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Outcomes by planned place of birth in Australia 2000 – 2012: A linked population data study

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SCHOLARONE™
Manuscripts

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1
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3 64 **ABSTRACT**
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6 65 **Objective** – To compare perinatal and maternal outcomes for Australian women with
7
8 66 uncomplicated pregnancies according to planned place of birth, that is, in hospital labour
9
10 67 wards, birth centres or at home.

11
12 68 **Design** – A population-based retrospective design, linking and analysing routinely collected
13
14 69 electronic data about women and their infants. Analysis comprised chi-square tests and
15
16 70 binary logistic regression for categorical data, yielding adjusted odds ratios. Continuous data
17
18 71 were analysed using ANOVA.

19
20 72 **Setting** – All eight Australian states and territories.

21
22
23 73 **Participants** – Women with low-risk pregnancies who gave birth between 2000 and 2012 to
24
25 74 a singleton baby in cephalic presentation at between 37 and 41 completed weeks' gestation.
26
27 75 Of the 1 251 420 births, 1 171 703 (93.6%) were planned in hospital labour wards or birth
28
29 76 suites, 71 505 (5.7%) in birth centres and 8212 (0.7%) at home.

30
31 77 **Main outcome measures** – Mode of birth, interventions and procedures during labour and
32
33 78 birth, maternal complications, admission to special care/high dependency or intensive care
34
35 79 units (mother or infant) and perinatal mortality (intrapartum stillbirth and neonatal death).

36
37 80 **Results** – Compared with planned hospital births, the odds of normal labour and birth were
38
39 81 over twice as high in planned birth centre births (AOR 2.72; 99% CI 2.63-2.81) and nearly six
40
41 82 times as high in planned home births (AOR 5.91; 99% CI 5.15-6.78). There were no
42
43 83 statistically significant differences in the proportion of intrapartum stillbirths, early or late
44
45 84 neonatal deaths between the three planned places of birth.

46
47 85 **Conclusions** – This is the first Australia-wide study to examine outcomes by planned place of
48
49 86 birth. It demonstrates that for low-risk healthy women in Australia, planned births in birth
50
51 87 centres or at home are associated with positive maternal outcomes. There were no
52
53 88 significant differences in the perinatal mortality rate, although the absolute numbers of
54
55 89 deaths were very small.
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60

91 ARTICLE SUMMARY

92 Strengths and limitations of this study

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

104 Funding statement

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107 Competing interest statement

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

110 Acknowledgements

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

113 Ethics approval

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

117 Author contribution

1
2
3 118 CSEH as the lead investigator was responsible for the overall leadership of the study
4
5 119 including the initial conception and design, grant application, ethical approval processes,
6
7 120 leading the project, drafting the manuscript and finalising the paper.
8

9
10 121 SLC was the data analyst responsible for merging the datasets from each jurisdiction,
11
12 122 refining the datasets, developing the analysis codes and processes and conducting the
13
14 123 statistical analysis and has provided final approval of this version.
15

16 124 CR worked with the data analyst to support data analysis and interpretation as well as
17
18 125 taking a key role in supporting the drafting of the manuscript and has provided final
19
20 126 approval of this version.
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22 127 HGD was involved in the initial design of the study, played a key role in developing the study
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24 128 questions and data analytic processes, was involved in drafting the work and/or revising it
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26 129 critically for important intellectual content and has provided final approval of this version.
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28 130 DAE was involved in the initial design of the study, played a key role in developing the study
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30 131 questions and providing expert review, was involved in drafting the work and/or revising it
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32 132 critically for important intellectual content and has provided final approval of this version.
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35 133 MJF was involved in the initial design of the study, played a key role in developing the study
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37 134 questions and providing expert review, was involved in drafting the work and/or revising it
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39 135 critically for important intellectual content and has provided final approval of this version.
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41 136 DF was involved in the initial design of the study, played a key role in developing the study
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43 137 questions and providing expert review, was involved in drafting the work and/or revising it
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45 138 critically for important intellectual content and has provided final approval of this version.
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47 139 HMc was involved in the initial design of the study, played a key role in developing the study
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49 140 questions and providing expert review, was involved in drafting the work and/or revising it
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51 141 critically for important intellectual content and has provided final approval of this version.
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54 142 JO was involved in the initial design of the study, played a key role in developing the study
55
56 143 questions and providing expert review, was involved in drafting the work and/or revising it
57
58 144 critically for important intellectual content and has provided final approval of this version.
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1
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3 145 DS was involved in the initial design of the study, played a key role in developing the study
4
5 146 questions and analytic processes and providing expert statistical planning and review, was
6
7 147 involved in drafting the work and/or revising it critically for important intellectual content
8
9 148 and has provided final approval of this version.

10
11 149 CT played a key role in developing the study questions and analytic plan, assisted with
12
13 150 planning the data set merging and cleaning of the data and providing expert epidemiological
14
15 151 review, was involved in drafting the work and/or revising it critically for important
16
17 152 intellectual content and has provided final approval of this version.

18
19 153 VS was the project coordinator responsible for the ethical approval processes, took a key
20
21 154 role in coordinating the acquisition of the data from the different states and territories as
22
23 155 well as a lead role in planning and undertaking the analysis and interpretation, was involved
24
25 156 in drafting the work and/or revising it critically for important intellectual content and has
26
27 157 provided final approval of this version.

28 29 158 **Reporting statement**

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31
32 159 The STROBE Statement for a cohort study is included as a Supplementary File.

33 34 160 **Consent**

35
36
37 161 Individual consent by participants was deemed to not be required due to the population-
38
39 162 based de-identified form of the data released to the researchers.

40 41 163 **Data sharing statement**

42
43
44 164 The data that support the findings of this study are not available. It was a condition of the
45
46 165 agreement between the data linkage units and the researchers that the dataset remain
47
48 166 confidential. We are not permitted to make any part of the linked data available to any
49
50 167 party outside those named on the research team who have been granted access.

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53 168

169 INTRODUCTION

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

181 While most births take place in hospital labour wards or birth suites, a small proportion
182 (1.8% nationally) take place in midwife-run birth centres.¹ Australian birth centres are
183 typically co-located with hospitals (alongside midwifery units) although a small number of
184 stand-alone birth centres exist.⁴ Less than 0.3% of Australian births take place at home,
185 ranging from 0.1% of births in New South Wales to 0.6% in the Northern Territory.^{1,5} Most
186 planned home births are attended by midwives working in private practice, some of whom
187 also attend women in birth centres and hospitals. A small number of hospitals and birth
188 centres offer home births through the public health system.⁶ An evaluation of the outcomes
189 of publicly funded models showed that the rate of stillbirth and early neonatal mortality was
190 low, at 1.7 per 1000 births. However, the sample size did not have sufficient power to
191 generate a conclusion about safety.⁷

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

1
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3 199 the odds of intrapartum stillbirth according to place of birth (compared with planned
4
5 200 hospital births, planned homebirth: OR=0.94; 95% CI: 0.76-1.17; planned birth centre
6
7 201 OR=0.66; 95% CI: 0.32-1.34) or in early neonatal deaths (planned home birth OR=1.00; 95%
8
9 202 CI: 0.78-1.27; planned birth centre 1.08; 95% CI: 0.42-2.78).

10
11 203 Previous Australian state-based studies into place of birth identified differing outcomes. For
12
13 204 example, a study of births in NSW (accounting for around 30.9% of Australian births)⁹ found
14
15 205 that women without pregnancy complications who planned a home or birth centre birth
16
17 206 had significantly higher proportions of normal birth than those planning hospital births
18
19 207 (home 97.4% vs birth centre 86.0% vs hospital 73.9%). The study detected no significant
20
21 208 difference in neonatal mortality although the overall sample size (n= 258 161, including only
22
23 209 742 planned home births), was insufficient to test reliably for differences by birth place for
24
25 210 these relatively rare outcomes. Another study in South Australia (SA) (297 192 planned
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27 211 hospital births and 1141 [0.38%] planned home births) found lower intervention rates and
28
29 212 equivalent perinatal death rates in home births compared to hospital births. However, the
30
31 213 odds of an intrapartum fetal death were significantly higher among planned home births
32
33 214 (two deaths in the planned home birth group; AOR 7.42; 95% CI: 1.53–35.87). This study
34
35 215 also included some women with obstetric risk factors in the home birth group including
36
37 216 twins.¹⁰ Large-scale studies in other countries have used larger data sets, generating greater
38
39 217 statistical power¹¹⁻¹⁴ and mostly showing similar perinatal outcomes between births planned
40
41 218 at home and in hospitals (and birth centres where these exist) with some differences for
42
43 219 nulliparous women.

44 220 Data from Australian birth centres indicate lower rates of maternal morbidity,¹⁵
45
46 221 intervention, preterm birth and low birthweight compared with hospital births for women
47
48 222 with similar low-risk profiles.¹⁶ One study identified no significant differences by birth place
49
50 223 in perinatal mortality¹⁶ and another reported lower perinatal mortality in birth centre births,
51
52 224 although based on actual rather than intended birth place.¹⁷ A smaller hospital-based study
53
54 225 found no significant difference in caesarean section rates between birth centre and labour
55
56 226 ward for women with low-risk pregnancies.¹⁸ Two other birth centre studies reported higher
57
58 227 rates of spontaneous vaginal birth and lower rates of adverse infant outcomes (neonatal
59
60 228 intensive care unit [NICU] admission, low birthweight) compared to hospital births.^{19,20}

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3 229 Place of birth continues to be controversial in Australia. To generate evidence to assist
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5 230 policy makers, health practitioners, and pregnant women and their families to make
6
7 231 informed decisions about place of birth, we undertook a national study combining data from
8
9 232 all eight Australian jurisdictions to examine the outcomes for women with low-risk
10
11 233 pregnancies related to three different birth settings. This is the first national study on the
12
13 234 comparative safety of different planned birth settings in Australia.

15 235 **Aim**

17
18 236 The study aimed to compare the perinatal and maternal outcomes for Australian women
19
20 237 with uncomplicated pregnancies according to planned place of birth, that is, hospital labour
21
22 238 wards, birth centres or at home.

24 239 **METHODS**

27 240 **Study design**

29
30 241 The study used a population-based retrospective design, linking and analysing routinely
31
32 242 collected electronic data from multiple sources about births between 2000 and 2012 to
33
34 243 women with low-risk pregnancies. We compared outcomes from three cohorts comprising
35
36 244 women who were as comparable as possible given the available data. In Australia,
37
38 245 homebirth and birth centre options are mostly restricted to women who meet low-risk
39
40 246 criteria. We therefore endeavoured to ensure that the hospital cohort shared the same
41
42 247 characteristics, clinically if not demographically and applied the same filters on all three
43
44 248 cohorts to increase the similarity between groups.

45 249 The study was approved by a university Human Research Ethics Committee (HREC). HRECs in
46
47 250 each state and territory also approved access to anonymised linked data (see
48
49 251 Supplementary File 1). Patients and the public were not involved in the design or conduct of
50
51 252 the study.

53 253 **Data sources**

55
56 254 All eight Australian states and territories compile electronic perinatal datasets with items on
57
58 255 maternal characteristics, labour, birth, and perinatal outcomes in the immediate
59
60 256 postpartum period. However, to eliminate women with complicating conditions from the

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2
3 257 sample and to examine deaths and major morbidity requiring hospitalisation beyond the
4
5 258 perinatal period, we examined additional data sources on deaths and hospital admissions
6
7 259 nine months before and twelve months following birth. This study used linked anonymous
8
9 260 data on all available mothers and infants from the following sources:

- 10 261 • *Perinatal Data Collection (PDC)* – maternal and infant data on all live births and
11
12 262 stillbirths from 20 weeks' gestation or >400g birth weight;
- 13
14 263 • *Admitted Patient Data Collection (APDC)* – services provided to all individuals
15
16 264 admitted to public and private hospitals, using the International Classification of
17
18 265 Diseases – Australian modifications (ICD-10-AM)²¹ for clinical data;
- 19
20 266 • *Registry of Births, Deaths and Marriages (RBDM)* – all registered births and deaths;
- 21
22 267 • *Australian Bureau of Statistics (ABS)* – data on deaths including primary cause of
23
24 268 death (only for NSW and Queensland).

25
26 269 It was not possible to obtain data from all sources for all states and territories for the full
27
28 270 study period due to differences in data collection systems. Table footnotes indicate the
29
30 271 scope of data for each variable. In addition, not all states and territories provided data on
31
32 272 maternal mortality.

33 34 273 **Definitions**

35
36
37 274 We defined *low-risk pregnancy* as a singleton fetus in cephalic presentation between 37 and
38
39 275 41 completed weeks' gestation and free of known and recorded complications. Exclusions
40
41 276 are detailed in Box 1.

42
43 277 < Insert Box 1 here >

44
45
46 278 *Planned place of birth* incorporates three possible locations: home, birth centre, and
47
48 279 hospital. *Homebirths* are instances where women intend to give birth outside a formal
49
50 280 health facility, usually their own home, and receive care from a registered midwife, funded
51
52 281 through either the public or private health system or self-funded. *Birth centres* provide a
53
54 282 home-like birth setting and are run by midwives. They can be located within a hospital
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56 283 campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the
57
58 284 main hospital service for access to interventions such as epidural analgesia or caesarean
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1
2
3 285 section. *Hospital births* take place in the labour ward or birth suite (terms vary across the
4
5 286 country) of either a public or private hospital, staffed by midwives and doctors.
6
7

8 287 The timing of the decision about birth setting is critical within the birthplace literature.

9 288 While women choose a birth location early in their pregnancy, clinical factors may preclude
10
11 289 them from achieving this intention. If they develop complications, they may no longer be
12
13 290 eligible to give birth in a birth centre or at home. These women are excluded from
14

15 291 comparisons of outcome by birth setting if they transfer to hospital care prior to labour.

16
17 292 Ideally, researchers should identify planned place of birth at labour onset, to ensure that all
18
19 293 participants have a similar level of clinical complexity. All Australian data collections record
20
21 294 intended place of birth, but the majority did not indicate intention at labour onset.

22 295 Therefore, the current study analyses data on planned place of birth identified at an
23
24 296 undetermined time in the pregnancy, as close to labour as we were able to identify. The
25
26 297 screening process eliminated women with many of the risk factors that would have
27
28 298 prompted antenatal transfer from a birth centre or homebirth.

29
30 299 *Maternal outcomes* include mode of birth, interventions and procedures during labour and
31
32 300 birth (episiotomy, epidural or spinal analgesia, oxytocin augmentation), intact perineum (no
33
34 301 tears or episiotomy), maternal complications, and admission to a high dependency or
35
36 302 intensive care unit.

37
38
39 303 *Mode of birth* includes caesarean section, forceps birth, vacuum extraction, and normal
40
41 304 vaginal birth (non-instrumental). More specifically, *normal labour and birth* is defined as
42
43 305 spontaneous labour, cephalic presentation, without epidural, spinal or general anaesthesia,
44
45 306 forceps, vacuum extraction or episiotomy. Measures of *maternal complications* were severe
46
47 307 perineal trauma (3rd or 4th degree tear), postpartum haemorrhage (PPH) requiring a
48
49 308 transfusion, admission to intensive care or high dependency unit for more than 48 hours
50
51 309 and hospital readmission within 28 days. *Perinatal outcomes* include intrapartum stillbirth,
52
53 310 early neonatal death (0-7 days), late neonatal death (8-28 days), admission to special care or
54
55 311 neonatal intensive care unit (NICU) for more than 48 hours and readmission to hospital
56
57 312 within 28 days. We also stratified combined perinatal mortality data by parity. Other specific
58
59 313 definitions are included in relevant tables.
60

315 **Data linkage**

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

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

328 < Insert Box 2 here >

329 **Data cleaning, screening and cohort selection**

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

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

341

342 **Data analysis**

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

358 No imputation was made to missing data. All calculations in regression and rates were
359 computed based on non-missing data. Wherever necessary, sizes of missing data (not
360 stated/inadequately described) on related variables were reported. The analysis reports
361 99% confidence intervals. Statistical significance level was set at $p < 0.01$. Ethics approval
362 requirements prevented us reporting cell sizes of less than five to maintain confidentiality.

363 **RESULTS**

364 **Demographic characteristics**

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

1
2
3 369 Women planning to give birth in hospital labour wards were more likely to be younger,
4
5 370 nulliparous, of a shorter gestation (less than 40 weeks) or Australian-born than those
6
7 371 planning birth centre or home births (Table 1).
8

9 372 <Insert Table 1 here>
10

11 373 **Mode of birth, intervention and analgesia by planned place of birth**

12
13
14
15 374 Planned birth at home or in a birth centre was associated with normal labour and birth
16
17 375 more often than planned hospital birth. Women planning a birth centre birth were almost
18
19 376 three times as likely (AOR 2.72, 99% CI 2.63-2.81) and women planning a home birth were
20
21 377 almost six times as likely (AOR 5.91, 99% CI 5.15-6.78) to have a normal birth (Table 2). The
22
23 378 odds for nulliparous and multiparous women were similar.
24

25 379 <Insert Table 2 here>
26

27 380 Conversely, women planning hospital births were more likely to experience interventions in
28
29 381 birth. Compared with planned hospital births, births planned in other settings had
30
31 382 significantly lower odds of: vacuum extraction (birth centre AOR 0.42; 99% CI 0.40-0.44 and
32
33 383 homebirth AOR 0.18; 99% CI 0.14-0.24), forceps (birth centre AOR 0.54; 99% CI 0.50-0.58
34
35 384 and homebirth AOR 0.21; 99% CI 0.14-0.31) and intrapartum caesarean section (birth centre
36
37 385 AOR 0.45; 99% CI 0.43-0.48 and homebirth AOR 0.29; 99% CI 0.24-0.35).
38

39 386 Women who planned a birth centre or home birth were significantly more likely to have an
40
41 387 intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI
42
43 388 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd
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45 389 or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-
46
47 390 0.73) and more likely in planned birth centre births (AOR 1.17; 53% CI 1.09-1.25). The odds
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49 391 of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI
50
51 392 0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births.
52

53 393 The odds of other interventions such as oxytocin augmentation and epidural or spinal
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55 394 analgesia were lower in planned birth centre or home births (Table 3).
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57 395 <Insert Table 3 here>
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396 **Postpartum complications**

397 Women who planned to give birth in a birth centre were less likely to have a PPH requiring a
398 blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78).

399 There was no significant difference in the odds for women who planned a home birth (AOR
400 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency
401 unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no
402 different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the
403 absolute number of admissions is small (Table 4). There were no significant differences
404 between the groups in the odds of readmission to hospital within a month.

405 <Insert Table 4 here>

406 **Perinatal outcomes by planned place of birth**

407 There were no significant differences in the odds of intrapartum stillbirth, or early or late
408 neonatal deaths between the three planned places of birth. Combined data on stillbirth
409 during labour, early and late neonatal death indicate that women planning a home birth
410 were no more likely to experience perinatal mortality than those planning a hospital birth
411 (AOR 1.55; 99% CI 0.65-3.69), although the absolute number of deaths was very small
412 (9/8182). Similarly, there was no significant difference for women planning a birth centre
413 birth (AOR 0.84; 99% CI 0.60-1.19). When women were stratified by parity, there were no
414 significant differences between any of the groups in the odds of perinatal mortality.

415 Women who planned a birth centre birth were more likely to have their baby admitted to
416 the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women
417 who planned hospital births. This trend was not seen in planned home births (AOR 0.63;
418 99% CI 0.39-1.01). There were no significant differences between the three groups in the
419 odds of readmission of the baby to hospital within 28 days (Table 5).

420 <Insert Table 5 here>

421 **DISCUSSION**

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

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3 424 demonstrated results consistent with several international studies of planned place of
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5 425 birth.^{11,12,14} Normal births were more likely for women who planned birth in birth centres or
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7 426 at home than in a hospital. Women who planned to give birth at home were older than
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9 427 women planning hospital or birth centre births, but despite this, had consistently lower
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11 428 rates of intervention.

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13 429 The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live
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15 430 births compared with 0.4 in planned birth centre births and 1.1 in planned home births,
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17 431 although the absolute risks were very small with low numbers of deaths overall. These
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19 432 differences by place of birth were neither statistically significant for all women nor for
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21 433 cohorts stratified by parity. However, the differences are more marked in nulliparous
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23 434 women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than
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25 435 multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned
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27 436 homebirth). Given the small number of deaths in the planned homebirth group (n=9) this
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29 437 may be a chance finding over a long period of time (13 years). However, it is similar the
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31 438 combined perinatal outcome in the Birthplace in England study¹¹, although that study did
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33 439 find statistically significant higher odds of perinatal mortality among nulliparous women
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35 440 planning home births. This highlights the need to explain the risks to women in absolute
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37 441 terms, as this is likely to be more helpful in assisting decision-making.

38 442 There were two negative findings in relation to birth centre outcomes, firstly, a significantly
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40 443 higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned
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42 444 hospital births. Another Australian study¹⁶ and one in New Zealand also found higher rates
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44 445 of perineal trauma in birth centres.²⁵ However, other research found no significant
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46 446 differences in perineal outcomes for example in studies in Norway,^{26,27} Denmark,²⁸
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48 447 Australia²⁹ or England.³⁰ The higher rate of severe perineal trauma may be related to the use
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50 448 of birth stools, more common in Australian birth centres but less frequently in hospitals or
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52 449 at home. Birth stools have been linked to higher rates of severe perineal trauma compared
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54 450 with other birth positions or waterbirth.³¹ The higher rates of trauma could be due to better
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56 451 case ascertainment or lower rates of episiotomy.

57 452 The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours
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59 453 (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other
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3 454 research, which either found higher rates associated with planned hospital births^{16,25} or else
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5 455 no statistically significant differences in NICU admission rates from birth centres and
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7 456 hospital births.^{26,28,32} The admissions to the NICU or SCN in the current study are low in
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9 457 absolute terms (1 per 100 for birth centre births) but higher than planned hospital births.
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11 458 This requires ongoing examination to determine possible reasons and ways to reduce the
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13 459 rate.

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15 460 The study findings are important especially in light of evidence that shows associations
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17 461 between intervention in labour and birth, and long-term maternal and newborn health. For
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19 462 example, a recent population-based study showed that caesarean section is associated with
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21 463 an increased risk of infections, eczema, and metabolic disorders in children aged five years,
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23 464 compared with spontaneous vaginal births, especially for emergency caesarean sections.³³

24 25 465 **Strengths and limitations**

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28 466 This study is the first to comprehensively examine maternal and perinatal outcomes from
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30 467 three birth settings across Australia. It used a population-based sample consisting of women
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32 468 with low-risk pregnancies. The large sample size was sufficient to detect differences
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34 469 between the three groups, although the numbers of homebirth nationally, even over this
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36 470 time period, were comparatively small (i.e. 8212 only 0.7% of the total low-risk sample).

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38 471 Low-risk pregnancies were defined consistently across all three cohorts in the dataset.
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40 472 However, merging linked data from multiple jurisdictions created several challenges and
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42 473 potential shortcomings, including missing responses, inconsistent variable definitions and
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44 474 limited data from some states. For example, Queensland's data collection only covered
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46 475 2007-2012, resulting in under-representation: 9.6% of the combined sample, compared with
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48 476 20.4% of Australian births in 2012.³⁴ Although we eliminated unintended home births
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50 477 among women intending hospital or birth centre births (births before arrival), the home
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52 478 birth data do not always record whether or not a qualified health professional attended.
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54 479 Within the constraints of the data available, we have only included births attended by a
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56 480 health professional. Moreover, different states recorded birthplace intentions at different
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58 481 times. Although this means that intended birth place is not always recorded at onset of
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60 482 labour, the scrupulous process of data cleaning and categorising eliminated most women
483 with risk factors which would have rendered them ineligible for birth centre or home births.

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3 484 Thus, the recorded birthplace intention was as close as possible to that at labour onset.
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5 485 Some data items were collected inconsistently across the jurisdictions, for example, transfer
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7 486 from home to hospital after the onset of labour. This was either because the data item did
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9 487 not exist or because it only recorded 'transfer', which could have been at any time during
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11 488 pregnancy. Therefore, we were unable to report on intrapartum transfer rates.

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13 489 Inconsistencies in the data from different jurisdictions also affected the data analysis. The
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15 490 regression analysis incorporated very few potential confounders, limited to those for which
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17 491 consistent data were available nation-wide (i.e. maternal age, gestational age, parity and
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19 492 whether born in Australia or not). Socio-economic status is also inconsistently collected
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21 493 across the country, as is maternal BMI and education, so we were unable to adjust for these
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23 494 factors. Although this introduced some risk of selection bias, the process of identifying
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25 495 women with low-risk pregnancies increased the comparability of the cohorts in terms of
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27 496 clinical factors.

28 497 **CONCLUSION**

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31 498 This study provides evidence on the safety of births planned in hospital, birth centre and at
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33 499 home across all states and territories in Australia by comparing cohorts of women with low-
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35 500 risk pregnancies. Inconsistencies between state-based datasets as described limited the
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37 501 number of variables available for analysis. However, for healthy women with low-risk
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39 502 pregnancies, planned birth centre births resulted in high rates of normal labour and birth,
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41 503 low rates of most maternal complications, and comparable perinatal mortality outcomes.
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43 504 Women planning home birth also had similarly positive maternal outcomes with no
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45 505 statistically significant differences in the rate of perinatal mortality or NICU admission. In
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47 506 absolute terms, the numbers of deaths were small, although the rate of perinatal mortality
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49 507 was higher among nulliparous women who planned homebirths than their multiparous
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51 508 counterparts.

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510 **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

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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.

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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 death¹				
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 death²				
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 days⁴				
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.

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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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For peer review only

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

1	Outcome data	15*	Report numbers of outcome events or summary measures over time	12-14
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4	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
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9			(b) Report category boundaries when continuous variables were categorized	Tables
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11			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
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14	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
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17	Discussion			
18	Key results	18	Summarise key results with reference to study objectives	14-15
19	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
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23	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
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27	Generalisability	21	Discuss the generalisability (external validity) of the study results	15-17
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29	Other information			
30	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
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*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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-029192.R1
Article Type:	Original research
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Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Obstetrics and gynaecology, Nursing
Keywords:	Maternal medicine < OBSTETRICS, EPIDEMIOLOGY, PERINATOLOGY

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Manuscripts

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3 62 **ABSTRACT**
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6 63 **Objective** – To compare perinatal and maternal outcomes for Australian women with
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8 64 uncomplicated pregnancies according to planned place of birth, that is, in hospital labour
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10 65 wards, birth centres or at home.

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12 66 **Design** – A population-based retrospective design, linking and analysing routinely collected
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14 67 electronic data. Analysis comprised chi-square tests and binary logistic regression for
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16 68 categorical data, yielding adjusted odds ratios. Continuous data were analysed using
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18 69 ANOVA.

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20 70 **Setting** – All eight Australian states and territories.

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23 71 **Participants** – Women with low-risk pregnancies who gave birth between 2000 and 2012 to
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25 72 a singleton baby in cephalic presentation at between 37 and 41 completed weeks' gestation.
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27 73 Of the 1 251 420 births, 1 171 703 (93.6%) were planned in hospital labour wards, 71 505
28
29 74 (5.7%) in birth centres and 8212 (0.7%) at home.

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31 75 **Main outcome measures** – Mode of birth, normal labour and birth, interventions and
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33 76 procedures during labour and birth, maternal complications, admission to special care/high
34
35 77 dependency or intensive care units (mother or infant) and perinatal mortality (intrapartum
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37 78 stillbirth and neonatal death).

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39 79 **Results** – Compared with planned hospital births, the odds of normal labour and birth were
40
41 80 over twice as high in planned birth centre births (AOR 2.72; 99% CI 2.63-2.81) and nearly six
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43 81 times as high in planned home births (AOR 5.91; 99% CI 5.15-6.78). There were no
44
45 82 statistically significant differences in the proportion of intrapartum stillbirths, early or late
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47 83 neonatal deaths between the three planned places of birth.

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49 84 **Conclusions** – This is the first Australia-wide study to examine outcomes by planned place of
50
51 85 birth. For low-risk healthy women in Australia, planned births in birth centres or at home
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53 86 are associated with positive maternal outcomes although the number of homebirths was
54
55 87 small overall. There were no significant differences in the perinatal mortality rate, although
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57 88 the absolute numbers of deaths were very small.
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90 ARTICLE SUMMARY

91 Strengths and limitations of this study

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

103 Funding statement

104 This work was supported by the National Health and Medical Research Council Australia,
105 Grant ID 1022422 (2012-2017).

106 Competing interest statement

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

109 Acknowledgements

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

112 Ethics approval

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

116 Author contribution

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2
3 117 CSEH as the lead investigator was responsible for the overall leadership of the study
4
5 118 including the initial conception and design, grant application, ethical approval processes,
6
7 119 leading the project, drafting the manuscript and finalising the paper.

8
9 120 SLC was the data analyst responsible for merging the datasets from each jurisdiction,
10
11 121 refining the datasets, developing the analysis codes and processes and conducting the
12
13 122 statistical analysis and has provided final approval of this version.

14
15 123 CR worked with the data analyst to support data analysis and interpretation as well as
16
17 124 taking a key role in supporting the drafting of the manuscript and has provided final
18
19 125 approval of this version.

20
21 126 HGD was involved in the initial design of the study, played a key role in developing the study
22
23 127 questions and data analytic processes, was involved in drafting the work and/or revising it
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25 128 critically for important intellectual content and has provided final approval of this version.

26
27 129 DAE was involved in the initial design of the study, played a key role in developing the study
28
29 130 questions and providing expert review, was involved in drafting the work and/or revising it
30
31 131 critically for important intellectual content and has provided final approval of this version.

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33 132 MJF was involved in the initial design of the study, played a key role in developing the study
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37 134 critically for important intellectual content and has provided final approval of this version.

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43 137 critically for important intellectual content and has provided final approval of this version.

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45 138 HMc was involved in the initial design of the study, played a key role in developing the study
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47 139 questions and providing expert review, was involved in drafting the work and/or revising it
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49 140 critically for important intellectual content and has provided final approval of this version.

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51 141 JO was involved in the initial design of the study, played a key role in developing the study
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53 142 questions and providing expert review, was involved in drafting the work and/or revising it
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55 143 critically for important intellectual content and has provided final approval of this version.
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3 144 DS was involved in the initial design of the study, played a key role in developing the study
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5 145 questions and analytic processes and providing expert statistical planning and review, was
6
7 146 involved in drafting the work and/or revising it critically for important intellectual content
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9 147 and has provided final approval of this version.

10
11 148 CT played a key role in developing the study questions and analytic plan, assisted with
12
13 149 planning the data set merging and cleaning of the data and providing expert epidemiological
14
15 150 review, was involved in drafting the work and/or revising it critically for important
16
17 151 intellectual content and has provided final approval of this version.

18
19 152 VS was the project coordinator responsible for the ethical approval processes, took a key
20
21 153 role in coordinating the acquisition of the data from the different states and territories as
22
23 154 well as a lead role in planning and undertaking the analysis and interpretation, was involved
24
25 155 in drafting the work and/or revising it critically for important intellectual content and has
26
27 156 provided final approval of this version.

28 29 157 **Consent**

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32 158 Individual consent by participants was deemed to not be required due to the population-
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34 159 based de-identified form of the data released to the researchers.

35 36 160 **Data sharing statement**

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39 161 The data that support the findings of this study are not available. It was a condition of the
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41 162 agreement between the data linkage units and the researchers that the dataset remain
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43 163 confidential. We are not permitted to make any part of the linked data available to any
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45 164 party outside those named on the research team who have been granted access.

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166 INTRODUCTION

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

180 While most births take place in hospital labour wards or birth suites, a small proportion
181 (1.8% nationally) take place in midwife-run birth centres.¹ These birth centres in Australia
182 are typically co-located with hospitals (similar to alongside midwifery units in other
183 countries) although a small number of stand-alone birth centres exist.⁴ Birth centres
184 typically provide midwifery continuity of care to women with uncomplicated pregnancies in
185 a home-like environment and are well integrated into the health system.

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

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

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3 196 countries.⁸ In this analysis of 28 studies from 13 countries, women who planned hospital
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5 197 births had significantly higher rates of perineal trauma and instrumental/caesarean birth
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7 198 than those who planned other birth places. Overall, there was no significant difference in
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9 199 the odds of intrapartum stillbirth according to place of birth (compared with planned
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11 200 hospital births, planned homebirth: OR=0.94; 95% CI: 0.76-1.17; planned birth centre
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13 201 OR=0.66; 95% CI: 0.32-1.34) or in early neonatal deaths (planned home birth OR=1.00; 95%
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15 202 CI: 0.78-1.27; planned birth centre 1.08; 95% CI: 0.42-2.78).

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17 203 Previous Australian state-based studies into place of birth have showed variation in findings.
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19 204 In New South Wales (the most populous state accounting for around 30.9% of births)⁹,
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21 205 women without pregnancy complications who planned a home or birth centre birth had
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23 206 significantly higher proportions of normal birth than those planning hospital births (home
24
25 207 97.4% vs birth centre 86.0% vs hospital 73.9%). There was no significant difference in
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27 208 neonatal mortality although the overall sample size (n= 258 161, including only 742 planned
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29 209 home births), had insufficient power for these relatively rare outcomes. In South Australia
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31 210 (SA) (297 192 planned hospital births and 1141 [0.38%] planned home births), another study
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33 211 found lower intervention rates and equivalent perinatal death rates in home births
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35 212 compared to hospital births. However, the odds of an intrapartum fetal death were
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37 213 significantly higher among planned home births (two deaths in the planned home birth
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39 214 group; AOR 7.42; 95% CI: 1.53–35.87). This study included some women with recognised risk
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41 215 factors in the home birth group including twins.¹⁰ Large-scale studies in other countries
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43 216 mostly showing similar perinatal outcomes between births planned at home and in hospitals
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45 217 (and birth centres where these exist) with some differences for primiparous women.¹¹⁻¹⁴

46
47 218 There is less controversy about birth centres. Data from Australian birth centres indicate
48
49 219 lower rates of maternal morbidity,¹⁵ intervention, preterm birth and low birthweight
50
51 220 compared with hospital births for women with similar low-risk profiles.¹⁶ One study
52
53 221 identified no significant differences by birth place in perinatal mortality¹⁶ and another
54
55 222 reported lower perinatal mortality in birth centre births, although based on actual rather
56
57 223 than intended birth place.¹⁷ A smaller hospital-based study found no significant difference in
58
59 224 caesarean section rates between the birth centre and labour ward for women with low-risk
60
225 pregnancies.¹⁸ Two other birth centre studies reported higher rates of spontaneous vaginal

1
2
3 226 birth and lower rates of adverse infant outcomes (neonatal intensive care unit [NICU]
4 admission, low birthweight) compared to hospital births.^{19,20}
5
6

7
8 228 The safety of place of birth continues to be questioned in Australia.²¹ To generate evidence
9
10 229 to assist policy makers, health practitioners, and pregnant women and their families to
11
12 230 make informed decisions about place of birth, we undertook a national study combining
13
14 231 data from all eight Australian jurisdictions to examine the outcomes for women with low-
15
16 232 risk pregnancies related to three different birth settings. This is the first national study on
17
18 233 the comparative safety of different planned birth settings in Australia.

19 234 **Aim and objectives**

20
21
22 235 The study aimed to compare the perinatal and maternal outcomes for Australian women
23
24 236 with uncomplicated pregnancies according to planned place of birth, that is, hospital labour
25
26 237 wards, birth centres or at home. We defined *uncomplicated pregnancy* as a singleton fetus
27
28 238 in cephalic presentation between 37 and 41 completed weeks' gestation and free of known
29
30 239 and recorded complications. Exclusions are detailed in Box 1.

31
32 240 The objectives were to compare the three planned places of birth by:

- 33
34
35 241 • Mode of birth, rate of normal labour and birth, augmentation, analgesia during
36
37 242 labour and episiotomy
38
39 243 • Postpartum complications including postpartum haemorrhage, perineal trauma,
40
41 244 admission to an intensive care or high dependency unit and readmission to hospital
42
43 245 within 28 days. Women who gave birth at home and required transfer to hospital
44
45 246 either during labour or after the birth are counted as an admission.
46
47 247 • Intrapartum stillbirth or neonatal deaths
48

49 248

50 51 249 **METHODS**

52 53 54 250 **Study design**

55
56
57 251 The study used a population-based retrospective design, linking and analysing routinely
58
59 252 collected electronic data from multiple sources about births between 2000 and 2012 to
60

1
2
3 253 women with low-risk pregnancies. We compared outcomes from three cohorts comprising
4
5 254 women who were as comparable as possible given the available data. In Australia,
6
7 255 homebirth and birth centre options are mostly restricted to women who meet low-risk
8
9 256 criteria, that is, have an uncomplicated pregnancy and no relevant past medical or obstetric
10
11 257 history. We therefore endeavoured to ensure that the hospital cohort shared the same
12
13 258 characteristics, clinically if not demographically and applied the same filters on all three
14
15 259 cohorts to increase the similarity between groups.

16
17 260 The study was approved by a university Human Research Ethics Committee (HREC). HRECs in
18
19 261 each state and territory also approved access to anonymised linked data (see
20
21 262 Supplementary File 1).

22 23 263 **Patient and Public Involvement**

24
25
26 264 Patients and the public were not involved in the design or conduct of the study.

27 28 265 **Data sources**

29
30
31 266 All eight Australian states and territories compile electronic perinatal datasets with items on
32
33 267 maternal characteristics, labour, birth, and perinatal outcomes in the immediate
34
35 268 postpartum period, that is, during the birth admission. However, to eliminate women with
36
37 269 conditions that made them fall out of the uncomplicated criteria from the sample and to
38
39 270 examine deaths and major morbidity requiring hospitalisation beyond the perinatal period,
40
41 271 we examined additional data sources on deaths and hospital admissions nine months before
42
43 272 and twelve months following birth. This study used linked anonymous data on all available
44
45 273 mothers and infants from the following sources:

- 46 274 • *Perinatal Data Collection (PDC)* – maternal and infant data on all live births and
47
48 275 stillbirths from 20 weeks' gestation or >400g birth weight;
 - 49 276 • *Admitted Patient Data Collection (APDC)* – services provided to all individuals
50
51 277 admitted to public and private hospitals, using the International Classification of
52
53 278 Diseases – Australian modifications (ICD-10-AM)²² for clinical data;
 - 54
55 279 • *Registry of Births, Deaths and Marriages (RBDM)* – all registered births and deaths;
 - 56
57 280 • *Australian Bureau of Statistics (ABS)* – data on deaths including primary cause of
58
59 281 death (only for NSW and Queensland).
- 60

1
2
3 282 It was not possible to obtain data from all sources for all states and territories for the full
4
5 283 study period due to differences in data collection systems. Table footnotes indicate the
6
7 284 scope of data for each variable. In addition, not all states and territories provided data on
8
9 285 maternal mortality.

10 11 286 **Definitions**

12
13
14 287 The definition of *uncomplicated pregnancies* (those without medical or obstetric risk
15
16 288 factors) was determined a priori by the research team. For the most part, this used the
17
18 289 Australian College of Midwives Guidelines for Consultation and Referral²³ as a basis for the
19
20 290 description of uncomplicated pregnancies.

21
22 291 < Insert Box 1 here >

23
24
25 292 *Planned place of birth* incorporates three possible locations: home, birth centre, and
26
27 293 hospital. *Homebirths* are instances where women intend to give birth outside a formal
28
29 294 health facility, usually their own home, and receive care from a registered midwife, funded
30
31 295 through either the public or private health system or self-funded. *Birth centres* provide a
32
33 296 home-like birth setting and are run by midwives. They can be located within a hospital
34
35 297 campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the
36
37 298 main hospital service for access to interventions such as epidural analgesia or caesarean
38
39 299 section. *Hospital births* take place in the labour ward or birth suite (terms vary across the
40
41 300 country) of either a public or private hospital, and women are attended by midwives,
42
43 301 obstetricians and/or general practitioner (GP) obstetricians.

44 302 The timing of the decision about birth setting is critical within the birthplace literature.
45
46 303 While women choose a birth location early in their pregnancy, clinical factors may preclude
47
48 304 them from achieving this intention. If they develop complications, they may no longer be
49
50 305 eligible to give birth in a birth centre or at home. These women are excluded from
51
52 306 comparisons of outcome by birth setting if they transfer to hospital care prior to labour.
53
54 307 Ideally, researchers should identify planned place of birth at labour onset, to ensure that all
55
56 308 participants have a similar level of clinical complexity. All Australian data collections record
57
58 309 intended place of birth, but the majority did not indicate intention at labour onset.
59
60 310 Therefore, the current study analyses data on planned place of birth identified at an

1
2
3 311 undetermined time in the pregnancy, as close to labour as we were able to identify. The
4
5 312 screening process eliminated women with many of the risk factors that would have
6
7 313 prompted antenatal transfer from a birth centre or homebirth.
8

9 314 Box 2 provides the definitions of the maternal and perinatal outcomes.
10

11
12 315 < Insert Box 2 here >
13
14

15 316 **Data linkage**

16
17 317 Independent data linkage units (DLU) in each state and territory matched information from
18
19 318 the four data sources (where available), using probabilistic linkage techniques.^{24,25} This
20
21 319 generated de-identified health records linking information from multiple datasets about the
22
23 320 same individuals. This process yields the best available data on maternal and infant health
24
25 321 status. However, it is not infallible and has estimated false positive and false negative rates
26
27 322 of 0.5% each.²⁶
28

29 323 Cross-jurisdictional data linkage was not possible, as independent DLUs had diverging
30
31 324 protocols for maintaining patient privacy. We therefore applied to the individual data
32
33 325 custodians for access to the linked data, through the six DLUs (data linkage for the
34
35 326 Australian Capital Territory and the Northern Territory is provided by NSW and SA units
36
37 327 respectively). Data were combined on relevant variables, where comparable, into a national
38
39 328 dataset. Box 3 provides details on the datasets. Our approach to the data linkages and
40
41 329 combining issues are detailed elsewhere.²⁷
42

43 330 < Insert Box 3 here >
44
45

46 331 **Data cleaning, screening and cohort selection**

47
48 332 Because the data collections were developed separately in each state and territory (except
49
50 333 ABS collections), they had different characteristics and components. In particular, several
51
52 334 PDC and APDC variables differed in name and type by jurisdiction. Even within the same
53
54 335 state, some variable definitions changed over the study period, with items merged or split
55
56 336 into multiple variables over time. The researchers scrutinised definitions to ensure accurate
57
58 337 matching between variables with different names and attributes into a standardised
59
60

1
2
3 338 dataset. The variables on mode of birth and intervention are all as defined by each state or
4
5 339 territory.

6
7
8 340 Our broad request to state DLUs specified data on women with singleton pregnancies and a
9
10 341 cephalic presentation at 37 to 41 completed weeks' gestation. Datasets arrived in different
11
12 342 formats and met our low-risk criteria to varying extents. We then applied more specific
13
14 343 inclusion and exclusion criteria (Box 1) to generate the low-risk sample.

15 16 344 **Data analysis**

17
18 345 Data were converted to SPSS Version 24, then grouped according to women's planned place
19
20 346 of birth for intention to treat analysis. Descriptive statistics were generated and reported
21
22 347 using percentages (or incidence per 1000 births for postpartum complications and perinatal
23
24 348 outcomes). Categorical variables were initially compared using chi-square tests, followed by
25
26 349 odds ratios from binary logistic regression adjusted for maternal age, maternal country of
27
28 350 birth (Australia or elsewhere), gestational age and parity (dichotomised as primiparous vs
29
30 351 multiparous) (adjusted odds ratio=AOR). These confounders were decided *a priori* based on
31
32 352 what is known in the literature to affect outcomes. For simplicity, percentages were
33
34 353 computed for the incidence of events at each birth setting. Unfortunately, state and
35
36 354 territory-based data collections have inconsistent variables on other potential demographic
37
38 355 factors such as maternal education, socioeconomic status or body mass index, limiting the
39
40 356 variables available for controlling the analysis. We present analysis stratified by parity (first
41
42 357 baby versus other) for normal labour and birth and perinatal mortality. For continuous data
43
44 358 such as maternal age and gestation week, we used univariate general linear model for
45
46 359 analysis of variance (ANOVA) to examine the differences between the means.

47 360 No imputation was made to missing data. All calculations in regression and rates were
48
49 361 computed based on non-missing data. Wherever necessary, sizes of missing data (not
50
51 362 stated/inadequately described) on related variables were reported. The analysis reports
52
53 363 99% confidence intervals. The statistical significance level was set at $p < 0.01$ to have more
54
55 364 precision due to the large sample size. Ethics approval requirements prevented us reporting
56
57 365 cell sizes of less than five to maintain confidentiality. Further details on the methods is
58
59 366 presented elsewhere.²⁷
60

367 RESULTS

368 Demographic characteristics

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

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

376 <Insert Table 1 here>

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

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

384 <Insert Table 2 here>

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

1
2
3 393 Women who planned a birth centre or home birth were significantly more likely to have an
4
5 394 intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI
6
7 395 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd
8
9 396 or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-
10
11 397 0.73) and more likely in planned birth centre births (AOR 1.17; 99% CI 1.09-1.25). The odds
12
13 398 of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI
14
15 399 0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births. The
16
17 400 odds of other interventions such as oxytocin augmentation and epidural or spinal analgesia
18
19 401 were lower in planned birth centre or home births (Table 3).

20
21 402 <Insert Table 3 here>

22 23 403 **Maternal postpartum complications**

24
25
26 404 Women who planned to give birth in a birth centre were less likely to have a PPH requiring a
27
28 405 blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78).
29
30 406 There was no significant difference in the odds for women who planned a home birth (AOR
31
32 407 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency
33
34 408 unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no
35
36 409 different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the
37
38 410 absolute number of admissions is small (Table 4). There were no significant differences
39
40 411 between the groups in the odds of readmission to hospital within a month.

41
42 412 <Insert Table 4 here>

43 44 413 **Perinatal outcomes by planned place of birth**

45
46
47 414 There were no significant differences in the odds of intrapartum stillbirth, or early or late
48
49 415 neonatal deaths between the three planned places of birth. Combined data on stillbirth
50
51 416 during labour, early and late neonatal death indicate that women planning a home birth
52
53 417 were no more likely to experience perinatal mortality than those planning a hospital birth
54
55 418 (AOR 1.55; 99% CI 0.65-3.69), although the absolute number of deaths was very small
56
57 419 (9/8182). Similarly, there was no significant difference for women planning a birth centre
58
59 420 birth (AOR 0.84; 99% CI 0.60-1.19). When women were stratified by parity, there were no
60
61 421 significant differences between any of the groups in the odds of perinatal mortality.

1
2
3 422 Women who planned a birth centre birth were more likely to have their baby admitted to
4 423 the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women
5 424 who planned hospital births. This trend was not seen in planned home births (AOR 0.63;
6 425 99% CI 0.39-1.01). There were no significant differences between the three groups in the
7 426 odds of readmission of the baby to hospital within 28 days (Table 5).

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9
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13 427 <Insert Table 5 here>

14 15 16 428 **DISCUSSION**

17
18 429 This study, the first in Australia, has examined maternal and perinatal outcomes nationally
19 430 by planned place of birth including all eight states and territories. Our study has
20 431 demonstrated results consistent with several international studies of planned place of
21 432 birth.^{11,12,14} Normal births were more likely for women who planned birth in birth centres or
22 433 at home than in a hospital. Women who planned to give birth at home were slightly older
23 434 than women planning hospital or birth centre births, but despite this, had consistently lower
24 435 rates of intervention.

25
26 436 The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live
27 437 births compared with 0.4 in planned birth centre births and 1.1 in planned home births,
28 438 although the absolute risks were very small with low numbers of deaths overall. These
29 439 differences by place of birth were neither statistically significant for all women nor for
30 440 cohorts stratified by parity. However, the differences are more marked in primiparous
31 441 women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than
32 442 multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned
33 443 homebirth). Given the small number of deaths in the planned homebirth group (n=9) this
34 444 may be a chance finding over a long period of time (13 years). However, it is similar the
35 445 combined perinatal outcome in the Birthplace in England study¹¹, although that study did
36 446 find statistically significant higher odds of a composite of perinatal mortality and selected
37 447 early neonatal morbidities among primiparous women planning home births. This highlights
38 448 the need to explain the risks to women in absolute terms, as this is likely to be more helpful
39 449 in assisting decision-making.

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3 450 There were two negative findings in relation to birth centre outcomes, firstly, a significantly
4 451 higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned
5 452 hospital births. Another Australian study¹⁶ and one in New Zealand also found higher rates
6
7 453 of perineal trauma in birth centres.²⁸ However, other research found no significant
8
9 454 differences in perineal outcomes for example in studies in Norway,^{29,30} Denmark,³¹
10
11 455 Australia³² or England.³³ The higher rate of severe perineal trauma may be related to the use
12
13 456 of birth stools, more common in Australian birth centres but less frequently in hospitals or
14
15 457 at home. Birth stools have been linked to higher rates of severe perineal trauma compared
16
17 458 with other birth positions or waterbirth.³⁴ The higher rates of trauma could be due to better
18
19 459 case ascertainment or lower rates of episiotomy.

20
21
22 460 The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours
23
24 461 (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other
25
26 462 research, which either found higher rates associated with planned hospital births^{16,28} or else
27
28 463 no statistically significant differences in NICU admission rates from birth centres and
29
30 464 hospital births.^{29,31,35} The admissions to the NICU or SCN in the current study are low in
31
32 465 absolute terms (1 per 100 for birth centre births) but higher than planned hospital births.
33
34 466 This requires ongoing examination to determine possible reasons and ways to reduce the
35
36 467 rate.

37 38 468 **Strengths and limitations**

39
40
41 469 This study is the first to comprehensively examine maternal and perinatal outcomes from
42
43 470 three birth settings across Australia. It used a population-based sample consisting of women
44
45 471 with low-risk pregnancies. The large sample size was sufficient to detect differences
46
47 472 between the three groups, although the numbers of homebirth nationally, even over this
48
49 473 time period, were comparatively small (i.e. 8212 only 0.7% of the total low-risk sample).

50
51 474 The context of homebirth in Australia means there are still low numbers of women choosing
52
53 475 homebirth and hence small numbers in this population. Private practising midwives do not
54
55 476 have access to professional indemnity insurance which means the option for women is
56
57 477 limited although still available in some parts of the country. Some private practising
58
59 478 midwives in some states have visiting rights to hospitals but this is not universal leading to a
60
479 lack of potential lack of integration. The publicly funded home birth models are relatively

1
2
3 480 few (no more than 20 services across the country) and cater for small numbers of women.
4
5 481 The policy and professional context has not been highly supportive of homebirth which has
6
7 482 made scaling up of public services difficult.
8

9 483 Women with uncomplicated pregnancies were defined consistently across all three cohorts
10
11 484 in the dataset. However, merging linked data from multiple jurisdictions created several
12
13 485 challenges and potential shortcomings, including missing responses, inconsistent variable
14
15 486 definitions and limited data from some states.²⁷ For example, Queensland's data collection
16
17 487 only covered 2007-2012, resulting in under-representation: 9.6% of the combined sample,
18
19 488 compared with 20.4% of Australian births in 2012.³⁶ The linked data sets also could not
20
21 489 account for women who may have moved to another state or territory in the follow-up time
22
23 490 frame.

24
25 491 Although we eliminated unintended home births among women intending hospital or birth
26
27 492 centre births (births before arrival), the home birth data do not always record whether or
28
29 493 not a qualified health professional attended. Within the constraints of the data available, we
30
31 494 have only included births attended by a health professional. Moreover, different states
32
33 495 recorded birthplace intentions at different times. Although this means that intended birth
34
35 496 place is not always recorded at onset of labour, the scrupulous process of data cleaning and
36
37 497 categorising eliminated most women with risk factors which would have rendered them
38
39 498 ineligible for birth centre or home births. Thus, the recorded birthplace intention was as
40
41 499 close as possible to that at labour onset. However, there is a possibility that some planned
42
43 500 birth centre/home births were erroneously classified as planned hospital births.

44 501 Some data items were collected inconsistently across the jurisdictions, for example, transfer
45
46 502 from home to hospital after the onset of labour. This was either because the data item did
47
48 503 not exist or because it only recorded 'transfer', which could have been at any time during
49
50 504 pregnancy. Therefore, we were unable to report on intrapartum transfer rates.

51
52 505 Inconsistencies in the data from different jurisdictions also affected the data analysis. The
53
54 506 regression analysis incorporated very few potential confounders, limited to those for which
55
56 507 consistent data were available nation-wide (i.e. maternal age, gestational age, parity and
57
58 508 whether born in Australia or not). Socio-economic status is also inconsistently collected
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60

1
2
3 509 across the country, as is maternal BMI and education, so we were unable to adjust for these
4
5 510 factors.
6
7

8 511 It is possible, despite our best efforts to reduce selection bias is that there remains some
9
10 512 residual confounding especially given the small numbers of women planning a homebirth. It
11
12 513 is likely that women planning to give birth in a birth centre or at home, are likely to be
13
14 514 different from those planning a hospital birth in a number of ways, including their attitudes
15
16 515 to intervention and approach to birth. These are not able to be measured but may impact
17
18 516 on the findings in relation to interventions and outcomes.
19

20 517 **CONCLUSION**

21
22 518 This study provides evidence on the safety of births planned in hospital, birth centre and at
23
24 519 home across all states and territories in Australia by comparing cohorts of women with low-
25
26 520 risk pregnancies. Inconsistencies between state-based datasets as described limited the
27
28 521 number of variables available for analysis. However, for healthy women with low-risk
29
30 522 pregnancies, planned birth centre births resulted in high rates of normal labour and birth,
31
32 523 low rates of most maternal complications, and comparable perinatal mortality outcomes.
33
34 524 Women planning home birth also had similarly positive maternal outcomes with no
35
36 525 statistically significant differences in the rate of perinatal mortality or NICU admission. In
37
38 526 absolute terms, the numbers of deaths were small, although the rate of perinatal mortality
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40 527 was higher among primiparous women who planned homebirths than their multiparous
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42 528 counterparts.
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530 **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

531

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3 532 **Box 2: Maternal and perinatal outcomes**
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6 *Maternal outcomes* include mode of birth, interventions and procedures during labour
7 and birth (episiotomy, epidural or spinal analgesia, oxytocin augmentation) and perineal
8 status.
9

10
11 *Mode of birth* includes caesarean section, forceps birth, vacuum extraction, and normal
12 vaginal birth (non-instrumental).
13

14
15 *Normal labour and birth* is defined as spontaneous labour, cephalic presentation, without
16 epidural, spinal or general anaesthesia, forceps, vacuum extraction, episiotomy or
17 caesarean section.
18

19
20 *Postpartum complications* were severe perineal trauma (3rd or 4th degree tear),
21 postpartum haemorrhage (PPH) requiring a transfusion, admission to intensive care or
22 high dependency unit for more than 48 hours and hospital readmission within 28 days.
23

24
25 *Perinatal outcomes* include intrapartum stillbirth, early neonatal death (0-7 days), late
26 neonatal death (8-28 days), admission to special care or neonatal intensive care unit
27 (NICU) for more than 48 hours and readmission to hospital within 28 days. We also
28 stratified combined perinatal mortality data by parity. Combined perinatal loss included
29 stillbirth during labour, early and late neonatal death.
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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 ^{AE}
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)

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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 death¹	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 death²	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 >48hrs³	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 days⁴	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.

^{^E} 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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For peer review only

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3 **SUPPLEMENTARY FILE 1**
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5 **Ethics approval**
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8 The study received initial ethical approval from the lead university's Human Research Ethics
9 Committee (HREC) – University of Technology Sydney, Australia (university reference
10 number: 2012000167). Each state and territory also provided ethical approval.
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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

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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.

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Manuscripts

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

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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.

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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

1
2
3 CH as the lead investigator was responsible for the overall leadership of the study including
4 the initial conception and design, grant application, ethical approval processes, leading the
5 project, drafting the manuscript and finalising the paper.
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9 SC was the data analyst responsible for merging the datasets from each jurisdiction, refining
10 the datasets, developing the analysis codes and processes, and conducting the statistical
11 analysis and has provided final approval of this version.
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14

15 CR worked with the data analyst to support data analysis and interpretation as well as
16 taking a key role in supporting the drafting of the manuscript and has provided final
17 approval of this version.
18
19
20

21 HD was involved in the initial design of the study, played a key role in developing the study
22 questions and data analytic processes, was involved in drafting the work and/or revising it
23 critically for important intellectual content and has provided final approval of this version.
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28 questions and providing expert review, was involved in drafting the work and/or revising it
29 critically for important intellectual content and has provided final approval of this version.
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34 questions and providing expert review, was involved in drafting the work and/or revising it
35 critically for important intellectual content and has provided final approval of this version.
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40 questions and providing expert review, was involved in drafting the work and/or revising it
41 critically for important intellectual content and has provided final approval of this version.
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45 HM was involved in the initial design of the study, played a key role in developing the study
46 questions and providing expert review, was involved in drafting the work and/or revising it
47 critically for important intellectual content and has provided final approval of this version.
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51 JO was involved in the initial design of the study, played a key role in developing the study
52 questions and providing expert review, was involved in drafting the work and/or revising it
53 critically for important intellectual content and has provided final approval of this version.
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3 DS was involved in the initial design of the study, played a key role in developing the study
4 questions and analytic processes and providing expert statistical planning and review, was
5 involved in drafting the work and/or revising it critically for important intellectual content
6 and has provided final approval of this version.
7
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10
11 CT played a key role in developing the study questions and analytic plan, assisted with
12 planning the data set merging and cleaning of the data and providing expert epidemiological
13 review, was involved in drafting the work and/or revising it critically for important
14 intellectual content and has provided final approval of this version.
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18
19 VS was the project coordinator responsible for the ethical approval processes, took a key
20 role in coordinating the acquisition of the data from the different states and territories as
21 well as a lead role in planning and undertaking the analysis and interpretation, was involved
22 in drafting the work and/or revising it critically for important intellectual content and has
23 provided final approval of this version.
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29 **Consent**

30
31 Individual consent by participants was deemed to not be required due to the population-
32 based de-identified form of the data released to the researchers.
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36 **Data sharing statement**

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

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

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21 Previous Australian state-based studies into place of birth have showed variation in findings.
22 In New South Wales (the most populous state accounting for around 30.9% of births)¹⁰,
23 women without pregnancy complications who planned a home or birth centre birth had
24 significantly higher proportions of normal birth than those planning hospital births (home
25 97.4% vs birth centre 86.0% vs hospital 73.9%). There was no significant difference in
26 neonatal mortality although the overall sample size (n= 258 161, including only 742 planned
27 home births), had insufficient power for these relatively rare outcomes. In South Australia
28 (SA) (297 192 planned hospital births and 1141 [0.38%] planned home births), another study
29 found lower intervention rates and equivalent perinatal death rates in home births
30 compared to hospital births. However, the odds of an intrapartum fetal death were
31 significantly higher among planned home births (two deaths in the planned home birth
32 group; AOR 7.42; 95% CI: 1.53–35.87). This study included some women with recognised risk
33 factors in the home birth group including twins.¹¹ Large-scale studies in other countries
34 show similar perinatal outcomes between births planned at home and in hospitals (and birth
35 centres where these exist) with some differences for primiparous women.¹²⁻¹⁵

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49 There is less controversy about birth centres compared with homebirth. Data from
50 Australian birth centres indicate lower rates of maternal morbidity,¹⁶ intervention, preterm
51 birth and low birthweight compared with hospital births for women with similar risk
52 profiles.¹⁷ One study identified no significant differences by birth place in perinatal
53 mortality¹⁷ and another reported lower perinatal mortality in birth centre births, although
54 based on actual rather than intended birth place.¹⁸ A smaller hospital-based study found no
55 significant difference in caesarean section rates between the birth centre and labour ward
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3 for women with uncomplicated pregnancies.¹⁹ Two other birth centre studies reported
4 higher rates of spontaneous vaginal birth and lower rates of adverse infant outcomes
5 (neonatal intensive care unit [NICU] admission, low birthweight) compared to hospital
6 births.^{20,21}
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11 The safety of place of birth continues to be questioned in Australia.²² To generate evidence
12 to assist policy makers, health practitioners, and pregnant women and their families to
13 make informed decisions about place of birth, we undertook a national study combining
14 data from all eight Australian jurisdictions to examine the outcomes for women with
15 uncomplicated pregnancies related to three different birth settings. This is the first national
16 study on the comparative safety of different planned birth settings in Australia.
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23 **Aim and objectives**

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

41 **Study design**

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43 The study used a population-based retrospective design, linking and analysing routinely
44 collected electronic data from multiple sources about births between 2000 and 2012 to
45 women with uncomplicated pregnancies. We compared outcomes from three cohorts
46 comprising women who were as comparable as possible given the available data. In
47 Australia, homebirth and birth centre options are mostly restricted to women who meet
48 specific criteria, that is, have an uncomplicated pregnancy and no relevant past medical or
49 obstetric history. We therefore endeavoured to ensure that the hospital cohort shared the
50 same characteristics, clinically if not demographically and applied the same filters on all
51 three cohorts to increase the similarity between groups.
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3 The study was approved by a university Human Research Ethics Committee (HREC). HRECs in
4 each state and territory also approved access to anonymised linked data (see
5 Supplementary File 1).
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9 **Patient and Public Involvement**

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11 Patients and the public were not involved in the design or conduct of the study.
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14 **Data sources**

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16 All eight Australian states and territories compile electronic perinatal datasets with items on
17 maternal characteristics, labour, birth, and perinatal outcomes in the immediate
18 postpartum period, that is, during the birth admission. However, to eliminate women with
19 conditions that made them fall out of the uncomplicated criteria from the sample and to
20 examine deaths and major morbidity requiring hospitalisation beyond the perinatal period,
21 we examined additional data sources on deaths and hospital admissions nine months before
22 and twelve months following birth. This study used linked anonymous data on all available
23 mothers and infants from the following sources:
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- 32 • *Perinatal Data Collection (PDC)* – maternal and infant data on all live births and
33 stillbirths from 20 weeks' gestation or >400g birth weight;
- 34 • *Admitted Patient Data Collection (APDC)* – services provided to all individuals
35 admitted to public and private hospitals, using the International Classification of
36 Diseases – Australian modifications (ICD-10-AM)²³ for clinical data;
- 37 • *Registry of Births, Deaths and Marriages (RBDM)* – all registered births and deaths;
- 38 • *Australian Bureau of Statistics (ABS)* – data on deaths including primary cause of
39 death (only for NSW and Queensland).
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48 It was not possible to obtain data from all sources for all states and territories for the full
49 study period due to differences in data collection systems. Table footnotes indicate the
50 scope of data for each variable. In addition, not all states and territories provided data on
51 maternal mortality.
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55 **Definitions**

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3 The definition of *uncomplicated pregnancies* (those without medical or obstetric risk
4 factors) was determined a priori by the research team. For the most part, this used the
5 Australian College of Midwives Guidelines for Consultation and Referral² as a basis for the
6 description of uncomplicated pregnancies.
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14 *Planned place of birth* incorporates three possible locations: home, birth centre, and
15 hospital. *Homebirths* are instances where women intend to give birth outside a formal
16 health facility, usually their own home, and receive care from a registered midwife, funded
17 through either the public or private health system or self-funded. *Birth centres* provide a
18 home-like birth setting and are run by midwives. They can be located within a hospital
19 campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the
20 main hospital service for access to interventions such as epidural analgesia or caesarean
21 section. *Hospital births* take place in the labour ward or birth suite (terms vary across the
22 country) of either a public or private hospital, and women are attended by midwives,
23 obstetricians and/or general practitioner (GP) obstetricians.
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33 The timing of the decision about birth setting is critical within the birthplace literature.
34 While women choose a birth location early in their pregnancy, clinical factors may preclude
35 them from achieving this intention. If they develop complications, they may no longer be
36 eligible to give birth in a birth centre or at home. These women are excluded from
37 comparisons of outcome by birth setting if they transfer to hospital care prior to labour.
38 Ideally, researchers should identify planned place of birth at labour onset, to ensure that all
39 participants have a similar level of clinical complexity. All Australian data collections record
40 intended place of birth, but the majority did not indicate intention at labour onset.
41 Therefore, the current study analyses data on planned place of birth identified at an
42 undetermined time in the pregnancy, as close to labour as we were able to identify. The
43 screening process eliminated women with many of the risk factors that would have
44 prompted antenatal transfer from a birth centre or homebirth.
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56 Box 2 provides the definitions of the maternal and perinatal outcomes.
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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 3 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. 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.

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

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

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

28
29 Women planning hospital births were more likely to experience interventions in birth.
30 Compared with planned hospital births, births planned in other settings had significantly
31 lower odds of: vacuum extraction (birth centre AOR 0.42; 99% CI 0.40-0.44 and homebirth
32 AOR 0.18; 99% CI 0.14-0.24), forceps (birth centre AOR 0.54; 99% CI 0.50-0.58 and
33 homebirth AOR 0.21; 99% CI 0.14-0.31) and intrapartum caesarean section (birth centre
34 AOR 0.45; 99% CI 0.43-0.48 and homebirth AOR 0.29; 99% CI 0.24-0.35). Overall, the rates of
35 interventions in the whole cohort were low with a rate of intrapartum caesarean section of
36 only 8%.
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45 Women who planned a birth centre or home birth were significantly more likely to have an
46 intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI
47 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd
48 or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-
49 0.73) and more likely in planned birth centre births (AOR 1.17; 53% CI 1.09-1.25). The odds
50 of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI
51 0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births. The
52 odds of other interventions such as oxytocin augmentation and epidural or spinal analgesia
53 were lower in planned birth centre or home births (Table 3).
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6 **Maternal postpartum complications**

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8 Women who planned to give birth in a birth centre were less likely to have a PPH requiring a
9 blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78).
10 There was no significant difference in the odds for women who planned a home birth (AOR
11 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency
12 unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no
13 different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the
14 absolute number of admissions is small (Table 4). There were no significant differences
15 between the groups in the odds of readmission to hospital within a month.
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24 <Insert Table 4 here>
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26 **Perinatal outcomes by planned place of birth**

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28 Although the planned homebirth group had higher odds ratios for intrapartum stillbirth and
29 early neonatal death than the other planned places of birth, the differences were not
30 statistically significant. Combined data on stillbirth during labour, early and late neonatal
31 death indicate that indicate that perinatal death is no more likely to occur after planned
32 homebirth than in hospital birth (AOR 1.55; 99% CI 0.65-3.69), although the absolute
33 number of deaths was very small (9/8182). Similarly, there was no significant difference for
34 women planning a birth centre birth (AOR 0.84; 99% CI 0.60-1.19). When women were
35 stratified by parity, there were no significant differences between any of the groups in the
36 odds of perinatal mortality.
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46 Women who planned a birth centre birth were more likely to have their baby admitted to
47 the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women
48 who planned hospital births. This trend was not seen in planned home births (AOR 0.63;
49 99% CI 0.39-1.01). There were no significant differences between the three groups in the
50 odds of readmission of the baby to hospital within 28 days (Table 5).
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58 **DISCUSSION**

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3 This study, the first in Australia, has examined maternal and perinatal outcomes nationally
4 by planned place of birth including all eight states and territories. Our study has
5 demonstrated results consistent with several international studies of planned place of
6 birth.^{12,13,15} Normal births were more likely for women who planned birth in birth centres or
7 at home than in a hospital. Women who planned to give birth at home were slightly older
8 than women planning hospital or birth centre births, but despite this, had consistently lower
9 rates of intervention.
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17 The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live
18 births compared with 0.4 in planned birth centre births and 1.1 in planned home births,
19 although the absolute risks were very small with low numbers of deaths overall. These
20 differences by place of birth were neither statistically significant for all women nor for
21 cohorts stratified by parity. However, the differences are more marked in primiparous
22 women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than
23 multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned
24 homebirth). Given the small number of deaths in the planned homebirth group (n=9) this
25 may be a chance finding over a long period of time (13 years). However, it is similar to the
26 findings of the Birthplace in England study, which found a statistically significant higher odds
27 of a composite outcome combining perinatal mortality and selected early neonatal
28 morbidities among primiparous women planning home birth.¹² This highlights the need to
29 explain the risks to women in absolute terms, as this is likely to be more helpful in assisting
30 decision-making.
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44 There were two negative findings in relation to birth centre outcomes, firstly, a significantly
45 higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned
46 hospital births. Another Australian study¹⁷ and one in New Zealand also found higher rates
47 of perineal trauma in birth centres.²⁸ However, other research found no significant
48 differences in perineal outcomes, for example in studies in Norway,^{29,30} Denmark,³¹
49 Australia³² or England.³³ The higher rate of severe perineal trauma may be related to the use
50 of birth stools, more common in Australian birth centres but less frequently in hospitals or
51 at home. Birth stools have been linked to higher rates of severe perineal trauma compared
52 with other birth positions or waterbirth.³⁴ The higher rates of trauma could also be due to
53 better case ascertainment or lower rates of episiotomy.
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3 The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours
4 (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other
5 research, which either found higher rates associated with planned hospital births^{17,28} or else
6 no statistically significant differences in NICU admission rates from birth centres and
7 hospital births.^{29,31,35} The admissions to the NICU or SCN in the current study are low in
8 absolute terms (1 per 100 for birth centre births) but higher than planned hospital births.
9 This requires ongoing examination to determine possible reasons and ways to reduce the
10 rate.
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19 **Strengths and limitations**

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21 This study is the first to comprehensively examine maternal and perinatal outcomes from
22 three birth settings across Australia. It used a population-based sample consisting of women
23 with uncomplicated pregnancies. The large sample size was sufficient to detect differences
24 between the three groups, although the numbers of homebirth nationally, even over this
25 time period, were comparatively small (i.e. 8212 only 0.7% of the total sample).
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31 The context of homebirth in Australia means there are still low numbers of women choosing
32 homebirth and hence small numbers in this population. Private practising midwives do not
33 have access to professional indemnity insurance which means the option for women is
34 limited although still available in some parts of the country. Some private practising
35 midwives in some states have visiting rights to hospitals but this is not universal leading to a
36 lack of potential lack of integration. The publicly funded home birth models are relatively
37 few (no more than 20 services across the country) and cater for small numbers of women.
38 The policy and professional context has not been highly supportive of homebirth which has
39 made scaling up of public services difficult.
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48 Women with uncomplicated pregnancies were defined consistently across all three cohorts
49 in the dataset. However, merging linked data from multiple jurisdictions created several
50 challenges and potential shortcomings, including missing responses, inconsistent variable
51 definitions and limited data from some states.²⁷ For example, Queensland's data collection
52 only covered 2007-2012, resulting in under-representation: 9.6% of the combined sample,
53 compared with 20.4% of Australian births in 2012.³⁶ The linked data sets also could not
54 account for women who may have moved to another state or territory in the follow-up time
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3 frame. In addition, state and territory-based data collections have inconsistent variables on
4 other potential demographic factors such as maternal education, socioeconomic status or
5 body mass index, limiting the variables available for controlling the analysis.
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9 Although we eliminated unintended home births among women intending hospital or birth
10 centre births (births before arrival), the home birth data do not always record whether or
11 not a qualified health professional attended. Within the constraints of the data available, we
12 have only included births attended by a health professional. Moreover, different states
13 recorded birthplace intentions at different times. Although this means that intended birth
14 place is not always recorded at onset of labour, the scrupulous process of data cleaning and
15 categorising eliminated most women with risk factors which would have rendered them
16 ineligible for birth centre or home births. Thus, the recorded birthplace intention was as
17 close as possible to that at labour onset. However, there is a possibility that some planned
18 birth centre/home births were erroneously classified as planned hospital births.
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28 Some data items were collected inconsistently across the jurisdictions, for example, transfer
29 from home to hospital after the onset of labour. This was either because the data item did
30 not exist or because it only recorded 'transfer', which could have been at any time during
31 pregnancy. Therefore, we were unable to report on intrapartum transfer rates.
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36 Inconsistencies in the data from different jurisdictions also affected the data analysis. The
37 regression analysis incorporated very few potential confounders, limited to those for which
38 consistent data were available nation-wide (i.e. maternal age, gestational age, parity and
39 whether born in Australia or not). Socio-economic status is also inconsistently collected
40 across the country, as is maternal BMI and education, so we were unable to adjust for these
41 factors.
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48 It is possible that there remains some residual *unobservable differences in the groups*. It is
49 possible that women planning to give birth in a birth centre or at home are different from
50 those planning a hospital birth in a number of ways, including their motivation, attitudes to
51 intervention and approach to birth. These are not able to be measured but may impact on
52 the findings in relation to interventions and outcomes.
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58 **CONCLUSION**

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

Postpartum 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 ^{AE}
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 death¹	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 death²	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 >48hrs³	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 days⁴	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.

^{^E} 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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For peer review only

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

1 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

Journal:	<i>BMJ Open</i>
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Article Type:	Original research
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Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Obstetrics and gynaecology, Nursing
Keywords:	Maternal medicine < OBSTETRICS, EPIDEMIOLOGY, PERINATOLOGY

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Manuscripts

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21 58 Keywords: Maternal medicine, obstetrics, epidemiology, perinatology
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23 60 Word count - excluding title page, references, figures: 5475
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3 **63 ABSTRACT**
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6 **64 Objective** – To compare perinatal and maternal outcomes for Australian women with
7
8 **65** uncomplicated pregnancies according to planned place of birth, that is, in hospital labour
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10 **66** wards, birth centres or at home.

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12 **67 Design** – A population-based retrospective design, linking and analysing routinely collected
13
14 **68** electronic data. Analysis comprised chi-square tests and binary logistic regression for
15
16 **69** categorical data, yielding adjusted odds ratios. Continuous data were analysed using
17
18 **70** ANOVA.

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20 **71 Setting** – All eight Australian states and territories.

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23 **72 Participants** – Women with uncomplicated pregnancies who gave birth between 2000 and
24
25 **73** 2012 to a singleton baby in cephalic presentation at between 37 and 41 completed weeks'
26
27 **74** gestation. Of the 1 251 420 births, 1 171 703 (93.6%) were planned in hospital labour wards,
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29 **75** 71 505 (5.7%) in birth centres and 8212 (0.7%) at home.

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31 **76 Main outcome measures** – Mode of birth, normal labour and birth, interventions and
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33 **77** procedures during labour and birth, maternal complications, admission to special care/high
34
35 **78** dependency or intensive care units (mother or infant) and perinatal mortality (intrapartum
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37 **79** stillbirth and neonatal death).

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39 **80 Results** – Compared with planned hospital births, the odds of normal labour and birth were
40
41 **81** over twice as high in planned birth centre births (AOR 2.72; 99% CI 2.63-2.81) and nearly six
42
43 **82** times as high in planned home births (AOR 5.91; 99% CI 5.15-6.78). There were no
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45 **83** statistically significant differences in the proportion of intrapartum stillbirths, early or late
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47 **84** neonatal deaths between the three planned places of birth.

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49 **85 Conclusions** – This is the first Australia-wide study to examine outcomes by planned place of
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51 **86** birth. For healthy women in Australia having an uncomplicated pregnancy, planned births in
52
53 **87** birth centres or at home are associated with positive maternal outcomes although the
54
55 **88** number of homebirths was small overall. There were no significant differences in the
56
57 **89** perinatal mortality rate, although the absolute numbers of deaths were very small and
58
59 **90** therefore firm conclusions cannot be drawn about perinatal mortality outcomes.
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92 ARTICLE SUMMARY

93 Strengths and limitations of this study

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

105 Funding statement

106 This work was supported by the National Health and Medical Research Council Australia,
107 Grant ID 1022422 (2012-2017).

108 Competing interest statement

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

111 Acknowledgements

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

114 Ethics approval

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

118 Author contribution

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2
3 119 CH as the lead investigator was responsible for the overall leadership of the study including
4
5 120 the initial conception and design, grant application, ethical approval processes, leading the
6
7 121 project, drafting the manuscript and finalising the paper.
8

9
10 122 SC was the data analyst responsible for merging the datasets from each jurisdiction, refining
11
12 123 the datasets, developing the analysis codes and processes, and conducting the statistical
13
14 124 analysis and has provided final approval of this version.
15

16 125 CR worked with the data analyst to support data analysis and interpretation as well as
17
18 126 taking a key role in supporting the drafting of the manuscript and has provided final
19
20 127 approval of this version.
21

22 128 HD was involved in the initial design of the study, played a key role in developing the study
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25
26 130 critically for important intellectual content and has provided final approval of this version.
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29 131 DE was involved in the initial design of the study, played a key role in developing the study
30
31 132 questions and providing expert review, was involved in drafting the work and/or revising it
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33 133 critically for important intellectual content and has provided final approval of this version.
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35 134 MF was involved in the initial design of the study, played a key role in developing the study
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37 135 questions and providing expert review, was involved in drafting the work and/or revising it
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39 136 critically for important intellectual content and has provided final approval of this version.
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41 137 DF was involved in the initial design of the study, played a key role in developing the study
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43 138 questions and providing expert review, was involved in drafting the work and/or revising it
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45 139 critically for important intellectual content and has provided final approval of this version.
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47 140 HM was involved in the initial design of the study, played a key role in developing the study
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49 141 questions and providing expert review, was involved in drafting the work and/or revising it
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51 142 critically for important intellectual content and has provided final approval of this version.
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54 143 JO was involved in the initial design of the study, played a key role in developing the study
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56 144 questions and providing expert review, was involved in drafting the work and/or revising it
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58 145 critically for important intellectual content and has provided final approval of this version.
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3 146 DS was involved in the initial design of the study, played a key role in developing the study
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5 147 questions and analytic processes and providing expert statistical planning and review, was
6
7 148 involved in drafting the work and/or revising it critically for important intellectual content
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9 149 and has provided final approval of this version.

10
11 150 CT played a key role in developing the study questions and analytic plan, assisted with
12
13 151 planning the data set merging and cleaning of the data and providing expert epidemiological
14
15 152 review, was involved in drafting the work and/or revising it critically for important
16
17 153 intellectual content and has provided final approval of this version.

18
19 154 VS was the project coordinator responsible for the ethical approval processes, took a key
20
21 155 role in coordinating the acquisition of the data from the different states and territories as
22
23 156 well as a lead role in planning and undertaking the analysis and interpretation, was involved
24
25 157 in drafting the work and/or revising it critically for important intellectual content and has
26
27 158 provided final approval of this version.

28 29 159 **Consent**

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32 160 Individual consent by participants was deemed to not be required due to the population-
33
34 161 based de-identified form of the data released to the researchers.

35 36 162 **Data sharing statement**

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39 163 The data that support the findings of this study are not available. It was a condition of the
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41 164 agreement between the data linkage units and the researchers that the dataset remain
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43 165 confidential. We are not permitted to make any part of the linked data available to any
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45 166 party outside those named on the research team who have been granted access.

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168 INTRODUCTION

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

181 While most births take place in hospital labour wards or birth suites, a small proportion
182 (1.8% nationally) take place in midwife-run birth centres.¹ In Australia these birth centres
183 are typically co-located with hospitals (similar to alongside midwifery units in other
184 countries) although a small number of stand-alone birth centres exist.⁴ Birth centres
185 typically provide midwifery continuity of care to women with uncomplicated pregnancies in
186 a home-like environment and are well integrated into the health system.

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

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

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3 198 income countries.⁸ In this analysis of 28 studies from 13 countries, women who planned
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5 199 hospital births had significantly higher rates of perineal trauma and instrumental/caesarean
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7 200 birth than those who planned other birth places. Overall, there was no significant difference
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9 201 in the odds of intrapartum stillbirth according to place of birth (compared with planned
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11 202 hospital births, planned homebirth: OR=0.94; 95% CI: 0.76-1.17; planned birth centre
12
13 203 OR=0.66; 95% CI: 0.32-1.34) or in early neonatal deaths (planned home birth OR=1.00; 95%
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15 204 CI: 0.78-1.27; planned birth centre 0.87; 95% CI: 0.29-2.61).

16
17 205 Previous Australian state-based studies into place of birth have showed variation in findings.
18
19 206 In New South Wales (the most populous state accounting for around 30.9% of births)⁹,
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21 207 women without pregnancy complications who planned a home or birth centre birth had
22
23 208 significantly higher proportions of normal birth than those planning hospital births (home
24
25 209 97.4% vs birth centre 86.0% vs hospital 73.9%). There was no significant difference in
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27 210 neonatal mortality although the overall sample size (n= 258 161, including only 742 planned
28
29 211 home births), had insufficient power for these relatively rare outcomes. In South Australia
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31 212 (SA) (297 192 planned hospital births and 1141 [0.38%] planned home births), another study
32
33 213 found lower intervention rates and equivalent perinatal death rates in home births
34
35 214 compared to hospital births. However, the odds of an intrapartum fetal death were
36
37 215 significantly higher among planned home births (two deaths in the planned home birth
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39 216 group; AOR 7.42; 95% CI: 1.53–35.87). This study included some women with recognised risk
40
41 217 factors in the home birth group including twins.¹⁰ Large-scale studies in other countries
42
43 218 show similar perinatal outcomes between births planned at home and in hospitals (and birth
44
45 219 centres where these exist) with some differences for primiparous women.¹¹⁻¹⁴

46
47 220 There is less controversy about birth centres compared with homebirth. Data from
48
49 221 Australian birth centres indicate lower rates of maternal morbidity,¹⁵ intervention, preterm
50
51 222 birth and low birthweight compared with hospital births for women with similar risk
52
53 223 profiles.¹⁶ One study identified no significant differences by birth place in perinatal
54
55 224 mortality¹⁶ and another reported lower perinatal mortality in birth centre births, although
56
57 225 based on actual rather than intended birth place.¹⁷ A smaller hospital-based study found no
58
59 226 significant difference in caesarean section rates between the birth centre and labour ward
60
61 227 for women with uncomplicated pregnancies.¹⁸ Two other birth centre studies reported
62
63 228 higher rates of spontaneous vaginal birth and lower rates of adverse infant outcomes

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3 229 (neonatal intensive care unit [NICU] admission, low birthweight) compared to hospital
4
5 230 births.^{19,20}
6
7

8 231 The safety of place of birth continues to be questioned in Australia.²¹ To generate evidence
9
10 232 to assist policy makers, health practitioners, and pregnant women and their families to
11
12 233 make informed decisions about place of birth, we undertook a national study combining
13
14 234 data from all eight Australian jurisdictions to examine the outcomes for women with
15
16 235 uncomplicated pregnancies related to three different birth settings. This is the first national
17
18 236 study on the comparative safety of different planned birth settings in Australia.
19

20 237 **Aim and objectives**

21
22 238 The study aimed to compare the perinatal and maternal outcomes for Australian women
23
24 239 with uncomplicated pregnancies according to planned place of birth, that is, hospital labour
25
26 240 wards, birth centres or at home. Outcomes investigated included normal labour and birth,
27
28 241 mode of birth, interventions during labour, postpartum maternal complications and
29
30 242 perinatal mortality and morbidity. We defined *uncomplicated pregnancy* as a singleton fetus
31
32 243 in cephalic presentation between 37 and 41 completed weeks' gestation and free of known
33
34 244 and recorded complications. Exclusions are detailed in Box 1.
35

36 245 **METHODS**

37 38 246 **Study design**

39
40
41 247 The study used a population-based retrospective design, linking and analysing routinely
42
43 248 collected electronic data from multiple sources about births between 2000 and 2012 to
44
45 249 women with uncomplicated pregnancies. We compared outcomes from three cohorts
46
47 250 comprising women who were as comparable as possible given the available data. In
48
49 251 Australia, homebirth and birth centre options are mostly restricted to women who meet
50
51 252 specific criteria, that is, have an uncomplicated pregnancy and no relevant past medical or
52
53 253 obstetric history. We therefore endeavoured to ensure that the hospital cohort shared the
54
55 254 same characteristics, clinically if not demographically and applied the same filters on all
56
57 255 three cohorts to increase the similarity between groups.
58
59
60

1
2
3 256 The study was approved by a university Human Research Ethics Committee (HREC). HRECs in
4
5 257 each state and territory also approved access to anonymised linked data (see
6
7 258 Supplementary File 1).

9 259 **Patient and Public Involvement**

11
12 260 Patients and the public were not involved in the design or conduct of the study.

14 15 261 **Data sources**

16
17 262 All eight Australian states and territories compile electronic perinatal datasets with items on
18
19 263 maternal characteristics, labour, birth, and perinatal outcomes in the immediate
20
21 264 postpartum period, that is, during the birth admission. However, to eliminate women with
22
23 265 conditions that made them fall out of the uncomplicated criteria from the sample and to
24
25 266 examine deaths and major morbidity requiring hospitalisation beyond the perinatal period,
26
27 267 we examined additional data sources on deaths and hospital admissions nine months before
28
29 268 and twelve months following birth. This study used linked anonymous data on all available
30
31 269 mothers and infants from the following sources:

- 32 270 • *Perinatal Data Collection (PDC)* – maternal and infant data on all live births and
33
34 271 stillbirths from 20 weeks' gestation or >400g birth weight;
- 35
36 272 • *Admitted Patient Data Collection (APDC)* – services provided to all individuals
37
38 273 admitted to public and private hospitals, using the International Classification of
39
40 274 Diseases – Australian modifications (ICD-10-AM)²² for clinical data;
- 41
42 275 • *Registry of Births, Deaths and Marriages (RBDM)* – all registered births and deaths;
- 43
44 276 • *Australian Bureau of Statistics (ABS)* – data on deaths including primary cause of
45
46 277 death (only for NSW and Queensland).

47
48 278 It was not possible to obtain data from all sources for all states and territories for the full
49
50 279 study period due to differences in data collection systems. Table footnotes indicate the
51
52 280 scope of data for each variable. In addition, not all states and territories provided data on
53
54 281 maternal mortality.

55 56 282 **Definitions**

57
58
59
60

1
2
3 283 The definition of *uncomplicated pregnancies* (those without medical or obstetric risk
4
5 284 factors) was determined a priori by the research team. For the most part, this used the
6
7 285 Australian College of Midwives Guidelines for Consultation and Referral²³ as a basis for the
8
9 286 description of uncomplicated pregnancies.

10
11 287 < Insert Box 1 here >

12
13
14 288 *Planned place of birth* incorporates three possible locations: home, birth centre, and
15
16 289 hospital. *Homebirths* are instances where women intend to give birth outside a formal
17
18 290 health facility, usually their own home, and receive care from a registered midwife, funded
19
20 291 through either the public or private health system or self-funded. *Birth centres* provide a
21
22 292 home-like birth setting and are run by midwives. They can be located within a hospital
23
24 293 campus (alongside unit) or in a separate area (stand-alone unit) and require transfer to the
25
26 294 main hospital service for access to interventions such as epidural analgesia or caesarean
27
28 295 section. *Hospital births* take place in the labour ward or birth suite (terms vary across the
29
30 296 country) of either a public or private hospital, and women are attended by midwives,
31
32 297 obstetricians and/or general practitioner (GP) obstetricians.

33
34 298 The timing of the decision about birth setting is critical within the birthplace literature.
35
36 299 While women choose a birth location early in their pregnancy, clinical factors may preclude
37
38 300 them from achieving this intention. If they develop complications, they may no longer be
39
40 301 eligible to give birth in a birth centre or at home. These women are excluded from
41
42 302 comparisons of outcome by birth setting if they transfer to hospital care prior to labour.
43
44 303 Ideally, researchers should identify planned place of birth at labour onset, to ensure that all
45
46 304 participants have a similar level of clinical complexity. All Australian data collections record
47
48 305 intended place of birth, but the majority did not indicate intention at labour onset.
49
50 306 Therefore, the current study analyses data on planned place of birth identified at an
51
52 307 undetermined time in the pregnancy, as close to labour as we were able to identify. The
53
54 308 screening process eliminated women with many of the risk factors that would have
55
56 309 prompted antenatal transfer from a birth centre or homebirth.

57
58 310 Box 2 provides the definitions of the maternal and perinatal outcomes.

59 311 < Insert Box 2 here >

312 **Data linkage**

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

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

326 < Insert Box 3 here >

327 **Data cleaning, screening and cohort selection**

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

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

340 **Data analysis**

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

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

355 No imputation was made to missing data. All calculations in regression and rates were
356 computed based on non-missing data. Wherever necessary, sizes of missing data (not
357 stated/inadequately described) on related variables were reported. The analysis reports
358 99% confidence intervals. The statistical significance level was set at $p < 0.01$ to have more
359 precision due to the large sample size.

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

363 **RESULTS**

364 **Demographic characteristics**

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

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

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

372 <Insert Table 1 here>

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

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

380 <Insert Table 2 here>

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

389 Women who planned a birth centre or home birth were significantly more likely to have an
390 intact perineum (birth centre AOR 1.16; 99% CI 1.14-1.19 and homebirth AOR 2.07; 99% CI
391 1.95-2.20) than those planning a hospital birth. Compared with planned hospital births, 3rd
392 or 4th degree perineal tears were less likely in planned home births (AOR 0.53; 99% CI 0.39-
393 0.73) and more likely in planned birth centre births (AOR 1.17; 99% CI 1.09-1.25). The odds
394 of episiotomy were much lower in both non-hospital groups (birth centre AOR 0.37; 99% CI

1
2
3 395 0.36-0.39 and homebirth AOR 0.13; 99% CI 0.10-0.15) than in planned hospital births. The
4
5 396 odds of other interventions such as oxytocin augmentation and epidural or spinal analgesia
6
7 397 were lower in planned birth centre or home births (Table 3).
8

9
10 398 <Insert Table 3 here>
11

12 399 **Maternal postpartum complications**

13
14
15 400 Women who planned to give birth in a birth centre were less likely to have a PPH requiring a
16
17 401 blood transfusion than women who planned hospital births (AOR 0.66; 99% CI 0.56-0.78).
18
19 402 There was no significant difference in the odds for women who planned a home birth (AOR
20
21 403 1.08; 99% CI 0.73-1.60). The odds for admission to an intensive care or a high dependency
22
23 404 unit were lower for the planned birth centre group (AOR 0.42; 99% CI 0.31-0.56) but no
24
25 405 different for the planned home birth group (AOR 0.41; 99% CI 0.15-1.08). However, the
26
27 406 absolute number of admissions is small (Table 4). There were no significant differences
28
29 407 between the groups in the odds of readmission to hospital within a month.

30
31 408 <Insert Table 4 here>
32

33 409 **Perinatal outcomes by planned place of birth**

34
35
36 410 Although the planned homebirth group had higher odds ratios for intrapartum stillbirth and
37
38 411 early neonatal death than the other planned places of birth, the differences were not
39
40 412 statistically significant. Combined data on stillbirth during labour, early and late neonatal
41
42 413 death indicate that indicate that perinatal death is no more likely to occur after planned
43
44 414 homebirth than in hospital birth (AOR 1.55; 99% CI 0.65-3.69), although the absolute
45
46 415 number of deaths was very small (9/8182). Similarly, there was no significant difference for
47
48 416 women planning a birth centre birth (AOR 0.84; 99% CI 0.60-1.19). When women were
49
50 417 stratified by parity, there were no significant differences between any of the groups in the
51
52 418 odds of perinatal mortality.

53
54 419 Women who planned a birth centre birth were more likely to have their baby admitted to
55
56 420 the NICU and/or SCU for longer than 48 hours (AOR 1.24; 99% CI 1.10-1.39) than women
57
58 421 who planned hospital births. This trend was not seen in planned home births (AOR 0.63;
59
60

1
2
3 422 99% CI 0.39-1.01). There were no significant differences between the three groups in the
4
5 423 odds of readmission of the baby to hospital within 28 days (Table 5).
6
7

8 424 <Insert Table 5 here>
9

10 425 **DISCUSSION**

11
12
13 426 This study, the first in Australia, has examined maternal and perinatal outcomes nationally
14
15 427 by planned place of birth including all eight states and territories. Our study has
16
17 428 demonstrated results consistent with several international studies of planned place of
18
19 429 birth.^{11,12,14} Normal births were more likely for women who planned birth in birth centres or
20
21 430 at home than in a hospital. Women who planned to give birth at home were slightly older
22
23 431 than women planning hospital or birth centre births, but despite this, had consistently lower
24
25 432 rates of intervention.

26
27 433 The unadjusted perinatal mortality ratio for planned hospital births was 0.8 per 1000 live
28
29 434 births compared with 0.4 in planned birth centre births and 1.1 in planned home births,
30
31 435 although the absolute risks were very small with low numbers of deaths overall. These
32
33 436 differences by place of birth were neither statistically significant for all women nor for
34
35 437 cohorts stratified by parity. However, the differences are more marked in primiparous
36
37 438 women (0.8 per 1000 in planned hospital vs 1.7 per 1000 in planned homebirth) than
38
39 439 multiparous women (0.7 per 1000 in planned hospital vs 0.8 per 1000 in planned
40
41 440 homebirth). Given the small number of deaths in the planned homebirth group (n=9) this
42
43 441 may be a chance finding over a long period of time (13 years). However, it is similar to the
44
45 442 findings of the Birthplace in England study, which found a statistically significant higher odds
46
47 443 of a composite outcome combining perinatal mortality and selected early neonatal
48
49 444 morbidities among primiparous women planning home birth.¹¹ This highlights the need to
50
51 445 explain the risks to women in absolute terms, as this is likely to be more helpful in assisting
52
53 446 decision-making.

54
55 447 There were two negative findings in relation to birth centre outcomes, firstly, a significantly
56
57 448 higher rate of severe perineal trauma (AOR 1.17; 99% CI 1.09-1.25) compared with planned
58
59 449 hospital births. Another Australian study¹⁶ and one in New Zealand also found higher rates
60
450 of perineal trauma in birth centres.²⁸ However, other research found no significant

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2
3 451 differences in perineal outcomes, for example in studies in Norway,^{29,30} Denmark,³¹
4
5 452 Australia³² or England.³³ The higher rate of severe perineal trauma may be related to the use
6
7 453 of birth stools, more common in Australian birth centres but less frequently in hospitals or
8
9 454 at home. Birth stools have been linked to higher rates of severe perineal trauma compared
10
11 455 with other birth positions or waterbirth.³⁴ The higher rates of trauma could also be due to
12
13 456 better case ascertainment or lower rates of episiotomy.

14
15 457 The study also found higher rates of infant admission to NICU/SCN for greater than 48 hours
16
17 458 (AOR 1.24; 99% CI 1.10-1.39) among planned birth centre births. This is different from other
18
19 459 research, which either found higher rates associated with planned hospital births^{16,28} or else
20
21 460 no statistically significant differences in NICU admission rates from birth centres and
22
23 461 hospital births.^{29,31,35} The admissions to the NICU or SCN in the current study are low in
24
25 462 absolute terms (1 per 100 for birth centre births) but higher than planned hospital births.
26
27 463 This requires ongoing examination to determine possible reasons and ways to reduce the
28
29 464 rate.

30 465 **Strengths and limitations**

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32
33 466 This study is the first to comprehensively examine maternal and perinatal outcomes from
34
35 467 three birth settings across Australia. It used a population-based sample consisting of women
36
37 468 with uncomplicated pregnancies. The large sample size was sufficient to detect differences
38
39 469 between the three groups, although the numbers of homebirth nationally, even over this
40
41 470 time period, were comparatively small (i.e. 8212 only 0.7% of the total sample).

42
43 471 The context of homebirth in Australia means there are still low numbers of women choosing
44
45 472 homebirth and hence small numbers in this population. Private practising midwives do not
46
47 473 have access to professional indemnity insurance which means the option for women is
48
49 474 limited although still available in some parts of the country. Some private practising
50
51 475 midwives in some states have visiting rights to hospitals but this is not universal leading to a
52
53 476 lack of potential lack of integration. The publicly funded home birth models are relatively
54
55 477 few (no more than 20 services across the country) and cater for small numbers of women.
56
57 478 The policy and professional context has not been highly supportive of homebirth which has
58
59 479 made scaling up of public services difficult.
60

1
2
3 480 Women with uncomplicated pregnancies were defined consistently across all three cohorts
4
5 481 in the dataset. However, merging linked data from multiple jurisdictions created several
6
7 482 challenges and potential shortcomings, including missing responses, inconsistent variable
8
9 483 definitions and limited data from some states.²⁷ For example, Queensland's data collection
10
11 484 only covered 2007-2012, resulting in under-representation: 9.6% of the combined sample,
12
13 485 compared with 20.4% of Australian births in 2012.³⁶ The linked data sets also could not
14
15 486 account for women who may have moved to another state or territory in the follow-up time
16
17 487 frame. State and territory-based data collections have inconsistent variables on other
18
19 488 potential demographic factors such as maternal education, socioeconomic status or body
20
21 489 mass index, limiting the variables available for controlling the analysis. Further, the small cell
22
23 490 sizes generated meant that we were not able to report findings under the terms of ethics
24
25 491 agreements with data custodians.

26 492 Although we eliminated unintended home births among women intending hospital or birth
27
28 493 centre births (births before arrival), the home birth data do not always record whether or
29
30 494 not a qualified health professional attended. Within the constraints of the data available, we
31
32 495 have only included births attended by a health professional. Moreover, different states
33
34 496 recorded birthplace intentions at different times. Although this means that intended birth
35
36 497 place is not always recorded at onset of labour, the scrupulous process of data cleaning and
37
38 498 categorising eliminated most women with risk factors which would have rendered them
39
40 499 ineligible for birth centre or home births. Thus, the recorded birthplace intention was as
41
42 500 close as possible to that at labour onset. However, there is a possibility that some planned
43
44 501 birth centre/home births were erroneously classified as planned hospital births.

45 502 Some data items were collected inconsistently across the jurisdictions, for example, transfer
46
47 503 from home to hospital after the onset of labour. This was either because the data item did
48
49 504 not exist or because it only recorded 'transfer', which could have been at any time during
50
51 505 pregnancy. Therefore, we were unable to report on intrapartum transfer rates.

52
53 506 Inconsistencies in the data from different jurisdictions also affected the data analysis. The
54
55 507 regression analysis incorporated very few potential confounders, limited to those for which
56
57 508 consistent data were available nation-wide (i.e. maternal age, gestational age, parity and
58
59 509 whether born in Australia or not). Socio-economic status is also inconsistently collected
60

1
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3 510 across the country, as is maternal BMI and education, so we were unable to adjust for these
4
5 511 factors.
6
7

8 512 It is possible that there remain some residual *unobservable differences in the groups*. It is
9
10 513 possible that women planning to give birth in a birth centre or at home are different from
11 514 those planning a hospital birth in a number of ways, including their motivation, attitudes to
12 515 intervention and approach to birth. These are not able to be measured but may impact on
13 516 the findings in relation to interventions and outcomes.
14
15
16

17 517 **CONCLUSION**

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19
20 518 This study provides evidence on the safety of births planned in hospital, birth centre and at
21 519 home across all states and territories in Australia by comparing cohorts of women with
22 520 uncomplicated pregnancies. Inconsistencies between state-based datasets as described
23 521 limited the number of variables available for analysis. However, for healthy women with
24 522 uncomplicated pregnancies, planned birth centre births resulted in high rates of normal
25 523 labour and birth, low rates of most maternal complications, and comparable perinatal
26 524 mortality outcomes. Women planning home birth also had similarly positive maternal
27 525 outcomes with no statistically significant differences in the rate of perinatal mortality or
28 526 NICU admission. In absolute terms, the numbers of deaths were small, although the rate of
29 527 perinatal mortality was higher among primiparous women who planned homebirths than
30 528 their multiparous counterparts.
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530 **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

531

532 **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)

Postpartum 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.

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534

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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 ^{AE}
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 death¹	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 death²	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 >48hrs³	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 days⁴	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.

^{^E} 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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For peer review only

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>.