively rare outcomes. In South Australia (SA) (297 192 planned hospital births and 1141 [0.38%] planned home births), another study found lower intervention rates and equivalent perinatal death rates in home births compared to hospital births. However, the odds of an intrapartum fetal death were significantly higher among planned home births (two deaths in the planned home birth group; AOR 7.42; 95% CI: 1.53–35.87). This study included some women with recognised risk factors in the home birth group including twins.[10] Large-scale studies in other countries mostly showing similar perinatal outcomes between births planned at home and in hospitals (and birth centres where these exist) with some differences for primiparous women.[11-14]

There is less controversy about birth centres. Data from Australian birth centres indicate lower rates of maternal morbidity,[15] intervention, preterm birth and low birthweight compared with hospital births for women with similar low-risk profiles.[16] One study identified no significant differences by birth place in perinatal mortality[16] and another reported lower perinatal mortality in birth centre births, although based on actual rather than intended birth place.[17] A smaller hospital-based study found no significant difference in caesarean section rates between the birth centre and labour ward for women with low-risk pregnancies.[18] Two other birth centre studies reported higher rates of spontaneous vaginal

birth and lower rates of adverse infant outcomes (neonatal intensive care unit [NICU] admission, low birthweight) compared to hospital births.[19,20]

The safety of place of birth continues to be questioned in Australia.[21] To generate evidence to assist policy makers, health practitioners, and pregnant women and their families to make informed decisions about place of birth, we undertook a national study combining data from all eight Australian jurisdictions to examine the outcomes for women with low-risk pregnancies related to three different birth settings. This is the first national study on the comparative safety of different planned birth settings in Australia.

Aim and objectives

The study aimed to compare the perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, hospital labour wards, birth centres or at home. We defined *uncomplicated pregnancy* as a singleton fetus in cephalic presentation between 37 and 41 completed weeks' gestation and free of known and recorded complications. Exclusions are detailed in Box 1.

The objectives were to compare the three planned places of birth by:

- Mode of birth, rate of normal labour and birth, augmentation, analgesia during labour and episiotomy
- Postpartum complications including postpartum haemorrhage, perineal trauma, admission to an intensive care or high dependency unit and readmission to hospital within 28 days. Women who gave birth at home and required transfer to hospital either during labour or after the birth are counted as an admission.
- Intrapartum stillbirth or neonatal deaths

METHODS

Study design

The study used a population-based retrospective design, linking and analysing routinely collected electronic data from multiple sources about births between 2000 and 2012 to

women with low-risk pregnancies. We compared outcomes from three cohorts comprising women who were as comparable as possible given the available data. In Australia, homebirth and birth centre options are mostly restricted to women who meet low-risk criteria, that is, have an uncomplicated pregnancy and no relevant past medical or obstetric history. We therefore endeavoured to ensure that the hospital cohort shared the same characteristics, clinically if not demographically and applied the same filters on all three cohorts to increase the similarity between groups.

The study was approved by a university Human Research Ethics Committee (HREC). HRECs in each state and territory also approved access to anonymised linked data (see Supplementary File 1).

Patient and Public Involvement

Patients and the public were not involved in the design or conduct of the study.

Data sources

All eight Australian states and territories compile electronic perinatal datasets with items on maternal characteristics, labour, birth, and perinatal outcomes in the immediate postpartum period, that is, during the birth admission. However, to eliminate women with conditions that made them fall out of the uncomplicated criteria from the sample and to examine deaths and major morbidity requiring hospitalisation beyond the perinatal period, we examined additional data sources on deaths and hospital admissions nine months before and twelve months following birth. This study used linked anonymous data on all available mothers and infants from the following sources:

- *Perinatal Data Collection* (PDC) – maternal and infant data on all live births and stillbirths from 20 weeks' gestation or >400g birth weight;
- *Admitted Patient Data Collection* (APDC) – services provided to all individuals admitted to public and private hospitals, using the International Classification of Diseases – Australian modifications (ICD-10-AM)[22] for clinical data;
- *Registry of Births, Deaths and Marriages* (RBDM) – all registered births and deaths;
- *Australian Bureau of Statistics* (ABS) – data on deaths including primary cause of death (only for NSW and Queensland).

It was not possible to obtain data from all sources for all states and territories for the full study period due to differences in data collection systems. Table footnotes indicate the scope of data for each variable. In addition, not all states and territories provided data on maternal mortality.

Definitions

The definition of *uncomplicated pregnancies* (those without medical or obstetric risk factors) was determined a priori by the research team. For the most part, this used the Australian College of Midwives Guidelines for Consultation and Referral [23] as a basis for the description of uncomplicated pregnancies.

< Insert Box 1 here >

Planned place of birth incorporates three possible locations: home, birth centre, and hospital. *Homebirths* are instances where women intend to give birth outside a formal health facility, usually their own home, and receive care from a registered midwife, funded through either the public or private health system or self-funded. *Birth centres* provide a home-like birth setting and are run by midwives. They can be located within a hospital campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the main hospital service for access to interventions such as epidural analgesia or caesarean section. *Hospital births* take place in the labour ward or birth suite (terms vary across the country) of either a public or private hospital, and women are attended by midwives, obstetricians and/or general practitioner (GP) obstetricians.

The timing of the decision about birth setting is critical within the birthplace literature. While women choose a birth location early in their pregnancy, clinical factors may preclude them from achieving this intention. If they develop complications, they may no longer be eligible to give birth in a birth centre or at home. These women are excluded from comparisons of outcome by birth setting if they transfer to hospital care prior to labour. Ideally, researchers should identify planned place of birth at labour onset, to ensure that all participants have a similar level of clinical complexity. All Australian data collections record intended place of birth, but the majority did not indicate intention at labour onset. Therefore, the current study analyses data on planned place of birth identified at an

undetermined time in the pregnancy, as close to labour as we were able to identify. The screening process eliminated women with many of the risk factors that would have prompted antenatal transfer from a birth centre or homebirth.

Box 2 provides the definitions of the maternal and perinatal outcomes.

< Insert Box 2 here >

Data linkage

Independent data linkage units (DLU) in each state and territory matched information from the four data sources (where available), using probabilistic linkage techniques.[24,25] This generated de-identified health records linking information from multiple datasets about the same individuals. This process yields the best available data on maternal and infant health status. However, it is not infallible and has estimated false positive and false negative rates of 0.5% each.[26]

Cross-jurisdictional data linkage was not possible, as independent DLUs had diverging protocols for maintaining patient privacy. We therefore applied to the individual data custodians for access to the linked data, through the six DLUs (data linkage for the Australian Capital Territory and the Northern Territory is provided by NSW and SA units respectively). Data were combined on relevant variables, where comparable, into a national dataset. Box 3 provides details on the datasets. Our approach to the data linkages and combining issues are detailed elsewhere. [27]

< Insert Box 3here >

Data cleaning, screening and cohort selection

Because the data collections were developed separately in each state and territory (except ABS collections), they had different characteristics and components. In particular, several PDC and APDC variables differed in name and type by jurisdiction. Even within the same state, some variable definitions changed over the study period, with items merged or split into multiple variables over time. The researchers scrutinised definitions to ensure accurate matching between variables with different names and attributes into a standardised

dataset. The variables on mode of birth and intervention are all as defined by each state or territory.

Our broad request to state DLUs specified data on women with singleton pregnancies and a cephalic presentation at 37 to 41 completed weeks' gestation. Datasets arrived in different formats and met our low-risk criteria to varying extents. We then applied more specific inclusion and exclusion criteria (Box 1) to generate the low-risk sample.

Data analysis

Data were converted to SPSS Version 24, then grouped according to women's planned place of birth for intention to treat analysis. Descriptive statistics were generated and reported using percentages (or incidence per 1000 births for postpartum complications and perinatal outcomes). Categorical variables were initially compared using chi-square tests, followed by odds ratios from binary logistic regression adjusted for maternal age, maternal country of birth (Australia or elsewhere), gestational age and parity (dichotomised as primiparous vs multiparous) (adjusted odds ratio=AOR). These confounders were decided *a priori* based on what is known in the literature to affect outcomes. For simplicity, percentages were computed for the incidence of events at each birth setting. Unfortunately, state and territory-based data collections have inconsistent variables on other potential demographic factors such as maternal education, socioeconomic status or body mass index, limiting the variables available for controlling the analysis. We present analysis stratified by parity (first baby versus other) for normal labour and birth and perinatal mortality. For continuous data such as maternal age and gestation week, we used univariate general linear model for analysis of variance (ANOVA) to examine the differences between the means.

No imputation was made to missing data. All calculations in regression and rates were computed based on non-missing data. Wherever necessary, sizes of missing data (not stated/inadequately described) on related variables were reported. The analysis reports 99% confidence intervals. The statistical significance level was set at $p<0.01$ to have more precision due to the large sample size. Ethics approval requirements prevented us reporting cell sizes of less than five to maintain confidentiality. Further details on the methods is presented elsewhere.[27]

RESULTS

Demographic characteristics

The sample comprised 1 251 420 births that occurred between 1 January 2000 and 31 December 2012 to women with full-term, singleton pregnancies without complications. Of these, 1 171 703 (93.6%) births were planned in hospital labour wards (referred to as 'hospital' births), 71 505 (5.7%) in a birth centre and 8212 (0.7%) at home.

Women planning to give birth in hospital labour wards were more likely to be younger, primiparous, of a shorter gestation (less than 40 weeks) or non-Australian-born than those planning birth centre or home births (Table 1).

<Insert Table 1 here>

Mode of birth, intervention and analgesia by planned place of birth

Planned birth at home or in a birth centre was associated with normal labour and birth more often than planned hospital birth. Women planning a birth centre birth were almost three times as likely (AOR 2.72, 99% CI 2.63-2.81) and women planning a home birth were almost six times as likely (AOR 5.91, 99% CI 5.15-6.78) to have a normal birth (Table 2). The odds for primiparous and multiparous women were similar. Overall, the proportion of women having a normal labour and birth were high (79% to 95% across the groups).

<Insert Table 2 here>

Women planning hospital births were more likely to experience interventions in birth. Compared with planned hospital births, births planned in other settings had significantly lower odds of: vacuum extraction (birth centre AOR 0.42; 99% CI 0.40-0.44 and homebirth AOR 0.18; 99% CI 0.14-0.24), forceps (birth centre AOR 0.54; 99% CI 0.50-0.58 and homebirth AOR 0.21; 99% CI 0.14-0.31) and intrapartum caesarean section (birth centre AOR 0.45; 99% CI 0.43-0.48 and homebirth AOR 0.29; 99% CI 0.24-0.35). Overall, the rates of interventions in the whole cohort were low with a rate of intrapartum caesarean section of only 8%.

Women who planned a birth centre or home birth were significantly more likely to have an intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-0.73) and more likely in planned birth centre births (AOR 1.17; 53% CI 1.09-1.25). The odds of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI 0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births. The odds of other interventions such as oxytocin augmentation and epidural or spinal analgesia were lower in planned birth centre or home births (Table 3).

<Insert Table 3 here>

Maternal postpartum complications

Women who planned to give birth in a birth centre were less likely to have a PPH requiring a blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78). There was no significant difference in the odds for women who planned a home birth (AOR 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the absolute number of admissions is small (Table 4). There were no significant differences between the groups in the odds of readmission to hospital within a month.

<Insert Table 4 here>

Perinatal outcomes by planned place of birth

There were no significant differences in the odds of intrapartum stillbirth, or early or late neonatal deaths between the three planned places of birth. Combined data on stillbirth during labour, early and late neonatal death indicate that women planning a home birth were no more likely to experience perinatal mortality than those planning a hospital birth (AOR 1.55; 99% CI 0.65-3.69), although the absolute number of deaths was very small (9/8182). Similarly, there was no significant difference for women planning a birth centre birth (AOR 0.84; 99% CI 0.60-1.19). When women were stratified by parity, there were no significant differences between any of the groups in the odds of perinatal mortality.

Women who planned a birth centre birth were more likely to have their baby admitted to the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women who planned hospital births. This trend was not seen in planned home births (AOR 0.63; 99% CI 0.39-1.01). There were no significant differences between the three groups in the odds of readmission of the baby to hospital within 28 days (Table 5).

<Insert Table 5 here>

DISCUSSION

This study, the first in Australia, has examined maternal and perinatal outcomes nationally by planned place of birth including all eight states and territories. Our study has demonstrated results consistent with several international studies of planned place of birth.[11,12,14] Normal births were more likely for women who planned birth in birth centres or at home than in a hospital. Women who planned to give birth at home were slightly older than women planning hospital or birth centre births, but despite this, had consistently lower rates of intervention.

The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live births compared with 0.4 in planned birth centre births and 1.1 in planned home births, although the absolute risks were very small with low numbers of deaths overall. These differences by place of birth were neither statistically significant for all women nor for cohorts stratified by parity. However, the differences are more marked in primiparous women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned homebirth). Given the small number of deaths in the planned homebirth group (n=9) this may be a chance finding over a long period of time (13 years). However, it is similar the combined perinatal outcome in the Birthplace in England study[11], although that study did find statistically significant higher odds of a composite of perinatal mortality and selected early neonatal morbidities among primiparous women planning home births. This highlights the need to explain the risks to women in absolute terms, as this is likely to be more helpful in assisting decision-making.

There were two negative findings in relation to birth centre outcomes, firstly, a significantly higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned hospital births. Another Australian study[16] and one in New Zealand also found higher rates of perineal trauma in birth centres.[28] However, other research found no significant differences in perineal outcomes for example in studies in Norway,[29,30] Denmark,[31] Australia[32] or England.[33] The higher rate of severe perineal trauma may be related to the use of birth stools, more common in Australian birth centres but less frequently in hospitals or at home. Birth stools have been linked to higher rates of severe perineal trauma compared with other birth positions or waterbirth.[34] The higher rates of trauma could be due to better case ascertainment or lower rates of episiotomy.

The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other research, which either found higher rates associated with planned hospital births[16,28] or else no statistically significant differences in NICU admission rates from birth centres and hospital births.[29,31,35] The admissions to the NICU or SCN in the current study are low in absolute terms (1 per 100 for birth centre births) but higher than planned hospital births. This requires ongoing examination to determine possible reasons and ways to reduce the rate.

Strengths and limitations

This study is the first to comprehensively examine maternal and perinatal outcomes from three birth settings across Australia. It used a population-based sample consisting of women with low-risk pregnancies. The large sample size was sufficient to detect differences between the three groups, although the numbers of homebirth nationally, even over this time period, were comparatively small (i.e. 8212 only 0.7% of the total low-risk sample).

The context of homebirth in Australia means there are still low numbers of women choosing homebirth and hence small numbers in this population. Private practising midwives do not have access to professional indemnity insurance which means the option for women is limited although still available in some parts of the country. Some private practising midwives in some states have visiting rights to hospitals but this is not universal leading to a lack of potential lack of integration. The publicly funded home birth models are relatively

few (no more than 20 services across the country) and cater for small numbers of women. The policy and professional context has not been highly supportive of homebirth which has made scaling up of public services difficult.

Women with uncomplicated pregnancies were defined consistently across all three cohorts in the dataset. However, merging linked data from multiple jurisdictions created several challenges and potential shortcomings, including missing responses, inconsistent variable definitions and limited data from some states.[27] For example, Queensland's data collection only covered 2007-2012, resulting in under-representation: 9.6% of the combined sample, compared with 20.4% of Australian births in 2012.[36] The linked data sets also could not account for women who may have moved to another state or territory in the follow-up time frame.

Although we eliminated unintended home births among women intending hospital or birth centre births (births before arrival), the home birth data do not always record whether or not a qualified health professional attended. Within the constraints of the data available, we have only included births attended by a health professional. Moreover, different states recorded birthplace intentions at different times. Although this means that intended birth place is not always recorded at onset of labour, the scrupulous process of data cleaning and categorising eliminated most women with risk factors which would have rendered them ineligible for birth centre or home births. Thus, the recorded birthplace intention was as close as possible to that at labour onset. However, there is a possibility that some planned birth centre/home births were erroneously classified as planned hospital births.

Some data items were collected inconsistently across the jurisdictions, for example, transfer from home to hospital after the onset of labour. This was either because the data item did not exist or because it only recorded 'transfer', which could have been at any time during pregnancy. Therefore, we were unable to report on intrapartum transfer rates.

Inconsistencies in the data from different jurisdictions also affected the data analysis. The regression analysis incorporated very few potential confounders, limited to those for which consistent data were available nation-wide (i.e. maternal age, gestational age, parity and whether born in Australia or not). Socio-economic status is also inconsistently collected

across the country, as is maternal BMI and education, so we were unable to adjust for these factors.

It is possible, despite our best efforts to reduce selection bias is that there remains some residual confounding especially given the small numbers of women planning a homebirth. It is likely that women planning to give birth in a birth centre or at home, are likely to be different from those planning a hospital birth in a number of ways, including their attitudes to intervention and approach to birth. These are not able to be measured but may impact on the findings in relation to interventions and outcomes.

CONCLUSION

This study provides evidence on the safety of births planned in hospital, birth centre and at home across all states and territories in Australia by comparing cohorts of women with low-risk pregnancies. Inconsistencies between state-based datasets as described limited the number of variables available for analysis. However, for healthy women with low-risk pregnancies, planned birth centre births resulted in high rates of normal labour and birth, low rates of most maternal complications, and comparable perinatal mortality outcomes. Women planning home birth also had similarly positive maternal outcomes with no statistically significant differences in the rate of perinatal mortality or NICU admission. In absolute terms, the numbers of deaths were small, although the rate of perinatal mortality was higher among primiparous women who planned homebirths than their multiparous counterparts.

Box 1: Exclusion criteria

Women were excluded if the baby was:

- Born before 37 and after 41 completed weeks' gestation;
- Born before arrival for a planned birth at hospital or birth centre;
- Diagnosed antenatally with a congenital abnormality (all ICD-10-AM Q codes)

Women were also excluded if they had:

- Received no antenatal care;
- A previous caesarean section;
- A breech or non-vertex presentation;
- Labour induced for any reason;
- An elective caesarean section (pre-labour);
- Pre-existing (essential) and/or pregnancy-related hypertension;
- Pre-existing or gestational diabetes;
- Antepartum haemorrhage or any other relevant pregnancy complications
- ICD-10-AM Diagnosis
    - O10 Pre-existing hypertension complicating pregnancy, childbirth and the puerperium
    - O11 Pre-eclampsia superimposed on chronic hypertension
    - O13 Gestational [pregnancy-induced] hypertension
    - O14 Pre-eclampsia
    - O15 Eclampsia
    - O24 Diabetes mellitus in pregnancy
    - O30 Multiple gestation
    - O31.2 Continuing pregnancy after intrauterine death of one fetus or more
    - O36.4 Maternal care for intrauterine death
    - O42 Premature rupture of membranes
    - O46 Antepartum haemorrhage
    - O75.5 Delayed delivery after artificial rupture of membranes
    - O75.7 Vaginal delivery following previous caesarean section
    - P95 Fetal death of unspecified cause

Box 2: Maternal and perinatal outcomes

Maternal outcomes include mode of birth, interventions and procedures during labour and birth (episiotomy, epidural or spinal analgesia, oxytocin augmentation) and perineal status.

Mode of birth includes caesarean section, forceps birth, vacuum extraction, and normal vaginal birth (non-instrumental).

Normal labour and birth is defined as spontaneous labour, cephalic presentation, without epidural, spinal or general anaesthesia, forceps, vacuum extraction, episiotomy or caesarean section.

P*ostpartum complications* were severe perineal trauma (3rd or 4th degree tear), postpartum haemorrhage (PPH) requiring a transfusion, admission to intensive care or high dependency unit for more than 48 hours and hospital readmission within 28 days.

Perinatal outcomes include intrapartum stillbirth, early neonatal death (0-7 days), late neonatal death (8-28 days), admission to special care or neonatal intensive care unit (NICU) for more than 48 hours and readmission to hospital within 28 days. We also stratified combined perinatal mortality data by parity. Combined perinatal loss included stillbirth during labour, early and late neonatal death.

Box 3: Proportion of births included in sample, by state and territory

State or Territory	NSW	QLD	VIC	SA	WA	TAS	ACT	NT	Total
Years of data provided	2000-2012	2007-2012	2000-2012	2000-2012	2000-2012	2005-2012	2000-2012	2000-2012	
Number of births which met low-risk criteria for this study	507 017	114 245	370 356	69 356	130 848	19 915	23 484	16 199	1 251 420
Proportion of total study sample	40.5%	9.1%	29.6%	5.5%	10.5%	1.6%	1.9%	1.3%	100%

Key to the states and territories: NSW - New South Wales; Qld - Queensland, VIC – Victoria; SA – South Australia; WA – Western Australia; TAS – Tasmania; ACT – Australian Capital Territory; NT – Northern Territory

Table 1: Demographic characteristics by planned place of birth

	Hospital	Birth Centre	Home
All women	**1 171 703 (93.6%)**	**71 505 (5.7%)**	**8212 (0.7%)**
Maternal age (years) - mean (sd)	29.0 (5.6)	29.8 (5.3)	31.8 (5.0)
Maternal age (years)			
<20	61 451 (5.2%)	2044 (2.9%)	71 (0.9%)
20-24	200 386 (17.1%)	10 116 (14.1%)	548 (6.7%)
25-29	348 785 (29.8%)	21 579 (30.2%)	2047 (24.9%)
30-34	365 022 (31.2%)	23 949 (33.5%)	3058 (37.2%)
35-39	167 803 (14.3%)	11 931 (16.7%)	1997 (24.3%)
≥40	28 177 (2.4%)	1886 (2.6%)	474 (5.8%)
Missing	79 (0.0%)	0 (0.0%)	17 (0.2%)
Previous pregnancies (≥20weeks)			
0	494 019 (42.2%)	28 891 (40.4%)	2295 (27.9%)
1	376 047 (32.1%)	25 079 (35.1%)	2745 (33.4%)
2	174 873 (14.9%)	11 364 (15.9%)	1688 (20.6%)
≥3	126 111 (10.8%)	6153 (8.6%)	1456 (17.7%)
Not stated	653 (0.1%)	18 (0.0%)	28 (0.3%)
Gestation* - mean (sd)	39.5 (1.0)	39.6 (1.0)	39.8 (1.0)
Gestation*			
37	54 825 (4.7%)	2403 (3.4%)	209 (2.5%)
38	155 764 (13.3%)	7470 (10.4%)	724 (8.8%)
39	323 179 (27.6%)	18 278 (25.6%)	1666 (20.3%)
40	481 665 (41.1%)	29 289 (41.0%)	3779 (46.0%)
41	156 270 (13.3%)	14 065 (19.7%)	1834 (22.3%)

Maternal country of birth			
Australia	889 550 (75.9%)	56 201 (78.6%)	6822 (83.1%)
Others	276 001 (23.6%)	15 105 (21.1%)	1188 (14.5%)
Inadequately described/not stated	6152 (0.5%)	199 (0.3%)	202 (2.5%)

*Gestation is in completed weeks

Note: Chi-square tests on categorical data within each sub-heading between birth settings yielded statistically significant differences with $p<0.001$ in all categories with no missing or not stated data. GLM revealed significant differences at $p<0.0001$ between means in all pairwise comparisons. Percentages may not total exactly 100% due to rounding.

Table 2: Normal labour and birth† by planned place of birth and parity

Planned place of birth	No. events – normal labour and birth†	Total number of births	Incidence of events (%)	Unadjusted OR	Adjusted OR Æ
All women	991 534	1 250 721	79.3		
Hospital	919 974	1 171 050	78.6	1	1
Birth Centre	63 773	71 487	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7787	8184	95.1	5.35 (4.69-6.11)	5.91 (5.15-6.78)
Primiparous women^^	322 640	525 205	61.4		
Hospital	298 243	494 019	60.4	1	1
Birth Centre	22 401	28 891	77.5	2.27 (2.18-2.35)	2.60 (2.50-2.70)
Home	1996	2295	87.0	4.38 (3.73-5.14)	5.99 (5.09-7.04)
Multiparous women^^	668 894	725 516	92.2		
Hospital	621 731	677 031	91.8	1	1
Birth Centre	41 372	42 596	97.1	3.01 (2.79-3.24)	3.27 (3.03-3.53)
Home	5791	5889	98.3	5.26 (4.04-6.83)	5.86 (4.50-7.62)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
† Normal labour and birth – spontaneous labour, no epidural or spinal, general anaesthesia, forceps, vacuum extraction, episiotomy or caesarean section.
^^ Parity refers to previous pregnancies >20 weeks and is dichotomised.
Cases with missing data were not included in rates or regression calculations

Table 3: Mode of birth and intervention rates by planned place of birth

Intervention and planned place of birth	No, of events	No of births	Incidence of events (%)	Unadjusted OR	Adjusted OR Æ
Normal vaginal birth	992 118	1 251 420	79.3		
Hospital	920 514	1 171 703	78.6	1	1
Birth Centre	63 790	71 505	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7814	8212	95.2	5.36 (4.69-6.12)	5.91 (5.15-6.78)
Vacuum extraction	88 586	1 251 420	7.1		
Hospital	85 975	1 171 703	7.3	1	1
Birth Centre	2503	71 505	3.5	0.46 (0.43-0.48)	0.42 (0.40-0.44)
Home	108	8212	1.3	0.17 (0.13-0.22)	0.18 (0.14-0.24)
Forceps birth	56 332	1 251 420	4.5		
Hospital	54 451	1 171 703	4.6	1	1
Birth Centre	1820	71 505	2.5	0.54 (0.50-0.57)	0.54 (0.50-0.58)
Home	61	8212	0.7	0.15 (0.11-0.21)	0.21 (0.14-0.31)
Intrapartum caesarean section	94 303	1 251 420	7.5		
Hospital	91 238	1 171 703	7.8	1	1
Birth Centre	2871	71 505	4.0	0.50 (0.47-0.52)	0.45 (0.43-0.48)
Home	194	8212	2.4	0.29 (0.24-0.35)	0.29 (0.24-0.35)
Mode of birth not stated	20 081	1 251 420	1.6		
Hospital	19 525	1 171 703	1.7	1	1
Birth Centre	521	71 505	0.7	0.43 (0.39-0.49)	0.41 (0.36-0.46)
Home	35	8212	0.4	0.25 (0.16-0.39)	0.26 (0.17-0.41)
Intact perineum*	308 232	1 157 117	26.6		
Hospital	283 887	1 080 465	26.3	1	1
Birth Centre	20 562	68 634	30.0	1.20(1.17-1.23)	1.39(1.36-1.43)
Home	3783	8018	47.2	2.51(2.37-2.66)	2.72(2.56-2.90)
3rd or 4th degree perineal trauma	23 165	1 157 117	2.0		
Hospital *¥	21 454	1 080 465	2.0	1	1
Birth Centre	1641	68 634	2.4	1.21 (1.13-1.29)	1.17 (1.09-1.25)
Home	70	8018	0.9	0.43 (0.32-0.59)	0.53 (0.36-0.73)

Episiotomy*	193 171	1 157 117	16.7		
Hospital	187 276	1 080 465	17.3	1	1
Birth Centre	5688	68 634	8.3	0.43 (0.42-0.45)	0.37 (0.36-0.39)
Home	207	8018	2.6	0.13 (0.11-0.15)	0.13 (0.10-0.15)
Oxytocin augmentation	199 302	1 251 420	15.9		
Hospital	193 229	1 171 703	16.5	1	1
Birth Centre	5790	71 505	8.1	0.45 (0.43-0.46)	0.41 (0.40-0.43)
Home	283	8212	3.4	0.18 (0.15-0.21)	0.19 (0.16-0.22)
Epidural or spinal analgesia for labour	166 746	1 251 420	13.3		
Hospital	161 796	1 171 703	13.8	1	1
Birth Centre	4675	71 505	6.5	0.44 (0.42-0.45)	0.41 (0.39-0.43)
Home	275	8212	3.3	0.22 (0.18-0.25)	0.22 (0.19-0.26)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
* Denominator = excluded caesarean section
¥ Included episiotomy extensions
Cases with missing data were not included in rates or regression calculations.
Variables on mode of birth and intervention are as defined by each state or territory.

Table 4: Maternal postpartum complications by planned place of birth

Complication and planned place of birth	No of events	No of births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Postpartum haemorrhage with blood transfusion	6518	1 251 420	5.2		
Hospital	6230	1 171 703	5.3	1	1
Birth Centre	244	71 505	3.4	0.64 (0.54-0.76)	0.66 (0.56-0.78)
Home	44	8212	5.4	1.01 (0.68-1.49)	1.08 (0.73-1.60)
Admission at least 48 hrs to intensive care or high dependency unit∞	2602	707 221*	3.7		
Hospital	2521	654 960	3.8	1	1
Birth Centre	74	47 266	1.6	0.41 (0.30-0.55)	0.42 (0.31-0,56)
Home	7	4995	1.4	0.36 (0.14-0.96)	0.41 (0.15-1.08)
Readmission to hospital (within 28 days)	917	864 865**	1.1		
Hospital	843	804 667	1.0	1	1
Birth Centre	68	54 522	1.2	1.19 (0.86-1.65)	1.18 (0.85-1.64)
Home	6	5676	1.1	1.01 (0.35-2.90)	1.08 (0.38-3.12)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
* Excluded QLD, VIC, NT, ACT, TAS
∞ Intensive care and high dependency units provided additional care – these were defined by each state and territory
** Excluded VIC, NT
Cases with missing data were not included in rates or regression calculations

Table 5: Perinatal outcomes by planned place of birth and parity^^

Planned place of birth	No. of events	No. of births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Stillbirth during labour, early and late neonatal death	921	1 251 420	0.7		
Hospital	880	1 171 050	0.8	1	1
Birth Centre	32	71 505	0.4	0.60 (0.37-0.95)	0.84 (0.60-1.19)
Home	9	8212	1.1	1.46 (0.62-3.47)	1.55 (0.65-3.69)
Primiparous women	425	525 205	0.8		
Hospital	406	494 019	0.8	1	1
Birth Centre	15	28 891	0.5	0.63 (0.32-1.24)	0.65 (0.33-1.27)
Home	na	2295	na	na	na
Multiparous women	496	725 516	0.7		
Hospital	474	677 031	0.7	1	1
Birth Centre	17	42 596	0.4	0.57 (0.30-1.08)	0.65 (0.34-1.23)
Home	5	5889	0.8	1.21 (0.38-3.86)	1.29 (0.40-4.14)
Stillbirth during labour	399	1 251 420	0.32		
Hospital	378	1 171 703	0.32	1	1
Birth Centre	17	71 505	0.24	0.74 (0.39-1.40)	0.78 (0.41-1.48)
Home	na	8212	na	na	na
Early neonatal death[1]	240	881 064*	0.27		
Hospital	221	819 963	0.27	1	1
Birth Centre	14	55 312	0.25	0.84 (0.46-1.91)	0.94 (0.46-1.92)
Home	5	5789	0.86	3.21 (1.00-10.28)	3.18 (0.98-10.30)
Late neonatal death[2]	95	881 064*	0.11		
Hospital	94	819 963	0.11	1	1
Birth Centre	na	55 312	na	na	na
Home	na	5789	na	na	na
Admission to SCN and/or NICU >48hrs[3]	7500	881 064*	8.51		
Hospital	6908	819 963	8.42	1	1
Birth Centre	562	55 312	10.16	1.21 (1.08-1.35)	1.24 (1.10-1.39)

Home	30	5789	5.18	0.61 (0.38-0.98)	0.63 (0.39-1.01)
Readmission to hospital within 28 days[4]	37 569	1 251 420	30.02		
Hospital	35 413	1 171 703	30.22	1	1
Birth Centre	1967	71 505	27.51	0.91 (0.85-0.96)	0.95 (0.90-1.01)
Home	189	8212	23.02	0.76 (0.63-0.91)	0.83 (0.68-1.00)

^Denominator excluded missing parity information. The denominator in the first section of this table has 699 records with missing data for parity. Because this part of the data analysis was stratified by parity, we excluded the women whose parity data were unavailable.

na: cell size <5 so unable to report data or calculate incidence or OR

[1] Early neonatal death: death of a liveborn infant occurring within 7 completed days from the time of birth.

[2] Late neonatal death: death of a liveborn infant occurring after 7 completed days but before 29 completed days.

[3] NICU and SCN were combined due to complexities in the data to separate them out for all states and territories, except the Northern Territory where there was only SCN available and for South Australia where only NICU was available.

[4] For home births, this is defined as admission to hospital following birth within 28 days.

* Excluded VIC.

Æ Logistic regression was undertaken with adjustments occurring for maternal age, country of birth, gestational age, and parity at 99% CI. Any case with missing data was excluded from the regression.

^^ Parity refers to previous pregnancies >20 weeks.

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SUPPLEMENTARY FILE 1

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) – University of Technology Sydney, Australia (university reference number: 2012000167). Each state and territory also provided ethical approval.

State or territory	Name of the ethics committee(s)	Number/ID of the approval
Australian Capital Territory	ACT Health HREC	ETH 3.14.061
New South Wales	NSW Population and Health Services HREC	HREC/14/CIPHS/15
Northern Territory	Department of Health of the Northern Territory and the Menzies School of Health Research HREC	HREC 2014-2247
Queensland	Qld Health Office of the HREC	HREC/14/QGC/175
South Australia	South Australian Health HREC	HREC/14/SAH/117
Tasmania	Tasmania Network HREC	Ref No: H0015023
Victoria	Department of Health and Human Services – Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM)	Ref: 14/12
Western Australia	Government of Western Australia, Department of Health HREC	HREC 2014/57

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page no
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8-9
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-11
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11-12
		(*b*) Describe any methods used to examine subgroups and interactions	11-12
		(*c*) Explain how missing data were addressed	12
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12 Table 1
		(b) Give reasons for non-participation at each stage	12
		(c) Consider use of a flow diagram	Table 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	In each table
		(c) Summarise follow-up time (eg, average and total amount)	NA

Outcome data	15*	Report numbers of outcome events or summary measures over time	12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14 Plus tables
		(*b*) Report category boundaries when continuous variables were categorized	Tables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Maternal and perinatal outcomes by planned place of birth in Australia 2000 – 2012: A linked population data study

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Complete List of Authors:	Homer, Caroline; University of Technology Sydney, Centre for Midwifery, Child and Family Health; Burnet Institute, Maternal and Child Health Cheah, Seong; University of Technology Sydney Faculty of Health, Centre for Midwifery, Child and Family Health Rossiter, Chris; University of Technology Sydney, Dahlen, Hannah; University of Western Sydney, School of Nursing and Midwifery Ellwood, David; Griffith University, School of Medicine Foureur, Maralyn; UTS, Health Forster, Della; La Trobe University, Judith Lumley Centre; Royal Women's Hospital, Maternity Services McLachlan, HL; La Trobe University, Judith Lumley Centre; La Trobe University, School of Nursing and Midwifery Oats, Jeremy; University of Melbourne Institute, Melbourne School of Population and Global Health Sibbritt, David; University of Technology Sydney, Faculty of Health Thornton , Charlene ; Flinders University Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Scarf, Vanessa; University of Technology Sydney, Centre for Midwifery, Child and Family Health
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Maternal and perinatal outcomes by planned place of birth in Australia 2000 – 2012: A linked population data study

Homer, Caroline SE
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia
Maternal and Child Health Program, Burnet Institute, Melbourne, Australia

Cheah, Seong
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Rossiter, Chris
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Dahlen, Hannah G
School of Nursing and Midwifery, University of Western Sydney, Sydney, Australia

Ellwood, David
School of Medicine, Griffith University, and Gold Coast University Hospital, Queensland, Australia

Foureur, Maralyn
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Forster, Della
Judith Lumley Centre; Royal Women's Hospital, Maternity Services, La Trobe University, Melbourne, Australia

McLachlan, Helen L
Judith Lumley Centre; La Trobe University, Melbourne, Australia

Oats, Jeremy
Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia

Sibbritt, David
Faculty of Health, University of Technology Sydney, Sydney, Australia

Thornton, Charlene
Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Flinders University, Adelaide, Australia

Scarf, Vanessa L
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Corresponding author
Professor Caroline Homer AO
University of Technology Sydney, Australia
T +613 8506 2454
M +61 418 466 974
E caroline.homer@uts.edu.au

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ABSTRACT

Objective – To compare perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, in hospital labour wards, birth centres or at home.

Design – A population-based retrospective design, linking and analysing routinely collected electronic data. Analysis comprised chi-square tests and binary logistic regression for categorical data, yielding adjusted odds ratios. Continuous data were analysed using ANOVA.

Setting – All eight Australian states and territories.

Participants – Women with uncomplicated pregnancies who gave birth between 2000 and 2012 to a singleton baby in cephalic presentation at between 37 and 41 completed weeks' gestation. Of the 1 251 420 births, 1 171 703 (93.6%) were planned in hospital labour wards, 71 505 (5.7%) in birth centres and 8212 (0.7%) at home.

Main outcome measures – Mode of birth, normal labour and birth, interventions and procedures during labour and birth, maternal complications, admission to special care/high dependency or intensive care units (mother or infant) and perinatal mortality (intrapartum stillbirth and neonatal death).

Results – Compared with planned hospital births, the odds of normal labour and birth were over twice as high in planned birth centre births (AOR 2.72; 99% CI 2.63-2.81) and nearly six times as high in planned home births (AOR 5.91; 99% CI 5.15-6.78). There were no statistically significant differences in the proportion of intrapartum stillbirths, early or late neonatal deaths between the three planned places of birth.

Conclusions – This is the first Australia-wide study to examine outcomes by planned place of birth. For healthy women in Australia having an uncomplicated pregnancy, planned births in birth centres or at home are associated with positive maternal outcomes although the number of homebirths was small overall. There were no significant differences in the perinatal mortality rate, although the absolute numbers of deaths were very small and therefore firm conclusions cannot be drawn about perinatal mortality outcomes.

ARTICLE SUMMARY

Strengths and limitations of this study

- This retrospective study reveals the first Australia-wide evidence on the relative safety of planned birth in hospital, a birth centre and at home.
- It analyses linked data on the outcomes for women with uncomplicated pregnancies and their infants in all eight Australian states and territories.
- Careful data screening eliminated most causes of obstetric complexity, resulting in three cohorts with equivalent levels of risk.
- Inconsistency between state-based datasets limited the number of confounding variables available for analysis.
- Insufficient data on changes in planned birth place prior to labour hampered identification of intrapartum transfers and analysis of the relationship between intended and actual place of birth.

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Competing interest statement

We have read and understood *BMJ* policy on declaration of interests and declare that we have no competing interests.

Acknowledgements

We acknowledge and thank the data custodians in each state and territory and the data linkage units who assisted with data collection at each jurisdictional level.

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) (university reference number: 2012000167) and from data custodians in each state and territory. The details are provided in a Supplementary File.

Author contribution

CH as the lead investigator was responsible for the overall leadership of the study including the initial conception and design, grant application, ethical approval processes, leading the project, drafting the manuscript and finalising the paper.

SC was the data analyst responsible for merging the datasets from each jurisdiction, refining the datasets, developing the analysis codes and processes, and conducting the statistical analysis and has provided final approval of this version.

CR worked with the data analyst to support data analysis and interpretation as well as taking a key role in supporting the drafting of the manuscript and has provided final approval of this version.

HD was involved in the initial design of the study, played a key role in developing the study questions and data analytic processes, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DE was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

MF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

HM was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

JO was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DS was involved in the initial design of the study, played a key role in developing the study questions and analytic processes and providing expert statistical planning and review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

CT played a key role in developing the study questions and analytic plan, assisted with planning the data set merging and cleaning of the data and providing expert epidemiological review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

VS was the project coordinator responsible for the ethical approval processes, took a key role in coordinating the acquisition of the data from the different states and territories as well as a lead role in planning and undertaking the analysis and interpretation, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

Consent

Individual consent by participants was deemed to not be required due to the population-based de-identified form of the data released to the researchers.

Data sharing statement

The data that support the findings of this study are not available. It was a condition of the agreement between the data linkage units and the researchers that the dataset remain confidential. We are not permitted to make any part of the linked data available to any party outside those named on the research team who have been granted access.

INTRODUCTION

In Australia, most births occur in hospitals (97.5% in 2015), with some variation across the eight states and territories (for example, 91% in the Australian Capital Territory to 99% in Victoria).[1] Women with uncomplicated pregnancies (women who are healthy without medical or obstetric risk factors [2] [see the Methods for the definition]) and are planning hospital births in the public health system receive antenatal care from hospital-based midwives and doctors, sometimes within continuity of care models, and often in partnership with local general practitioners. Hospital midwives attend their labour and birth, with medical involvement as required or in line with local protocols. In the private health system (where 25% of births take place), women receive antenatal care from private obstetricians or midwives employed by obstetricians. Hospital midwives attend their labour and birth and the obstetrician attends during the labour and is usually at the birth.[3,4] There are some differences across Australia in the way care is provided, especially the local guidelines and the choices available to women. The availability of different models of care varies across the country.

While most births take place in hospital labour wards or birth suites, a small proportion (1.8% nationally) take place in midwife-run birth centres.[1] In Australia these birth centres are typically co-located with hospitals (similar to alongside midwifery units in other countries) although a small number of stand-alone birth centres exist.[5] Birth centres typically provide midwifery continuity of care to women with uncomplicated pregnancies in a home-like environment and are well integrated into the health system.

Less than 0.3% of Australian births take place at home, ranging from 0.1% of births in New South Wales to 0.6% in the Northern Territory.[1,6] Most planned home births are attended by midwives working in private practice, some of whom also attend women in birth centres and hospitals. The integration of private homebirth services varies across the country. A small number of hospitals and birth centres offer home births through the public health system.[7] An evaluation of the outcomes of publicly funded models providing homebirth showed that the rate of stillbirth and early neonatal mortality was low, at 1.7 per 1000 births. However, the sample size did not have sufficient power to generate a conclusion about safety.[8]

We have conducted a systematic review to examine maternal and perinatal outcomes associated with planned place of birth for women with uncomplicated pregnancies in high-income countries.[9] In this analysis of 28 studies from 13 countries, women who planned hospital births had significantly higher rates of perineal trauma and instrumental/caesarean birth than those who planned other birth places. Overall, there was no significant difference in the odds of intrapartum stillbirth according to place of birth (compared with planned hospital births, planned homebirth: OR=0.94; 95% CI: 0.76-1.17; planned birth centre OR=0.66; 95% CI: 0.32-1.34) or in early neonatal deaths (planned home birth OR=1.00; 95% CI: 0.78-1.27; planned birth centre 0.87; 95% CI: 0.29-2.61).

Previous Australian state-based studies into place of birth have showed variation in findings. In New South Wales (the most populous state accounting for around 30.9% of births)[10], women without pregnancy complications who planned a home or birth centre birth had significantly higher proportions of normal birth than those planning hospital births (home 97.4% vs birth centre 86.0% vs hospital 73.9%). There was no significant difference in neonatal mortality although the overall sample size (n= 258 161, including only 742 planned home births), had insufficient power for these relatively rare outcomes. In South Australia (SA) (297 192 planned hospital births and 1141 [0.38%] planned home births), another study found lower intervention rates and equivalent perinatal death rates in home births compared to hospital births. However, the odds of an intrapartum fetal death were significantly higher among planned home births (two deaths in the planned home birth group; AOR 7.42; 95% CI: 1.53–35.87). This study included some women with recognised risk factors in the home birth group including twins.[11] Large-scale studies in other countries show similar perinatal outcomes between births planned at home and in hospitals (and birth centres where these exist) with some differences for primiparous women.[12-15]

There is less controversy about birth centres compared with homebirth. Data from Australian birth centres indicate lower rates of maternal morbidity,[16] intervention, preterm birth and low birthweight compared with hospital births for women with similar risk profiles.[17] One study identified no significant differences by birth place in perinatal mortality[17] and another reported lower perinatal mortality in birth centre births, although based on actual rather than intended birth place.[18] A smaller hospital-based study found no significant difference in caesarean section rates between the birth centre and labour ward

for women with uncomplicated pregnancies.[19] Two other birth centre studies reported higher rates of spontaneous vaginal birth and lower rates of adverse infant outcomes (neonatal intensive care unit [NICU] admission, low birthweight) compared to hospital births.[20,21]

The safety of place of birth continues to be questioned in Australia.[22] To generate evidence to assist policy makers, health practitioners, and pregnant women and their families to make informed decisions about place of birth, we undertook a national study combining data from all eight Australian jurisdictions to examine the outcomes for women with uncomplicated pregnancies related to three different birth settings. This is the first national study on the comparative safety of different planned birth settings in Australia.

Aim and objectives

The study aimed to compare the perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, hospital labour wards, birth centres or at home. Outcomes investigated included normal labour and birth, mode of birth, interventions during labour, postpartum maternal complications and perinatal mortality and morbidity. We defined *uncomplicated pregnancy* as a singleton fetus in cephalic presentation between 37 and 41 completed weeks' gestation and free of known and recorded complications. Exclusions are detailed in Box 1.

METHODS

Study design

The study used a population-based retrospective design, linking and analysing routinely collected electronic data from multiple sources about births between 2000 and 2012 to women with uncomplicated pregnancies. We compared outcomes from three cohorts comprising women who were as comparable as possible given the available data. In Australia, homebirth and birth centre options are mostly restricted to women who meet specific criteria, that is, have an uncomplicated pregnancy and no relevant past medical or obstetric history. We therefore endeavoured to ensure that the hospital cohort shared the same characteristics, clinically if not demographically and applied the same filters on all three cohorts to increase the similarity between groups.

The study was approved by a university Human Research Ethics Committee (HREC). HRECs in each state and territory also approved access to anonymised linked data (see Supplementary File 1).

Patient and Public Involvement

Patients and the public were not involved in the design or conduct of the study.

Data sources

All eight Australian states and territories compile electronic perinatal datasets with items on maternal characteristics, labour, birth, and perinatal outcomes in the immediate postpartum period, that is, during the birth admission. However, to eliminate women with conditions that made them fall out of the uncomplicated criteria from the sample and to examine deaths and major morbidity requiring hospitalisation beyond the perinatal period, we examined additional data sources on deaths and hospital admissions nine months before and twelve months following birth. This study used linked anonymous data on all available mothers and infants from the following sources:

- *Perinatal Data Collection* (PDC) – maternal and infant data on all live births and stillbirths from 20 weeks' gestation or >400g birth weight;
- *Admitted Patient Data Collection* (APDC) – services provided to all individuals admitted to public and private hospitals, using the International Classification of Diseases – Australian modifications (ICD-10-AM)[23] for clinical data;
- *Registry of Births, Deaths and Marriages* (RBDM) – all registered births and deaths;
- *Australian Bureau of Statistics* (ABS) – data on deaths including primary cause of death (only for NSW and Queensland).

It was not possible to obtain data from all sources for all states and territories for the full study period due to differences in data collection systems. Table footnotes indicate the scope of data for each variable. In addition, not all states and territories provided data on maternal mortality.

Definitions

The definition of *uncomplicated pregnancies* (those without medical or obstetric risk factors) was determined a priori by the research team. For the most part, this used the Australian College of Midwives Guidelines for Consultation and Referral[2] as a basis for the description of uncomplicated pregnancies.

< Insert Box 1 here >

Planned place of birth incorporates three possible locations: home, birth centre, and hospital. *Homebirths* are instances where women intend to give birth outside a formal health facility, usually their own home, and receive care from a registered midwife, funded through either the public or private health system or self-funded. *Birth centres* provide a home-like birth setting and are run by midwives. They can be located within a hospital campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the main hospital service for access to interventions such as epidural analgesia or caesarean section. *Hospital births* take place in the labour ward or birth suite (terms vary across the country) of either a public or private hospital, and women are attended by midwives, obstetricians and/or general practitioner (GP) obstetricians.

The timing of the decision about birth setting is critical within the birthplace literature. While women choose a birth location early in their pregnancy, clinical factors may preclude them from achieving this intention. If they develop complications, they may no longer be eligible to give birth in a birth centre or at home. These women are excluded from comparisons of outcome by birth setting if they transfer to hospital care prior to labour. Ideally, researchers should identify planned place of birth at labour onset, to ensure that all participants have a similar level of clinical complexity. All Australian data collections record intended place of birth, but the majority did not indicate intention at labour onset. Therefore, the current study analyses data on planned place of birth identified at an undetermined time in the pregnancy, as close to labour as we were able to identify. The screening process eliminated women with many of the risk factors that would have prompted antenatal transfer from a birth centre or homebirth.

Box 2 provides the definitions of the maternal and perinatal outcomes.

< Insert Box 2 here >

Data linkage

Independent data linkage units (DLU) in each state and territory matched information from the four data sources (where available), using probabilistic linkage techniques.[24,25] This generated de-identified health records linking information from multiple datasets about the same individuals. This process yields the best available data on maternal and infant health status. However, it is not infallible and has estimated false positive and false negative rates of 0.5% each.[26]

Cross-jurisdictional data linkage was not possible, as independent DLUs had diverging protocols for maintaining patient privacy. We therefore applied to the individual data custodians for access to the linked data, through the six DLUs (data linkage for the Australian Capital Territory and the Northern Territory is provided by NSW and SA units respectively). Data were combined on relevant variables, where comparable, into a national dataset. Box 3 provides details on the datasets. Our approach to the data linkages and combining issues are detailed elsewhere. [27]

< Insert Box 3here >

Data cleaning, screening and cohort selection

Because the data collections were developed separately in each state and territory (except ABS collections), they had different characteristics and components. In particular, several PDC and APDC variables differed in name and type by jurisdiction. Even within the same state, some variable definitions changed over the study period, with items merged or split into multiple variables over time. The researchers scrutinised definitions to ensure accurate matching between variables with different names and attributes into a standardised dataset. The variables on mode of birth and intervention are all as defined by each state or territory.

Our broad request to state DLUs specified data on women with singleton pregnancies and a cephalic presentation at 37 to 41 completed weeks' gestation. Datasets arrived in different formats and met our criteria to varying extents. We then applied more specific inclusion and exclusion criteria (Box 1) to generate the sample.

Data analysis

Data were converted to SPSS Version 24, then grouped according to women's planned place of birth for intention to treat analysis. Descriptive statistics were generated and reported using percentages (or incidence per 1000 births for postpartum complications and perinatal outcomes).

Categorical variables were initially compared using chi-square tests. For continuous data such as maternal age and gestation week, we used univariate general linear model for analysis of variance (ANOVA) to examine the differences between the means. Odds ratios comparing each outcome by planned place of birth were calculated using logistic regression, adjusted for maternal age, maternal country of birth (Australia or elsewhere), gestational age and parity (dichotomised as primiparous vs multiparous) (adjusted odds ratio=AOR). These confounders were decided *a priori* based on what is known in the literature to affect outcomes. Percentages or proportions (events per 1000) were computed for the incidence of events at each birth setting. We present analysis stratified by parity (first baby versus other) for normal labour and birth and perinatal mortality.

No imputation was made to missing data. All calculations in regression and rates were computed based on non-missing data. Wherever necessary, sizes of missing data (not stated/inadequately described) on related variables were reported. The analysis reports 99% confidence intervals. The statistical significance level was set at $p<0.01$ to have more precision due to the large sample size. Ethics approval requirements prevented us reporting cell sizes of less than five to maintain confidentiality. Further details on the methods is presented elsewhere.[27]

RESULTS

Demographic characteristics

The sample comprised 1 251 420 births that occurred between 1 January 2000 and 31 December 2012 to women with full-term, singleton pregnancies without complications. Of these, 1 171 703 (93.6%) births were planned in hospital labour wards (referred to as 'hospital' births), 71 505 (5.7%) in a birth centre and 8212 (0.7%) at home.

Women planning to give birth in hospital labour wards were more likely to be younger, having their first birth (primiparous), of a shorter gestation (less than 40 weeks) or non-Australian-born than those planning birth centre or home births (Table 1).

<Insert Table 1 here>

Mode of birth, intervention and analgesia by planned place of birth

Planned birth at home or in a birth centre was associated with normal labour and birth more often than planned hospital birth. Women planning a birth centre birth were almost three times as likely (AOR 2.72, 99% CI 2.63-2.81) and women planning a home birth were almost six times as likely (AOR 5.91, 99% CI 5.15-6.78) to have a normal birth (Table 2). The odds for primiparous and multiparous women were similar. Overall, the proportion of women having a normal labour and birth were high (79% to 95% across the groups).

<Insert Table 2 here>

Women planning hospital births were more likely to experience interventions in birth. Compared with planned hospital births, births planned in other settings had significantly lower odds of: vacuum extraction (birth centre AOR 0.42; 99% CI 0.40-0.44 and homebirth AOR 0.18; 99% CI 0.14-0.24), forceps (birth centre AOR 0.54; 99% CI 0.50-0.58 and homebirth AOR 0.21; 99% CI 0.14-0.31) and intrapartum caesarean section (birth centre AOR 0.45; 99% CI 0.43-0.48 and homebirth AOR 0.29; 99% CI 0.24-0.35). Overall, the rates of interventions in the whole cohort were low with a rate of intrapartum caesarean section of only 8%.

Women who planned a birth centre or home birth were significantly more likely to have an intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-0.73) and more likely in planned birth centre births (AOR 1.17; 53% CI 1.09-1.25). The odds of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI 0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births. The odds of other interventions such as oxytocin augmentation and epidural or spinal analgesia were lower in planned birth centre or home births (Table 3).

<Insert Table 3 here>

Maternal postpartum complications

Women who planned to give birth in a birth centre were less likely to have a PPH requiring a blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78). There was no significant difference in the odds for women who planned a home birth (AOR 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the absolute number of admissions is small (Table 4). There were no significant differences between the groups in the odds of readmission to hospital within a month.

<Insert Table 4 here>

Perinatal outcomes by planned place of birth

Although the planned homebirth group had higher odds ratios for intrapartum stillbirth and early neonatal death than the other planned places of birth, the differences were not statistically significant. Combined data on stillbirth during labour, early and late neonatal death indicate that indicate that perinatal death is no more likely to occur after planned homebirth than in hospital birth (AOR 1.55; 99% CI 0.65-3.69), although the absolute number of deaths was very small (9/8182). Similarly, there was no significant difference for women planning a birth centre birth (AOR 0.84; 99% CI 0.60-1.19). When women were stratified by parity, there were no significant differences between any of the groups in the odds of perinatal mortality.

Women who planned a birth centre birth were more likely to have their baby admitted to the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women who planned hospital births. This trend was not seen in planned home births (AOR 0.63; 99% CI 0.39-1.01). There were no significant differences between the three groups in the odds of readmission of the baby to hospital within 28 days (Table 5).

<Insert Table 5 here>

DISCUSSION

This study, the first in Australia, has examined maternal and perinatal outcomes nationally by planned place of birth including all eight states and territories. Our study has demonstrated results consistent with several international studies of planned place of birth.[12,13,15] Normal births were more likely for women who planned birth in birth centres or at home than in a hospital. Women who planned to give birth at home were slightly older than women planning hospital or birth centre births, but despite this, had consistently lower rates of intervention.

The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live births compared with 0.4 in planned birth centre births and 1.1 in planned home births, although the absolute risks were very small with low numbers of deaths overall. These differences by place of birth were neither statistically significant for all women nor for cohorts stratified by parity. However, the differences are more marked in primiparous women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned homebirth). Given the small number of deaths in the planned homebirth group (n=9) this may be a chance finding over a long period of time (13 years). However, it is similar to the findings of the Birthplace in England study, which found a statistically significant higher odds of a composite outcome combining perinatal mortality and selected early neonatal morbidities among primiparous women planning home birth.[12] This highlights the need to explain the risks to women in absolute terms, as this is likely to be more helpful in assisting decision-making.

There were two negative findings in relation to birth centre outcomes, firstly, a significantly higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned hospital births. Another Australian study[17] and one in New Zealand also found higher rates of perineal trauma in birth centres.[28] However, other research found no significant differences in perineal outcomes, for example in studies in Norway,[29,30] Denmark,[31] Australia[32] or England.[33] The higher rate of severe perineal trauma may be related to the use of birth stools, more common in Australian birth centres but less frequently in hospitals or at home. Birth stools have been linked to higher rates of severe perineal trauma compared with other birth positions or waterbirth.[34] The higher rates of trauma could also be due to better case ascertainment or lower rates of episiotomy.

The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other research, which either found higher rates associated with planned hospital births[17,28] or else no statistically significant differences in NICU admission rates from birth centres and hospital births.[29,31,35] The admissions to the NICU or SCN in the current study are low in absolute terms (1 per 100 for birth centre births) but higher than planned hospital births. This requires ongoing examination to determine possible reasons and ways to reduce the rate.

Strengths and limitations

This study is the first to comprehensively examine maternal and perinatal outcomes from three birth settings across Australia. It used a population-based sample consisting of women with uncomplicated pregnancies. The large sample size was sufficient to detect differences between the three groups, although the numbers of homebirth nationally, even over this time period, were comparatively small (i.e. 8212 only 0.7% of the total sample).

The context of homebirth in Australia means there are still low numbers of women choosing homebirth and hence small numbers in this population. Private practising midwives do not have access to professional indemnity insurance which means the option for women is limited although still available in some parts of the country. Some private practising midwives in some states have visiting rights to hospitals but this is not universal leading to a lack of potential lack of integration. The publicly funded home birth models are relatively few (no more than 20 services across the country) and cater for small numbers of women. The policy and professional context has not been highly supportive of homebirth which has made scaling up of public services difficult.

Women with uncomplicated pregnancies were defined consistently across all three cohorts in the dataset. However, merging linked data from multiple jurisdictions created several challenges and potential shortcomings, including missing responses, inconsistent variable definitions and limited data from some states.[27] For example, Queensland's data collection only covered 2007-2012, resulting in under-representation: 9.6% of the combined sample, compared with 20.4% of Australian births in 2012.[36] The linked data sets also could not account for women who may have moved to another state or territory in the follow-up time

frame. In addition, state and territory-based data collections have inconsistent variables on other potential demographic factors such as maternal education, socioeconomic status or body mass index, limiting the variables available for controlling the analysis.

Although we eliminated unintended home births among women intending hospital or birth centre births (births before arrival), the home birth data do not always record whether or not a qualified health professional attended. Within the constraints of the data available, we have only included births attended by a health professional. Moreover, different states recorded birthplace intentions at different times. Although this means that intended birth place is not always recorded at onset of labour, the scrupulous process of data cleaning and categorising eliminated most women with risk factors which would have rendered them ineligible for birth centre or home births. Thus, the recorded birthplace intention was as close as possible to that at labour onset. However, there is a possibility that some planned birth centre/home births were erroneously classified as planned hospital births.

Some data items were collected inconsistently across the jurisdictions, for example, transfer from home to hospital after the onset of labour. This was either because the data item did not exist or because it only recorded 'transfer', which could have been at any time during pregnancy. Therefore, we were unable to report on intrapartum transfer rates.

Inconsistencies in the data from different jurisdictions also affected the data analysis. The regression analysis incorporated very few potential confounders, limited to those for which consistent data were available nation-wide (i.e. maternal age, gestational age, parity and whether born in Australia or not). Socio-economic status is also inconsistently collected across the country, as is maternal BMI and education, so we were unable to adjust for these factors.

It is possible that there remains some residual *unobservable differences in the groups.* It is possible that women planning to give birth in a birth centre or at home are different from those planning a hospital birth in a number of ways, including their motivation, attitudes to intervention and approach to birth. These are not able to be measured but may impact on the findings in relation to interventions and outcomes.

CONCLUSION

This study provides evidence on the safety of births planned in hospital, birth centre and at home across all states and territories in Australia by comparing cohorts of women with uncomplicated pregnancies. Inconsistencies between state-based datasets as described limited the number of variables available for analysis. However, for healthy women with uncomplicated pregnancies, planned birth centre births resulted in high rates of normal labour and birth, low rates of most maternal complications, and comparable perinatal mortality outcomes. Women planning home birth also had similarly positive maternal outcomes with no statistically significant differences in the rate of perinatal mortality or NICU admission. In absolute terms, the numbers of deaths were small, although the rate of perinatal mortality was higher among primiparous women who planned homebirths than their multiparous counterparts.

Box 1: Exclusion criteria

Women were excluded if the baby was:

- Born before 37 and after 41 completed weeks' gestation;
- Born before arrival for a planned birth at hospital or birth centre;
- Diagnosed antenatally with a congenital abnormality (all ICD-10-AM Q codes)

Women were also excluded if they had:

- Received no antenatal care;
- A previous caesarean section;
- A breech or non-vertex presentation;
- Labour induced for any reason;
- An elective caesarean section (pre-labour);
- Pre-existing (essential) and/or pregnancy-related hypertension;
- Pre-existing or gestational diabetes;
- Antepartum haemorrhage or any other relevant pregnancy complications
- ICD-10-AM Diagnosis
    - O10 Pre-existing hypertension complicating pregnancy, childbirth and the puerperium
    - O11 Pre-eclampsia superimposed on chronic hypertension
    - O13 Gestational [pregnancy-induced] hypertension
    - O14 Pre-eclampsia
    - O15 Eclampsia
    - O24 Diabetes mellitus in pregnancy
    - O30 Multiple gestation
    - O31.2 Continuing pregnancy after intrauterine death of one fetus or more
    - O36.4 Maternal care for intrauterine death
    - O42 Premature rupture of membranes
    - O46 Antepartum haemorrhage
    - O75.5 Delayed delivery after artificial rupture of membranes
    - O75.7 Vaginal delivery following previous caesarean section
    - P95 Fetal death of unspecified cause

Box 2: Maternal and perinatal outcomes

Maternal outcomes

Normal labour and birth: defined as spontaneous labour, cephalic presentation, without epidural, spinal or general anaesthesia, forceps, vacuum extraction, episiotomy or caesarean section.

Mode of birth: caesarean section, forceps birth, vacuum extraction, and normal vaginal birth (non-instrumental).

Procedures during labour and birth: episiotomy, epidural or spinal analgesia, oxytocin augmentation.

Perineal status: severe perineal trauma (3rd or 4th degree tear)

P*ostpartum complications*: postpartum haemorrhage (PPH) requiring a transfusion, admission to intensive care or high dependency unit for more than 48 hours and hospital readmission within 28 days.

Perinatal outcomes:

Perinatal mortality: intrapartum stillbirth, early neonatal death (0-7 days), late neonatal death (8-28 days).

Perinatal complications: Admission to special care or neonatal intensive care unit (NICU) for more than 48 hours and readmission to hospital within 28 days.

Box 3: Proportion of births included in sample, by state and territory

State or Territory	NSW	QLD	VIC	SA	WA	TAS	ACT	NT	Total
Years of data provided	2000-2012	2007-2012	2000-2012	2000-2012	2000-2012	2005-2012	2000-2012	2000-2012	
Number of births which met the criteria for this study	507 017	114 245	370 356	69 356	130 848	19 915	23 484	16 199	1 251 420
Proportion of total study sample	40.5%	9.1%	29.6%	5.5%	10.5%	1.6%	1.9%	1.3%	100%

Key to the states and territories: NSW - New South Wales; Qld - Queensland, VIC – Victoria; SA – South Australia; WA – Western Australia; TAS – Tasmania; ACT – Australian Capital Territory; NT – Northern Territory

Table 1: Demographic characteristics by planned place of birth

	Hospital	Birth Centre	Home
All women	**1 171 703 (93.6%)**	**71 505 (5.7%)**	**8212 (0.7%)**
Maternal age (years) - mean (sd)	29.0 (5.6)	29.8 (5.3)	31.8 (5.0)
Maternal age (years)			
<20	61 451 (5.2%)	2044 (2.9%)	71 (0.9%)
20-24	200 386 (17.1%)	10 116 (14.1%)	548 (6.7%)
25-29	348 785 (29.8%)	21 579 (30.2%)	2047 (24.9%)
30-34	365 022 (31.2%)	23 949 (33.5%)	3058 (37.2%)
35-39	167 803 (14.3%)	11 931 (16.7%)	1997 (24.3%)
≥40	28 177 (2.4%)	1886 (2.6%)	474 (5.8%)
Missing	79 (0.0%)	0 (0.0%)	17 (0.2%)
Previous pregnancies (≥20weeks)			
0	494 019 (42.2%)	28 891 (40.4%)	2295 (27.9%)
1	376 047 (32.1%)	25 079 (35.1%)	2745 (33.4%)
2	174 873 (14.9%)	11 364 (15.9%)	1688 (20.6%)
≥3	126 111 (10.8%)	6153 (8.6%)	1456 (17.7%)
Not stated	653 (0.1%)	18 (0.0%)	28 (0.3%)
Gestation* - mean (sd)	39.5 (1.0)	39.6 (1.0)	39.8 (1.0)
Gestation*			
37	54 825 (4.7%)	2403 (3.4%)	209 (2.5%)
38	155 764 (13.3%)	7470 (10.4%)	724 (8.8%)
39	323 179 (27.6%)	18 278 (25.6%)	1666 (20.3%)
40	481 665 (41.1%)	29 289 (41.0%)	3779 (46.0%)
41	156 270 (13.3%)	14 065 (19.7%)	1834 (22.3%)

Maternal country of birth			
Australia	889 550 (75.9%)	56 201 (78.6%)	6822 (83.1%)
Others	276 001 (23.6%)	15 105 (21.1%)	1188 (14.5%)
Inadequately described/not stated	6152 (0.5%)	199 (0.3%)	202 (2.5%)

*Gestation is in completed weeks

Note: Chi-square tests on categorical data within each sub-heading between birth settings yielded statistically significant differences with $p<0.001$ in all categories with no missing or not stated data. GLM revealed significant differences at $p<0.0001$ between means in all pairwise comparisons. Percentages may not total exactly 100% due to rounding.

Table 2: Normal labour and birth† by planned place of birth and parity

Planned place of birth	No. events – normal labour and birth†	Total number of births	Incidence of events (%)	Unadjusted OR	Adjusted OR Æ
All women	991 534	1 250 721	79.3		
Hospital	919 974	1 171 050	78.6	1	1
Birth Centre	63 773	71 487	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7787	8184	95.1	5.35 (4.69-6.11)	5.91 (5.15-6.78)
Primiparous women^^	322 640	525 205	61.4		
Hospital	298 243	494 019	60.4	1	1
Birth Centre	22 401	28 891	77.5	2.27 (2.18-2.35)	2.60 (2.50-2.70)
Home	1996	2295	87.0	4.38 (3.73-5.14)	5.99 (5.09-7.04)
Multiparous women^^	668 894	725 516	92.2		
Hospital	621 731	677 031	91.8	1	1
Birth Centre	41 372	42 596	97.1	3.01 (2.79-3.24)	3.27 (3.03-3.53)
Home	5791	5889	98.3	5.26 (4.04-6.83)	5.86 (4.50-7.62)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
† Normal labour and birth – spontaneous labour, no epidural or spinal, general anaesthesia, forceps, vacuum extraction, episiotomy or caesarean section.
^^ Parity refers to previous pregnancies >20 weeks and is dichotomised.
Cases with missing data were not included in rates or regression calculations

Table 3: Mode of birth, intervention rates and perineal outcomes by planned place of birth

Intervention and planned place of birth	Number of events	No of births	Incidence of events (%)	Unadjusted OR	Adjusted OR [Æ]
Normal vaginal birth	992 118	1 251 420	79.3		
Hospital	920 514	1 171 703	78.6	1	1
Birth Centre	63 790	71 505	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7814	8212	95.2	5.36 (4.69-6.12)	5.91 (5.15-6.78)
Vacuum extraction	88 586	1 251 420	7.1		
Hospital	85 975	1 171 703	7.3	1	1
Birth Centre	2503	71 505	3.5	0.44 (0.42-0.47)	0.42 (0.40-0.44)
Home	108	8212	1.3	0.19 (0.15-0.24)	0.18 (0.14-0.24)
Forceps birth	56 332	1 251 420	4.5		
Hospital	54 451	1 171 703	4.6	1	1
Birth Centre	1820	71 505	2.5	0.54 (0.50-0.57)	0.54 (0.50-0.58)
Home	61	8212	0.7	0.15 (0.11-0.21)	0.21 (0.14-0.31)
Intrapartum caesarean section	94 303	1 251 420	7.5		
Hospital	91 238	1 171 703	7.8	1	1
Birth Centre	2871	71 505	4.0	0.50 (0.47-0.52)	0.45 (0.43-0.48)
Home	194	8212	2.4	0.29 (0.24-0.35)	0.29 (0.24-0.35)
Mode of birth not stated	20 081	1 251 420	1.6		
Hospital	19 525	1 171 703	1.7	1	1
Birth Centre	521	71 505	0.7	0.43 (0.39-0.49)	0.41 (0.36-0.46)
Home	35	8212	0.4	0.25 (0.16-0.39)	0.26 (0.17-0.41)
Oxytocin augmentation	199 302	1 251 420	15.9		
Hospital	193 229	1 171 703	16.5	1	1
Birth Centre	5790	71 505	8.1	0.45 (0.43-0.46)	0.41 (0.40-0.43)
Home	283	8212	3.4	0.18 (0.15-0.21)	0.19 (0.16-0.22)
Epidural or spinal analgesia for labour	166 746	1 251 420	13.3		
Hospital	161 796	1 171 703	13.8	1	1
Birth Centre	4675	71 505	6.5	0.44 (0.42-0.45)	0.41 (0.39-0.43)
Home	275	8212	3.3	0.22 (0.18-0.25)	0.22 (0.19-0.26)

Intact perineum*	308 232	1 157 117	26.6		
Hospital	283 887	1 080 465	26.3	1	1
Birth Centre	20 562	68 634	30.0	1.20(1.17-1.23)	1.39(1.36-1.43)
Home	3783	8018	47.2	2.51(2.37-2.66)	2.72(2.56-2.90)
Episiotomy*	193 171	1 157 117	16.7		
Hospital	187 276	1 080 465	17.3	1	1
Birth Centre	5688	68 634	8.3	0.43 (0.42-0.45)	0.37 (0.36-0.39)
Home	207	8018	2.6	0.13 (0.11-0.15)	0.13 (0.10-0.15)
3rd or 4th degree perineal trauma	23 165	1 157 117	2.0		
Hospital *¥	21 454	1 080 465	2.0	1	1
Birth Centre	1641	68 634	2.4	1.21 (1.13-1.29)	1.17 (1.09-1.25)
Home	70	8018	0.9	0.43 (0.32-0.59)	0.53 (0.36-0.73)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
* Denominator = excluded caesarean section
¥ Included episiotomy extensions
Cases with missing data were not included in rates or regression calculations.
Variables on mode of birth and intervention are as defined by each state or territory.

Table 4: Maternal postpartum complications by planned place of birth

Complication and planned place of birth	No of events	No of births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Postpartum haemorrhage with blood transfusion	6518	1 251 420	5.2		
Hospital	6230	1 171 703	5.3	1	1
Birth Centre	244	71 505	3.4	0.64 (0.54-0.76)	0.66 (0.56-0.78)
Home	44	8212	5.4	1.01 (0.68-1.49)	1.08 (0.73-1.60)
Admission at least 48 hrs to intensive care or high dependency unit∞	2602	707 221*	3.7		
Hospital	2521	654 960	3.8	1	1
Birth Centre	74	47 266	1.6	0.41 (0.30-0.55)	0.42 (0.31-0.56)
Home	7	4995	1.4	0.36 (0.14-0.96)	0.41 (0.15-1.08)
Readmission to hospital (within 28 days)	917	864 865**	1.1		
Hospital	843	804 667	1.0	1	1
Birth Centre	68	54 522	1.2	1.19 (0.86-1.65)	1.18 (0.85-1.64)
Home	6	5676	1.1	1.01 (0.35-2.90)	1.08 (0.38-3.12)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
* Excluded QLD, VIC, NT, ACT, TAS
∞ Intensive care and high dependency units provided additional care – these were defined by each state and territory
** Excluded VIC, NT
Cases with missing data were not included in rates or regression calculations

Table 5: Perinatal outcomes by planned place of birth and parity^^

Planned place of birth	No. of events	No. of births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Stillbirth during labour, early and late neonatal death	921	1 251 420	0.7		
Hospital	880	1 171 050	0.8	1	1
Birth Centre	32	71 505	0.4	0.60 (0.37-0.95)	0.64 (0.40-1.02)
Home	9	8212	1.1	1.46 (0.62-3.47)	1.55 (0.65-3.69)
Primiparous women	425	525 205	0.8		
Hospital	406	494 019	0.8	1	1
Birth Centre	15	28 891	0.5	0.63 (0.32-1.24)	0.65 (0.33-1.27)
Home	na	2295	na	na	2.12(0.58-7.82)
Multiparous women	496	725 516	0.7		
Hospital	474	677 031	0.7	1	1
Birth Centre	17	42 596	0.4	0.57 (0.30-1.08)	0.65 (0.34-1.23)
Home	na	5889	na	na	1.29 (0.40-4.14)
Stillbirth during labour	399	1 251 420	0.32		
Hospital	378	1 171 703	0.32	1	1
Birth Centre	17	71 505	0.24	0.74 (0.39-1.40)	0.78 (0.41-1.48)
Home	na	8212	na	na	1.56 (0.42-5.71)
Early neonatal death[1]	240	881 064*	0.27		
Hospital	221	819 963	0.27	1	1
Birth Centre	14	55 312	0.25	0.84 (0.46-1.91)	0.94 (0.46-1.92)
Home	na	5789	na	na	3.18 (0.98-10.30)
Late neonatal death[2]	95	881 064*	0.11		
Hospital	94	819 963	0.11	1	1
Birth Centre	na	55 312	na	na	0.19 (0.01-2.50)
Home	0	5789	0.0	na	na
Admission to SCN and/or NICU >48hrs[3]	7500	881 064*	8.51		
Hospital	6908	819 963	8.42	1	1
Birth Centre	562	55 312	10.16	1.21 (1.08-1.35)	1.24 (1.10-1.39)

Home	30	5789	5.18	0.61 (0.38-0.98)	0.63 (0.39-1.01)
Readmission to hospital within 28 days[4]	37 569	1 251 420	30.02		
Hospital	35 413	1 171 703	30.22	1	1
Birth Centre	1967	71 505	27.51	0.91 (0.85-0.96)	0.95 (0.90-1.01)
Home	189	8212	23.02	0.76 (0.63-0.91)	0.83 (0.68-1.00)

^Denominator excluded missing parity information. The denominator in the first section of this table has 699 records with missing data for parity. Because this part of the data analysis was stratified by parity, we excluded the women whose parity data were unavailable.

na: cell size <5 so unable to report data or calculate incidence or OR

[1] Early neonatal death: death of a liveborn infant occurring within 7 completed days from the time of birth.

[2] Late neonatal death: death of a liveborn infant occurring after 7 completed days but before 29 completed days.

[3] NICU and SCN were combined due to complexities in the data to separate them out for all states and territories, except the Northern Territory where there was only SCN available and for South Australia where only NICU was available.

[4] For home births, this is defined as admission to hospital following birth within 28 days.

* Excluded VIC.

Æ Logistic regression was undertaken with adjustments occurring for maternal age, country of birth, gestational age, and parity at 99% CI. Any case with missing data was excluded from the regression.

^^ Parity refers to previous pregnancies >20 weeks.

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SUPPLEMENTARY FILE 1

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) – University of Technology Sydney, Australia (university reference number: 2012000167). Each state and territory also provided ethical approval.

State or territory	Name of the ethics committee(s)	Number/ID of the approval
Australian Capital Territory	ACT Health HREC	ETH 3.14.061
New South Wales	NSW Population and Health Services HREC	HREC/14/CIPHS/15
Northern Territory	Department of Health of the Northern Territory and the Menzies School of Health Research HREC	HREC 2014-2247
Queensland	Qld Health Office of the HREC	HREC/14/QGC/175
South Australia	South Australian Health HREC	HREC/14/SAH/117
Tasmania	Tasmania Network HREC	Ref No: H0015023
Victoria	Department of Health and Human Services – Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM)	Ref: 14/12
Western Australia	Government of Western Australia, Department of Health HREC	HREC 2014/57

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page no
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8-9
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-11
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11-12
		(*b*) Describe any methods used to examine subgroups and interactions	11-12
		(*c*) Explain how missing data were addressed	12
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12 Table 1
		(b) Give reasons for non-participation at each stage	12
		(c) Consider use of a flow diagram	Table 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	In each table
		(c) Summarise follow-up time (eg, average and total amount)	NA

Outcome data	15*	Report numbers of outcome events or summary measures over time	12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14 Plus tables
		(*b*) Report category boundaries when continuous variables were categorized	Tables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Maternal and perinatal outcomes by planned place of birth in Australia 2000 – 2012: A linked population data study

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Complete List of Authors:	Homer, Caroline; University of Technology Sydney, Centre for Midwifery, Child and Family Health; Burnet Institute, Maternal and Child Health Cheah, Seong; University of Technology Sydney Faculty of Health, Centre for Midwifery, Child and Family Health Rossiter, Chris; University of Technology Sydney, Dahlen, Hannah; University of Western Sydney, School of Nursing and Midwifery Ellwood, David; Griffith University, School of Medicine Foureur, Maralyn; UTS, Health Forster, Della; La Trobe University, Judith Lumley Centre; Royal Women's Hospital, Maternity Services McLachlan, HL; La Trobe University, Judith Lumley Centre; La Trobe University, School of Nursing and Midwifery Oats, Jeremy; University of Melbourne Institute, Melbourne School of Population and Global Health Sibbritt, David; University of Technology Sydney, Faculty of Health Thornton , Charlene ; Flinders University Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Scarf, Vanessa; University of Technology Sydney, Centre for Midwifery, Child and Family Health
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Maternal and perinatal outcomes by planned place of birth in Australia 2000 – 2012: A linked population data study

Homer, Caroline SE
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia
Maternal and Child Health Program, Burnet Institute, Melbourne, Australia

Cheah, Seong
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Rossiter, Chris
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Dahlen, Hannah G
School of Nursing and Midwifery, University of Western Sydney, Sydney, Australia

Ellwood, David
School of Medicine, Griffith University, and Gold Coast University Hospital, Queensland, Australia

Foureur, Maralyn
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Forster, Della
Judith Lumley Centre; Royal Women's Hospital, Maternity Services, La Trobe University, Melbourne, Australia

McLachlan, Helen L
Judith Lumley Centre; La Trobe University, Melbourne, Australia

Oats, Jeremy
Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia

Sibbritt, David
Faculty of Health, University of Technology Sydney, Sydney, Australia

Thornton, Charlene
Faculty of Medicine Nursing and Health Sciences, College of Nursing and Health Sciences Flinders University, Adelaide, Australia

Scarf, Vanessa L
Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, Australia

Corresponding author
Professor Caroline Homer AO
University of Technology Sydney, Australia
T +613 8506 2454
M +61 418 466 974
E caroline.homer@uts.edu.au

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ABSTRACT

Objective – To compare perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, in hospital labour wards, birth centres or at home.

Design – A population-based retrospective design, linking and analysing routinely collected electronic data. Analysis comprised chi-square tests and binary logistic regression for categorical data, yielding adjusted odds ratios. Continuous data were analysed using ANOVA.

Setting – All eight Australian states and territories.

Participants – Women with uncomplicated pregnancies who gave birth between 2000 and 2012 to a singleton baby in cephalic presentation at between 37 and 41 completed weeks' gestation. Of the 1 251 420 births, 1 171 703 (93.6%) were planned in hospital labour wards, 71 505 (5.7%) in birth centres and 8212 (0.7%) at home.

Main outcome measures – Mode of birth, normal labour and birth, interventions and procedures during labour and birth, maternal complications, admission to special care/high dependency or intensive care units (mother or infant) and perinatal mortality (intrapartum stillbirth and neonatal death).

Results – Compared with planned hospital births, the odds of normal labour and birth were over twice as high in planned birth centre births (AOR 2.72; 99% CI 2.63-2.81) and nearly six times as high in planned home births (AOR 5.91; 99% CI 5.15-6.78). There were no statistically significant differences in the proportion of intrapartum stillbirths, early or late neonatal deaths between the three planned places of birth.

Conclusions – This is the first Australia-wide study to examine outcomes by planned place of birth. For healthy women in Australia having an uncomplicated pregnancy, planned births in birth centres or at home are associated with positive maternal outcomes although the number of homebirths was small overall. There were no significant differences in the perinatal mortality rate, although the absolute numbers of deaths were very small and therefore firm conclusions cannot be drawn about perinatal mortality outcomes.

ARTICLE SUMMARY

Strengths and limitations of this study

- This retrospective study reveals the first Australia-wide evidence on the relative safety of planned birth in hospital, a birth centre and at home.
- It analyses linked data on the outcomes for women with uncomplicated pregnancies and their infants in all eight Australian states and territories.
- Careful data screening eliminated most causes of obstetric complexity, resulting in three cohorts with equivalent levels of risk.
- Inconsistency between state-based datasets limited the number of confounding variables available for analysis.
- Insufficient data on changes in planned birth place prior to labour hampered identification of intrapartum transfers and analysis of the relationship between intended and actual place of birth.

Funding statement

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Competing interest statement

We have read and understood *BMJ* policy on declaration of interests and declare that we have no competing interests.

Acknowledgements

We acknowledge and thank the data custodians in each state and territory and the data linkage units who assisted with data collection at each jurisdictional level.

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) (university reference number: 2012000167) and from data custodians in each state and territory. The details are provided in a Supplementary File.

Author contribution

CH as the lead investigator was responsible for the overall leadership of the study including the initial conception and design, grant application, ethical approval processes, leading the project, drafting the manuscript and finalising the paper.

SC was the data analyst responsible for merging the datasets from each jurisdiction, refining the datasets, developing the analysis codes and processes, and conducting the statistical analysis and has provided final approval of this version.

CR worked with the data analyst to support data analysis and interpretation as well as taking a key role in supporting the drafting of the manuscript and has provided final approval of this version.

HD was involved in the initial design of the study, played a key role in developing the study questions and data analytic processes, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DE was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

MF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DF was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

HM was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

JO was involved in the initial design of the study, played a key role in developing the study questions and providing expert review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

DS was involved in the initial design of the study, played a key role in developing the study questions and analytic processes and providing expert statistical planning and review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

CT played a key role in developing the study questions and analytic plan, assisted with planning the data set merging and cleaning of the data and providing expert epidemiological review, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

VS was the project coordinator responsible for the ethical approval processes, took a key role in coordinating the acquisition of the data from the different states and territories as well as a lead role in planning and undertaking the analysis and interpretation, was involved in drafting the work and/or revising it critically for important intellectual content and has provided final approval of this version.

Consent

Individual consent by participants was deemed to not be required due to the population-based de-identified form of the data released to the researchers.

Data sharing statement

The data that support the findings of this study are not available. It was a condition of the agreement between the data linkage units and the researchers that the dataset remain confidential. We are not permitted to make any part of the linked data available to any party outside those named on the research team who have been granted access.

INTRODUCTION

In Australia, most births occur in hospitals (97.5% in 2015), with some variation across the eight states and territories (for example, 91% in the Australian Capital Territory to 99% in Victoria).[1] Women with uncomplicated pregnancies and who are planning hospital births in the public health system receive antenatal care from hospital-based midwives and doctors, sometimes within continuity of care models, and often in partnership with local general practitioners. Hospital midwives attend their labour and birth, with medical involvement as required or in line with local protocols. In the private health system (where 25% of births take place), women receive antenatal care from private obstetricians or midwives employed by obstetricians. Hospital midwives attend their labour and birth and the obstetrician attends during the labour and is usually at the birth.[2,3] There are some differences across Australia in the way care is provided, especially the local guidelines and the choices available to women. The availability of different models of care varies across the country.

While most births take place in hospital labour wards or birth suites, a small proportion (1.8% nationally) take place in midwife-run birth centres.[1] In Australia these birth centres are typically co-located with hospitals (similar to alongside midwifery units in other countries) although a small number of stand-alone birth centres exist.[4] Birth centres typically provide midwifery continuity of care to women with uncomplicated pregnancies in a home-like environment and are well integrated into the health system.

Less than 0.3% of Australian births take place at home, ranging from 0.1% of births in New South Wales to 0.6% in the Northern Territory.[1,5] Most planned home births are attended by midwives working in private practice, some of whom also attend women in birth centres and hospitals. The integration of private homebirth services varies across the country. A small number of hospitals and birth centres offer home births through the public health system.[6] An evaluation of the outcomes of publicly funded models providing homebirth showed that the rate of stillbirth and early neonatal mortality was low, at 1.7 per 1000 births. However, the sample size did not have sufficient power to generate a conclusion about safety.[7]

We have conducted a systematic review to examine maternal and perinatal outcomes associated with planned place of birth for women with uncomplicated pregnancies in high-

income countries.[8] In this analysis of 28 studies from 13 countries, women who planned hospital births had significantly higher rates of perineal trauma and instrumental/caesarean birth than those who planned other birth places. Overall, there was no significant difference in the odds of intrapartum stillbirth according to place of birth (compared with planned hospital births, planned homebirth: OR=0.94; 95% CI: 0.76-1.17; planned birth centre OR=0.66; 95% CI: 0.32-1.34) or in early neonatal deaths (planned home birth OR=1.00; 95% CI: 0.78-1.27; planned birth centre 0.87; 95% CI: 0.29-2.61).

Previous Australian state-based studies into place of birth have showed variation in findings. In New South Wales (the most populous state accounting for around 30.9% of births)[9], women without pregnancy complications who planned a home or birth centre birth had significantly higher proportions of normal birth than those planning hospital births (home 97.4% vs birth centre 86.0% vs hospital 73.9%). There was no significant difference in neonatal mortality although the overall sample size (n= 258 161, including only 742 planned home births), had insufficient power for these relatively rare outcomes. In South Australia (SA) (297 192 planned hospital births and 1141 [0.38%] planned home births), another study found lower intervention rates and equivalent perinatal death rates in home births compared to hospital births. However, the odds of an intrapartum fetal death were significantly higher among planned home births (two deaths in the planned home birth group; AOR 7.42; 95% CI: 1.53–35.87). This study included some women with recognised risk factors in the home birth group including twins.[10] Large-scale studies in other countries show similar perinatal outcomes between births planned at home and in hospitals (and birth centres where these exist) with some differences for primiparous women.[11-14]

There is less controversy about birth centres compared with homebirth. Data from Australian birth centres indicate lower rates of maternal morbidity,[15] intervention, preterm birth and low birthweight compared with hospital births for women with similar risk profiles.[16] One study identified no significant differences by birth place in perinatal mortality[16] and another reported lower perinatal mortality in birth centre births, although based on actual rather than intended birth place.[17] A smaller hospital-based study found no significant difference in caesarean section rates between the birth centre and labour ward for women with uncomplicated pregnancies.[18] Two other birth centre studies reported higher rates of spontaneous vaginal birth and lower rates of adverse infant outcomes

(neonatal intensive care unit [NICU] admission, low birthweight) compared to hospital births.[19,20]

The safety of place of birth continues to be questioned in Australia.[21] To generate evidence to assist policy makers, health practitioners, and pregnant women and their families to make informed decisions about place of birth, we undertook a national study combining data from all eight Australian jurisdictions to examine the outcomes for women with uncomplicated pregnancies related to three different birth settings. This is the first national study on the comparative safety of different planned birth settings in Australia.

Aim and objectives

The study aimed to compare the perinatal and maternal outcomes for Australian women with uncomplicated pregnancies according to planned place of birth, that is, hospital labour wards, birth centres or at home. Outcomes investigated included normal labour and birth, mode of birth, interventions during labour, postpartum maternal complications and perinatal mortality and morbidity. We defined *uncomplicated pregnancy* as a singleton fetus in cephalic presentation between 37 and 41 completed weeks' gestation and free of known and recorded complications. Exclusions are detailed in Box 1.

METHODS

Study design

The study used a population-based retrospective design, linking and analysing routinely collected electronic data from multiple sources about births between 2000 and 2012 to women with uncomplicated pregnancies. We compared outcomes from three cohorts comprising women who were as comparable as possible given the available data. In Australia, homebirth and birth centre options are mostly restricted to women who meet specific criteria, that is, have an uncomplicated pregnancy and no relevant past medical or obstetric history. We therefore endeavoured to ensure that the hospital cohort shared the same characteristics, clinically if not demographically and applied the same filters on all three cohorts to increase the similarity between groups.

The study was approved by a university Human Research Ethics Committee (HREC). HRECs in each state and territory also approved access to anonymised linked data (see Supplementary File 1).

Patient and Public Involvement

Patients and the public were not involved in the design or conduct of the study.

Data sources

All eight Australian states and territories compile electronic perinatal datasets with items on maternal characteristics, labour, birth, and perinatal outcomes in the immediate postpartum period, that is, during the birth admission. However, to eliminate women with conditions that made them fall out of the uncomplicated criteria from the sample and to examine deaths and major morbidity requiring hospitalisation beyond the perinatal period, we examined additional data sources on deaths and hospital admissions nine months before and twelve months following birth. This study used linked anonymous data on all available mothers and infants from the following sources:

- *Perinatal Data Collection* (PDC) – maternal and infant data on all live births and stillbirths from 20 weeks' gestation or >400g birth weight;
- *Admitted Patient Data Collection* (APDC) – services provided to all individuals admitted to public and private hospitals, using the International Classification of Diseases – Australian modifications (ICD-10-AM)[22] for clinical data;
- *Registry of Births, Deaths and Marriages* (RBDM) – all registered births and deaths;
- *Australian Bureau of Statistics* (ABS) – data on deaths including primary cause of death (only for NSW and Queensland).

It was not possible to obtain data from all sources for all states and territories for the full study period due to differences in data collection systems. Table footnotes indicate the scope of data for each variable. In addition, not all states and territories provided data on maternal mortality.

Definitions

The definition of *uncomplicated pregnancies* (those without medical or obstetric risk factors) was determined a priori by the research team. For the most part, this used the Australian College of Midwives Guidelines for Consultation and Referral[23] as a basis for the description of uncomplicated pregnancies.

< Insert Box 1 here >

Planned place of birth incorporates three possible locations: home, birth centre, and hospital. *Homebirths* are instances where women intend to give birth outside a formal health facility, usually their own home, and receive care from a registered midwife, funded through either the public or private health system or self-funded. *Birth centres* provide a home-like birth setting and are run by midwives. They can be located within a hospital campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the main hospital service for access to interventions such as epidural analgesia or caesarean section. *Hospital births* take place in the labour ward or birth suite (terms vary across the country) of either a public or private hospital, and women are attended by midwives, obstetricians and/or general practitioner (GP) obstetricians.

The timing of the decision about birth setting is critical within the birthplace literature. While women choose a birth location early in their pregnancy, clinical factors may preclude them from achieving this intention. If they develop complications, they may no longer be eligible to give birth in a birth centre or at home. These women are excluded from comparisons of outcome by birth setting if they transfer to hospital care prior to labour. Ideally, researchers should identify planned place of birth at labour onset, to ensure that all participants have a similar level of clinical complexity. All Australian data collections record intended place of birth, but the majority did not indicate intention at labour onset. Therefore, the current study analyses data on planned place of birth identified at an undetermined time in the pregnancy, as close to labour as we were able to identify. The screening process eliminated women with many of the risk factors that would have prompted antenatal transfer from a birth centre or homebirth.

Box 2 provides the definitions of the maternal and perinatal outcomes.

< Insert Box 2 here >

Data linkage

Independent data linkage units (DLU) in each state and territory matched information from the four data sources (where available), using probabilistic linkage techniques.[24,25] This generated de-identified health records linking information from multiple datasets about the same individuals. This process yields the best available data on maternal and infant health status. However, it is not infallible and has estimated false positive and false negative rates of 0.5% each.[26]

Cross-jurisdictional data linkage was not possible, as independent DLUs had diverging protocols for maintaining patient privacy. We therefore applied to the individual data custodians for access to the linked data, through the six DLUs (data linkage for the Australian Capital Territory and the Northern Territory is provided by NSW and SA units respectively). Data were combined on relevant variables, where comparable, into a national dataset. Box 3 provides details on the datasets. Our approach to the data linkages and combining issues are detailed elsewhere. [27]

< Insert Box 3here >

Data cleaning, screening and cohort selection

Because the data collections were developed separately in each state and territory (except ABS collections), they had different characteristics and components. In particular, several PDC and APDC variables differed in name and type by jurisdiction. Even within the same state, some variable definitions changed over the study period, with items merged or split into multiple variables over time. The researchers scrutinised definitions to ensure accurate matching between variables with different names and attributes into a standardised dataset. The variables on mode of birth and intervention are all as defined by each state or territory.

Our broad request to state DLUs specified data on women with singleton pregnancies and a cephalic presentation at 37 to 41 completed weeks' gestation. Datasets arrived in different formats and met our criteria to varying extents. We then applied more specific inclusion and exclusion criteria (Box 1) to generate the sample.

Data analysis

Data were converted to SPSS Version 24, then grouped according to women's planned place of birth for intention to treat analysis. Descriptive statistics were generated and reported using percentages (or incidence per 1000 births for postpartum complications and perinatal outcomes).

Categorical variables were initially compared using chi-square tests. For continuous data such as maternal age and gestation week, we used univariate general linear model for analysis of variance (ANOVA) to examine the differences between the means. Odds ratios comparing each outcome by planned place of birth were calculated using logistic regression, adjusted for maternal age, maternal country of birth (Australia or elsewhere), gestational age and parity (dichotomised as primiparous vs multiparous) (adjusted odds ratio=AOR). These confounders were decided *a priori* based on what is known in the literature to affect outcomes. Percentages or proportions (events per 1000) were computed for the incidence of events at each birth setting. We present analysis stratified by parity (first baby versus other) for normal labour and birth and perinatal mortality.

No imputation was made to missing data. All calculations in regression and rates were computed based on non-missing data. Wherever necessary, sizes of missing data (not stated/inadequately described) on related variables were reported. The analysis reports 99% confidence intervals. The statistical significance level was set at $p<0.01$ to have more precision due to the large sample size.

Ethical approval requirements prevented reporting cell sizes of less than five to maintain confidentiality and so data have been redated in the tables to ensure this requirement was met. Further details on the methods is presented elsewhere.[27]

RESULTS

Demographic characteristics

The sample comprised 1 251 420 births that occurred between 1 January 2000 and 31 December 2012 to women with full-term, singleton pregnancies without complications. Of

these, 1 171 703 (93.6%) births were planned in hospital labour wards (referred to as 'hospital' births), 71 505 (5.7%) in a birth centre and 8212 (0.7%) at home.

Women planning to give birth in hospital labour wards were more likely to be younger, having their first birth (primiparous), of a shorter gestation (less than 40 weeks) or non-Australian-born than those planning birth centre or home births (Table 1).

<Insert Table 1 here>

Mode of birth, intervention and analgesia by planned place of birth

Planned birth at home or in a birth centre was associated with normal labour and birth more often than planned hospital birth. Women planning a birth centre birth were almost three times as likely (AOR 2.72, 99% CI 2.63-2.81) and women planning a home birth were almost six times as likely (AOR 5.91, 99% CI 5.15-6.78) to have a normal birth (Table 2). The odds for primiparous and multiparous women were similar. Overall, the proportion of women having a normal labour and birth were high (79% to 95% across the groups).

<Insert Table 2 here>

Women planning hospital births were more likely to experience interventions in birth. Compared with planned hospital births, births planned in other settings had significantly lower odds of: vacuum extraction (birth centre AOR 0.42; 99% CI 0.40-0.44 and homebirth AOR 0.18; 99% CI 0.14-0.24), forceps (birth centre AOR 0.54; 99% CI 0.50-0.58 and homebirth AOR 0.21; 99% CI 0.14-0.31) and intrapartum caesarean section (birth centre AOR 0.45; 99% CI 0.43-0.48 and homebirth AOR 0.29; 99% CI 0.24-0.35). Overall, the rates of interventions in the whole cohort were low with a rate of intrapartum caesarean section of only 8%.

Women who planned a birth centre or home birth were significantly more likely to have an intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-0.73) and more likely in planned birth centre births (AOR 1.17; 53% CI 1.09-1.25). The odds of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI

0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births. The odds of other interventions such as oxytocin augmentation and epidural or spinal analgesia were lower in planned birth centre or home births (Table 3).

<Insert Table 3 here>

Maternal postpartum complications

Women who planned to give birth in a birth centre were less likely to have a PPH requiring a blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78). There was no significant difference in the odds for women who planned a home birth (AOR 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the absolute number of admissions is small (Table 4). There were no significant differences between the groups in the odds of readmission to hospital within a month.

<Insert Table 4 here>

Perinatal outcomes by planned place of birth

Although the planned homebirth group had higher odds ratios for intrapartum stillbirth and early neonatal death than the other planned places of birth, the differences were not statistically significant. Combined data on stillbirth during labour, early and late neonatal death indicate that indicate that perinatal death is no more likely to occur after planned homebirth than in hospital birth (AOR 1.55; 99% CI 0.65-3.69), although the absolute number of deaths was very small (9/8182). Similarly, there was no significant difference for women planning a birth centre birth (AOR 0.84; 99% CI 0.60-1.19). When women were stratified by parity, there were no significant differences between any of the groups in the odds of perinatal mortality.

Women who planned a birth centre birth were more likely to have their baby admitted to the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women who planned hospital births. This trend was not seen in planned home births (AOR 0.63;

99% CI 0.39-1.01). There were no significant differences between the three groups in the odds of readmission of the baby to hospital within 28 days (Table 5).

<Insert Table 5 here>

DISCUSSION

This study, the first in Australia, has examined maternal and perinatal outcomes nationally by planned place of birth including all eight states and territories. Our study has demonstrated results consistent with several international studies of planned place of birth.[11,12,14] Normal births were more likely for women who planned birth in birth centres or at home than in a hospital. Women who planned to give birth at home were slightly older than women planning hospital or birth centre births, but despite this, had consistently lower rates of intervention.

The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live births compared with 0.4 in planned birth centre births and 1.1 in planned home births, although the absolute risks were very small with low numbers of deaths overall. These differences by place of birth were neither statistically significant for all women nor for cohorts stratified by parity. However, the differences are more marked in primiparous women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned homebirth). Given the small number of deaths in the planned homebirth group (n=9) this may be a chance finding over a long period of time (13 years). However, it is similar to the findings of the Birthplace in England study, which found a statistically significant higher odds of a composite outcome combining perinatal mortality and selected early neonatal morbidities among primiparous women planning home birth.[11] This highlights the need to explain the risks to women in absolute terms, as this is likely to be more helpful in assisting decision-making.

There were two negative findings in relation to birth centre outcomes, firstly, a significantly higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned hospital births. Another Australian study[16] and one in New Zealand also found higher rates of perineal trauma in birth centres.[28] However, other research found no significant

differences in perineal outcomes, for example in studies in Norway,[29,30] Denmark,[31] Australia[32] or England.[33] The higher rate of severe perineal trauma may be related to the use of birth stools, more common in Australian birth centres but less frequently in hospitals or at home. Birth stools have been linked to higher rates of severe perineal trauma compared with other birth positions or waterbirth.[34] The higher rates of trauma could also be due to better case ascertainment or lower rates of episiotomy.

The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other research, which either found higher rates associated with planned hospital births[16,28] or else no statistically significant differences in NICU admission rates from birth centres and hospital births.[29,31,35] The admissions to the NICU or SCN in the current study are low in absolute terms (1 per 100 for birth centre births) but higher than planned hospital births. This requires ongoing examination to determine possible reasons and ways to reduce the rate.

Strengths and limitations

This study is the first to comprehensively examine maternal and perinatal outcomes from three birth settings across Australia. It used a population-based sample consisting of women with uncomplicated pregnancies. The large sample size was sufficient to detect differences between the three groups, although the numbers of homebirth nationally, even over this time period, were comparatively small (i.e. 8212 only 0.7% of the total sample).

The context of homebirth in Australia means there are still low numbers of women choosing homebirth and hence small numbers in this population. Private practising midwives do not have access to professional indemnity insurance which means the option for women is limited although still available in some parts of the country. Some private practising midwives in some states have visiting rights to hospitals but this is not universal leading to a lack of potential lack of integration. The publicly funded home birth models are relatively few (no more than 20 services across the country) and cater for small numbers of women. The policy and professional context has not been highly supportive of homebirth which has made scaling up of public services difficult.

Women with uncomplicated pregnancies were defined consistently across all three cohorts in the dataset. However, merging linked data from multiple jurisdictions created several challenges and potential shortcomings, including missing responses, inconsistent variable definitions and limited data from some states.[27] For example, Queensland's data collection only covered 2007-2012, resulting in under-representation: 9.6% of the combined sample, compared with 20.4% of Australian births in 2012.[36] The linked data sets also could not account for women who may have moved to another state or territory in the follow-up time frame. State and territory-based data collections have inconsistent variables on other potential demographic factors such as maternal education, socioeconomic status or body mass index, limiting the variables available for controlling the analysis. Further, the small cell sizes generated meant that we were not able to report findings under the terms of ethics agreements with data custodians.

Although we eliminated unintended home births among women intending hospital or birth centre births (births before arrival), the home birth data do not always record whether or not a qualified health professional attended. Within the constraints of the data available, we have only included births attended by a health professional. Moreover, different states recorded birthplace intentions at different times. Although this means that intended birth place is not always recorded at onset of labour, the scrupulous process of data cleaning and categorising eliminated most women with risk factors which would have rendered them ineligible for birth centre or home births. Thus, the recorded birthplace intention was as close as possible to that at labour onset. However, there is a possibility that some planned birth centre/home births were erroneously classified as planned hospital births.

Some data items were collected inconsistently across the jurisdictions, for example, transfer from home to hospital after the onset of labour. This was either because the data item did not exist or because it only recorded 'transfer', which could have been at any time during pregnancy. Therefore, we were unable to report on intrapartum transfer rates.

Inconsistencies in the data from different jurisdictions also affected the data analysis. The regression analysis incorporated very few potential confounders, limited to those for which consistent data were available nation-wide (i.e. maternal age, gestational age, parity and whether born in Australia or not). Socio-economic status is also inconsistently collected

across the country, as is maternal BMI and education, so we were unable to adjust for these factors.

It is possible that there remain some residual *unobservable differences in the groups.* It is possible that women planning to give birth in a birth centre or at home are different from those planning a hospital birth in a number of ways, including their motivation, attitudes to intervention and approach to birth. These are not able to be measured but may impact on the findings in relation to interventions and outcomes.

CONCLUSION

This study provides evidence on the safety of births planned in hospital, birth centre and at home across all states and territories in Australia by comparing cohorts of women with uncomplicated pregnancies. Inconsistencies between state-based datasets as described limited the number of variables available for analysis. However, for healthy women with uncomplicated pregnancies, planned birth centre births resulted in high rates of normal labour and birth, low rates of most maternal complications, and comparable perinatal mortality outcomes. Women planning home birth also had similarly positive maternal outcomes with no statistically significant differences in the rate of perinatal mortality or NICU admission. In absolute terms, the numbers of deaths were small, although the rate of perinatal mortality was higher among primiparous women who planned homebirths than their multiparous counterparts.

Box 1: Exclusion criteria

Women were excluded if the baby was:

- Born before 37 and after 41 completed weeks' gestation;
- Born before arrival for a planned birth at hospital or birth centre;
- Diagnosed antenatally with a congenital abnormality (all ICD-10-AM Q codes)

Women were also excluded if they had:

- Received no antenatal care;
- A previous caesarean section;
- A breech or non-vertex presentation;
- Labour induced for any reason;
- An elective caesarean section (pre-labour);
- Pre-existing (essential) and/or pregnancy-related hypertension;
- Pre-existing or gestational diabetes;
- Antepartum haemorrhage or any other relevant pregnancy complications
- ICD-10-AM Diagnosis
    - O10 Pre-existing hypertension complicating pregnancy, childbirth and the puerperium
    - O11 Pre-eclampsia superimposed on chronic hypertension
    - O13 Gestational [pregnancy-induced] hypertension
    - O14 Pre-eclampsia
    - O15 Eclampsia
    - O24 Diabetes mellitus in pregnancy
    - O30 Multiple gestation
    - O31.2 Continuing pregnancy after intrauterine death of one fetus or more
    - O36.4 Maternal care for intrauterine death
    - O42 Premature rupture of membranes
    - O46 Antepartum haemorrhage
    - O75.5 Delayed delivery after artificial rupture of membranes
    - O75.7 Vaginal delivery following previous caesarean section
    - P95 Fetal death of unspecified cause

Box 2: Maternal and perinatal outcomes

Maternal outcomes

Normal labour and birth: defined as spontaneous labour, cephalic presentation, without epidural, spinal or general anaesthesia, forceps, vacuum extraction, episiotomy or caesarean section.

Mode of birth: caesarean section, forceps birth, vacuum extraction, and normal vaginal birth (non-instrumental).

Procedures during labour and birth: episiotomy, epidural or spinal analgesia, oxytocin augmentation.

Perineal status: severe perineal trauma (3rd or 4th degree tear)

P*ostpartum complications*: postpartum haemorrhage (PPH) requiring a transfusion, admission to intensive care or high dependency unit for more than 48 hours and hospital readmission within 28 days.

Perinatal outcomes:

Perinatal mortality: intrapartum stillbirth, early neonatal death (0-7 days), late neonatal death (8-28 days).

Perinatal complications: Admission to special care or neonatal intensive care unit (NICU) for more than 48 hours and readmission to hospital within 28 days.

Box 3: Proportion of births included in sample, by state and territory

State or Territory	NSW	QLD	VIC	SA	WA	TAS	ACT	NT	Total
Years of data provided	2000-2012	2007-2012	2000-2012	2000-2012	2000-2012	2005-2012	2000-2012	2000-2012	
Number of births which met the criteria for this study	507 017	114 245	370 356	69 356	130 848	19 915	23 484	16 199	1 251 420
Proportion of total study sample	40.5%	9.1%	29.6%	5.5%	10.5%	1.6%	1.9%	1.3%	100%

Key to the states and territories: NSW - New South Wales; Qld - Queensland, VIC – Victoria; SA – South Australia; WA – Western Australia; TAS – Tasmania; ACT – Australian Capital Territory; NT – Northern Territory

Table 1: Demographic characteristics by planned place of birth

	Hospital	Birth Centre	Home
All women	**1 171 703 (93.6%)**	**71 505 (5.7%)**	**8212 (0.7%)**
Maternal age (years) - mean (sd)	29.0 (5.6)	29.8 (5.3)	31.8 (5.0)
Maternal age (years)			
<20	61 451 (5.2%)	2044 (2.9%)	71 (0.9%)
20-24	200 386 (17.1%)	10 116 (14.1%)	548 (6.7%)
25-29	348 785 (29.8%)	21 579 (30.2%)	2047 (24.9%)
30-34	365 022 (31.2%)	23 949 (33.5%)	3058 (37.2%)
35-39	167 803 (14.3%)	11 931 (16.7%)	1997 (24.3%)
≥40	28 177 (2.4%)	1886 (2.6%)	474 (5.8%)
Missing	79 (0.0%)	0 (0.0%)	17 (0.2%)
Previous pregnancies (≥20weeks)			
0	494 019 (42.2%)	28 891 (40.4%)	2295 (27.9%)
1	376 047 (32.1%)	25 079 (35.1%)	2745 (33.4%)
2	174 873 (14.9%)	11 364 (15.9%)	1688 (20.6%)
≥3	126 111 (10.8%)	6153 (8.6%)	1456 (17.7%)
Not stated	653 (0.1%)	18 (0.0%)	28 (0.3%)
Gestation* - mean (sd)	39.5 (1.0)	39.6 (1.0)	39.8 (1.0)
Gestation*			
37	54 825 (4.7%)	2403 (3.4%)	209 (2.5%)
38	155 764 (13.3%)	7470 (10.4%)	724 (8.8%)
39	323 179 (27.6%)	18 278 (25.6%)	1666 (20.3%)
40	481 665 (41.1%)	29 289 (41.0%)	3779 (46.0%)
41	156 270 (13.3%)	14 065 (19.7%)	1834 (22.3%)

Maternal country of birth			
Australia	889 550 (75.9%)	56 201 (78.6%)	6822 (83.1%)
Others	276 001 (23.6%)	15 105 (21.1%)	1188 (14.5%)
Inadequately described/not stated	6152 (0.5%)	199 (0.3%)	202 (2.5%)

*Gestation is in completed weeks

Note: Chi-square tests on categorical data within each sub-heading between birth settings yielded statistically significant differences with $p<0.001$ in all categories with no missing or not stated data. GLM revealed significant differences at $p<0.0001$ between means in all pairwise comparisons. Percentages may not total exactly 100% due to rounding.

Table 2: Normal labour and birth† by planned place of birth and parity

Planned place of birth	No. events – normal labour and birth†	Total number of births	Incidence of events (%)	Unadjusted OR	Adjusted OR Æ
All women	991 534	1 250 721	79.3		
Hospital	919 974	1 171 050	78.6	1	1
Birth Centre	63 773	71 487	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7787	8184	95.1	5.35 (4.69-6.11)	5.91 (5.15-6.78)
Primiparous women^^	322 640	525 205	61.4		
Hospital	298 243	494 019	60.4	1	1
Birth Centre	22 401	28 891	77.5	2.27 (2.18-2.35)	2.60 (2.50-2.70)
Home	1996	2295	87.0	4.38 (3.73-5.14)	5.99 (5.09-7.04)
Multiparous women^^	668 894	725 516	92.2		
Hospital	621 731	677 031	91.8	1	1
Birth Centre	41 372	42 596	97.1	3.01 (2.79-3.24)	3.27 (3.03-3.53)
Home	5791	5889	98.3	5.26 (4.04-6.83)	5.86 (4.50-7.62)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
† Normal labour and birth – spontaneous labour, no epidural or spinal, general anaesthesia, forceps, vacuum extraction, episiotomy or caesarean section.
^^ Parity refers to previous pregnancies >20 weeks and is dichotomised.
Cases with missing data were not included in rates or regression calculations

Table 3: Mode of birth, intervention rates and perineal outcomes by planned place of birth

Intervention and planned place of birth	Number of events	No of births	Incidence of events (%)	Unadjusted OR	Adjusted OR [Æ]
Normal vaginal birth	992 118	1 251 420	79.3		
Hospital	920 514	1 171 703	78.6	1	1
Birth Centre	63 790	71 505	89.2	2.26 (2.19-2.33)	2.72 (2.63-2.81)
Home	7814	8212	95.2	5.36 (4.69-6.12)	5.91 (5.15-6.78)
Vacuum extraction	88 586	1 251 420	7.1		
Hospital	85 975	1 171 703	7.3	1	1
Birth Centre	2503	71 505	3.5	0.44 (0.42-0.47)	0.42 (0.40-0.44)
Home	108	8212	1.3	0.19 (0.15-0.24)	0.18 (0.14-0.24)
Forceps birth	56 332	1 251 420	4.5		
Hospital	54 451	1 171 703	4.6	1	1
Birth Centre	1820	71 505	2.5	0.54 (0.50-0.57)	0.54 (0.50-0.58)
Home	61	8212	0.7	0.15 (0.11-0.21)	0.21 (0.14-0.31)
Intrapartum caesarean section	94 303	1 251 420	7.5		
Hospital	91 238	1 171 703	7.8	1	1
Birth Centre	2871	71 505	4.0	0.50 (0.47-0.52)	0.45 (0.43-0.48)
Home	194	8212	2.4	0.29 (0.24-0.35)	0.29 (0.24-0.35)
Mode of birth not stated	20 081	1 251 420	1.6		
Hospital	19 525	1 171 703	1.7	1	1
Birth Centre	521	71 505	0.7	0.43 (0.39-0.49)	0.41 (0.36-0.46)
Home	35	8212	0.4	0.25 (0.16-0.39)	0.26 (0.17-0.41)
Oxytocin augmentation	199 302	1 251 420	15.9		
Hospital	193 229	1 171 703	16.5	1	1
Birth Centre	5790	71 505	8.1	0.45 (0.43-0.46)	0.41 (0.40-0.43)
Home	283	8212	3.4	0.18 (0.15-0.21)	0.19 (0.16-0.22)
Epidural or spinal analgesia for labour	166 746	1 251 420	13.3		
Hospital	161 796	1 171 703	13.8	1	1
Birth Centre	4675	71 505	6.5	0.44 (0.42-0.45)	0.41 (0.39-0.43)
Home	275	8212	3.3	0.22 (0.18-0.25)	0.22 (0.19-0.26)

Intact perineum*	308 232	1 157 117	26.6		
Hospital	283 887	1 080 465	26.3	1	1
Birth Centre	20 562	68 634	30.0	1.20(1.17-1.23)	1.39(1.36-1.43)
Home	3783	8018	47.2	2.51(2.37-2.66)	2.72(2.56-2.90)
Episiotomy*	193 171	1 157 117	16.7		
Hospital	187 276	1 080 465	17.3	1	1
Birth Centre	5688	68 634	8.3	0.43 (0.42-0.45)	0.37 (0.36-0.39)
Home	207	8018	2.6	0.13 (0.11-0.15)	0.13 (0.10-0.15)
3rd or 4th degree perineal trauma	23 165	1 157 117	2.0		
Hospital *¥	21 454	1 080 465	2.0	1	1
Birth Centre	1641	68 634	2.4	1.21 (1.13-1.29)	1.17 (1.09-1.25)
Home	70	8018	0.9	0.43 (0.32-0.59)	0.53 (0.36-0.73)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
* Denominator = excluded caesarean section
¥ Included episiotomy extensions
Cases with missing data were not included in rates or regression calculations.
Variables on mode of birth and intervention are as defined by each state or territory.

Table 4: Maternal postpartum complications by planned place of birth

Complication and planned place of birth	No of events	No of births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Postpartum haemorrhage with blood transfusion	6518	1 251 420	5.2		
Hospital	6230	1 171 703	5.3	1	1
Birth Centre	244	71 505	3.4	0.64 (0.54-0.76)	0.66 (0.56-0.78)
Home	44	8212	5.4	1.01 (0.68-1.49)	1.08 (0.73-1.60)
Admission at least 48 hrs to intensive care or high dependency unit∞	2602	707 221*	3.7		
Hospital	2521	654 960	3.8	1	1
Birth Centre	74	47 266	1.6	0.41 (0.30-0.55)	0.42 (0.31-0.56)
Home	7	4995	1.4	0.36 (0.14-0.96)	0.41 (0.15-1.08)
Readmission to hospital (within 28 days)	917	864 865**	1.1		
Hospital	843	804 667	1.0	1	1
Birth Centre	68	54 522	1.2	1.19 (0.86-1.65)	1.18 (0.85-1.64)
Home	6	5676	1.1	1.01 (0.35-2.90)	1.08 (0.38-3.12)

Æ Logistic regression adjusted for maternal age, country of birth, gestational age and parity at 99% CI.
* Excluded QLD, VIC, NT, ACT, TAS
∞ Intensive care and high dependency units provided additional care – these were defined by each state and territory
** Excluded VIC, NT
Cases with missing data were not included in rates or regression calculations

Table 5: Perinatal outcomes by planned place of birth and parity^^

Planned place of birth	No. of events	No. of births	Incidence of events/1000 births	Unadjusted OR	Adjusted OR Æ
Stillbirth during labour, early and late neonatal death	921	1 251 420	0.7		
Hospital	880	1 171 050	0.8	1	1
Birth Centre	32	71 505	0.4	0.60 (0.37-0.95)	0.64 (0.40-1.02)
Home	9	8212	1.1	1.46 (0.62-3.47)	1.55 (0.65-3.69)
Primiparous women	425	525 205	0.8		
Hospital	406	494 019	0.8	1	1
Birth Centre	15	28 891	0.5	0.63 (0.32-1.24)	0.65 (0.33-1.27)
Home	na	2295	na	na	2.12(0.58-7.82)
Multiparous women	496	725 516	0.7		
Hospital	474	677 031	0.7	1	1
Birth Centre	17	42 596	0.4	0.57 (0.30-1.08)	0.65 (0.34-1.23)
Home	na	5889	na	na	1.29 (0.40-4.14)
Stillbirth during labour	399	1 251 420	0.32		
Hospital	378	1 171 703	0.32	1	1
Birth Centre	17	71 505	0.24	0.74 (0.39-1.40)	0.78 (0.41-1.48)
Home	na	8212	na	na	1.56 (0.42-5.71)
Early neonatal death[1]	240	881 064*	0.27		
Hospital	221	819 963	0.27	1	1
Birth Centre	14	55 312	0.25	0.84 (0.46-1.91)	0.94 (0.46-1.92)
Home	na	5789	na	na	3.18 (0.98-10.30)
Late neonatal death[2]	95	881 064*	0.11		
Hospital	94	819 963	0.11	1	1
Birth Centre	na	55 312	na	na	na
Home	0	5789	0.0	na	na
Admission to SCN and/or NICU >48hrs[3]	7500	881 064*	8.51		
Hospital	6908	819 963	8.42	1	1
Birth Centre	562	55 312	10.16	1.21 (1.08-1.35)	1.24 (1.10-1.39)

Home	30	5789	5.18	0.61 (0.38-0.98)	0.63 (0.39-1.01)
Readmission to hospital within 28 days[4]	37 569	1 251 420	30.02		
Hospital	35 413	1 171 703	30.22	1	1
Birth Centre	1967	71 505	27.51	0.91 (0.85-0.96)	0.95 (0.90-1.01)
Home	189	8212	23.02	0.76 (0.63-0.91)	0.83 (0.68-1.00)

^Denominator excluded missing parity information. The denominator in the first section of this table has 699 records with missing data for parity. Because this part of the data analysis was stratified by parity, we excluded the women whose parity data were unavailable.

na: cell size <5 so unable to report data or calculate incidence or OR

[1] Early neonatal death: death of a liveborn infant occurring within 7 completed days from the time of birth.

[2] Late neonatal death: death of a liveborn infant occurring after 7 completed days but before 29 completed days.

[3] NICU and SCN were combined due to complexities in the data to separate them out for all states and territories, except the Northern Territory where there was only SCN available and for South Australia where only NICU was available.

[4] For home births, this is defined as admission to hospital following birth within 28 days.

* Excluded VIC.

Æ Logistic regression was undertaken with adjustments occurring for maternal age, country of birth, gestational age, and parity at 99% CI. Any case with missing data was excluded from the regression.

^^ Parity refers to previous pregnancies >20 weeks.

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SUPPLEMENTARY FILE 1

Ethics approval

The study received initial ethical approval from the lead university's Human Research Ethics Committee (HREC) – University of Technology Sydney, Australia (university reference number: 2012000167). Each state and territory also provided ethical approval.

State or territory	Name of the ethics committee(s)	Number/ID of the approval
Australian Capital Territory	ACT Health HREC	ETH 3.14.061
New South Wales	NSW Population and Health Services HREC	HREC/14/CIPHS/15
Northern Territory	Department of Health of the Northern Territory and the Menzies School of Health Research HREC	HREC 2014-2247
Queensland	Qld Health Office of the HREC	HREC/14/QGC/175
South Australia	South Australian Health HREC	HREC/14/SAH/117
Tasmania	Tasmania Network HREC	Ref No: H0015023
Victoria	Department of Health and Human Services – Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM)	Ref: 14/12
Western Australia	Government of Western Australia, Department of Health HREC	HREC 2014/57

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page no
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8-9
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-11
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11-12
		(*b*) Describe any methods used to examine subgroups and interactions	11-12
		(*c*) Explain how missing data were addressed	12
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12 Table 1
		(b) Give reasons for non-participation at each stage	12
		(c) Consider use of a flow diagram	Table 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	In each table
		(c) Summarise follow-up time (eg, average and total amount)	NA

Outcome data	15*	Report numbers of outcome events or summary measures over time	12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14 Plus tables
		(*b*) Report category boundaries when continuous variables were categorized	Tables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.