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Maternal outcomes and birth interventions among women who begin labour intending to give birth at home compared to women of low obstetrical risk who intend to give birth in hospital: A systematic review and meta-analyses

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ABSTRACT

Background: We previously concluded that risk of stillbirth, neonatal mortality or morbidity is not different whether birth is intended at home or hospital. Here, we compare the occurrence of birth interventions and maternal outcomes among low-risk women who begin labour intending to birth at home compared to women intending to birth in hospital.

Methods: We used our registered protocol (PROSPERO, http://www.crd.york.ac.uk, No.CRD42013004046) and searched five databases from 1990–2018. Using R, we obtained pooled estimates of effect (accounting for study design, study setting and parity).

Findings: 16 studies provided data from ~500,000 intended home births for the meta-analyses. There were no reported maternal deaths. When controlling for parity in well-integrated settings we found women intending to give birth at home compared to hospital were less likely to experience: caesarean section OR 0.58 (0.44,0.77); operative vaginal birth OR 0.42(0.23,0.76); epidural analgesia OR 0.30(0.24,0.38); episiotomy OR 0.45(0.28,0.73); 3rd or 4th degree tear OR 0.57(0.43,0.75); oxytocin augmentation OR 0.37(0.26,0.51) and maternal infection OR 0.23(0.15,0.35). Pooled results for postpartum haemorrhage showed women intending home births were either less likely or did not differ from those intending hospital birth [OR 0.66(0.54,0.80) and RR 1.30(0.79,2.13) from 2 studies that could not be pooled with the others]. Similar results were found when data were stratified by parity and by degree of integration into health systems.

Interpretation: Among low-risk women, those intending to birth at home experienced fewer birth interventions and untoward maternal outcomes. These findings along with earlier work reporting neonatal outcomes inform families, health care providers and policy makers around the safety of intended home births.

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1. Introduction

Giving birth in hospital is assumed by many to be associated with improved outcomes for both those giving birth and their babies. Indeed, in well-resourced countries in the early 20th century there was a temporal relationship between the move of birth to hospital and a decline in perinatal and maternal mortality [1]. Although evidence is lacking that this apparent association is causal, the most common reason for hospital admission in well-resourced countries is to give birth and controversy continues about safety when parents choose to birth at home [2,3]. Prospective parents, maternity care providers and policy makers need quality evidence of outcomes associated with choice of birthplace. A Cochrane review on this topic proposed a systematic review and meta-analyses of high-quality cohort studies to evaluate outcomes of intended home birth [4]. To accomplish this goal, we developed, published and registered a study protocol [5] and have previously reported on neonatal outcomes among low-risk births planned at home compared to hospital [6]. We undertook this systematic review and meta-analyses to determine if low-risk women who begin labour intending to give birth at home are more or less likely to experience negative maternal outcomes

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Research in context

Evidence before this study

In many well-resourced countries, the most common reason for hospitalisation is to give birth. From a cost perspective, reducing hospital admissions is appealing, and families have shown a wide-spread desire for planning home birth, yet controversy continues about the safety of this birth choice. A Cochrane review of randomised controlled trials comparing intended home to intended hospital birth found only one small trial and recommended that in the absence of adequately sized randomised controlled trials, a peer reviewed protocol be published to guide a systematic review and meta-analysis including quality observational studies. Following this advice, we have previously published the findings of our systematic review and meta-analysis with respect to infant outcomes and reported no increase in perinatal or neonatal mortality or morbidity when birth was planned at home compared to hospital. To date, design and methodological issues have limited reviews of the impact of planned place of birth on maternal outcomes and none has used a protocol published *a priori*. Here we use an inclusive approach to report on maternal outcomes using our previously published protocol.

Added value of this study

This systematic review and meta-analysis compares the likelihood of adverse maternal outcomes and frequency of obstetrical interventions between low risk women who either began labour planning to give birth at home or in hospital. We followed a published, peer-reviewed, registered protocol, which is inclusive of various designs and settings, resulting in the largest and most comprehensive meta-analysis on the topic of planned place of birth. We take parity and jurisdictional support for home birth into account. Our findings provide important information that can be used by policy makers, care providers and women and families when planning for birth.

Implications of all available evidence

After accounting for parity, women who planned to give birth at home were less likely to experience obstetrical interventions, including caesarean section, operative vaginal birth, epidural analgesia, episiotomy, and oxytocin augmentation. They were also less likely to suffer 3rd or 4th degree perineal tear, maternal infection or postpartum haemorrhage. This held true among the subgroup of women giving birth for the first time, with the exception of 3rd or 4th degree tears, where no difference was found between groups. While it is possible that, compared to those planning to birth in hospital, women in our study who planned to birth at home may hold different values around birth outcomes, findings of this study suggest those planning home birth are less likely to experience interventions and untoward birth outcomes.

(maternal mortality, 3rd or 4th degree tear, maternal infection, and postpartum haemorrhage) and intrapartum interventions (caesarean section; operative vaginal births; epidural analgesia; episiotomy; and oxytocin augmentation) compared to those of similar low risk who begin labour with the intention of giving birth in hospital.

2. Methods

Methods, adherent to our peer-reviewed, published, registered protocol (PROSPERO, http://www.crd.york.ac.uk, No.CRD42013004046) [5] and described in detail in an earlier publication [6], are summarised here.

2.1. Search strategy and study selection

The search completed on April 11, 2018 used Embase, Medline, AMED, CINAHL, and the Cochrane Library and included studies from January 1, 1990 onward. As described in our protocol, we included studies published in or after 1990 to ensure the findings were reasonably generalisable to current practice [5]. Terms used as either keywords or subject headings included: home delivery, home birth, home childbirth, and homebirth. Two reviewers (AR, JS) independently selected studies for full review if they: (1) included comparison groups who were similarly at low risk of birth complications who intended at the beginning of labour to birth either at home, or in hospital, (2) conducted analyses (or presented data) by planned place of birth (rather than actual place of birth), and (3) accounted for parity and for missing cases (see Appendix 1 for details of the eligibility criteria). We excluded studies of free-standing birth centres because they are neither a home nor hospital setting and could not be deemed comparable to either.

2.2. Data collection

Two reviewers (AR, JS) independently extracted data from published reports and requested missing information from authors of included studies. Studies fell into one of two design categories: to determine the safety of home birth in actual practice, termed 'pragmatic design'; or those that included only women who met local criteria (often quite restrictive) for home birth; these studies were termed 'within standards' design.

We hypothesised *a priori* that the degree of support for home birth and home birth care providers within a given health care system would act as an effect modifier of the relationship between intended place of birth and maternal outcomes [5]. We termed the contextual environment for home birth, described in detail elsewhere, as 'well-integrated' versus 'less well-integrated' [7]. A well-integrated setting was a place where home birth practitioners: (1) are recognised by statute within their jurisdiction; (2) have received formal training; (3) can provide or arrange care in hospital; (4) have access to a well-established emergency transport system, and (5) carry emergency equipment and supplies. Less well-integrated settings were those where one or more of these criteria were absent. An independent team of researchers categorised the studies, as described elsewhere [7].

2.3. Outcomes

The primary neonatal outcomes of our study were reported earlier [6]. This study reports on the secondary outcomes, which are those related to the maternal experience of birth. We include interventions such as operative vaginal birth (vacuum or forceps), caesarean section, epidural analgesia, episiotomy and oxytocin augmentation. Maternal outcomes include mortality, postpartum infection (as defined by the authors), postpartum haemorrhage (as defined by the authors), and 3rd or 4th degree tear (see Appendix 2 for a summary of definitions used in the included studies).

2.4. Risk of Bias

Our eligibility criteria ensured that observational studies that were included had a control group, controlled for parity and used an intention-to-treat analysis (i.e. outcomes were attributed to the intended rather than actual place of birth). Therefore, interventions undertaken in the hospital following a transfer from home, such as epidural anesthesia or oxytocin augmentation, were attributed to the planned home birth group, even though the interventions themselves took place in hospital. The Newcastle Ottawa Quality Assessment Scale for Cohort Studies (NOS) was used to assess study quality [8].

2.5. Synthesis of results

The "metafor" package in R statistical software version 3.3.1 used count data or odds ratios (ORs) and confidence intervals to calculate log ORs and corresponding sampling variances for each study. Data were then pooled by fitting a random-effects model and forest plots were created. Pooled ORs, 95% confidence intervals and measures of consistency (I^2) were calculated for each outcome within strata and overall. Studies that reported only adjusted risk ratios (RRs) without providing count data could not be combined with ORs from other studies, but instead were used to calculate pooled RRs and 95% confidence intervals wherever possible or are described separately.

We planned *a priori* to stratify all analyses by parity since it is a predictor of outcome and is associated with choice of birthplace. Therefore, where available we presented data separately for nulliparous and multiparous women. When parity was accounted for in studies through statistical adjustment or matching we used the overall outcome data. In addition, we planned *a priori* to stratify all analyses by degree of support for home birth within the health care system (well-integrated or less well-integrated). We also stratified all analyses by study design (pragmatic or within-standards) and present findings within strata in the forest plots according to our *a priori* protocol. However, because outcomes between design strata did not substantively differ, we report outcomes without this stratification.

2.6. Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

3. Results

The search, undertaken for our companion paper on neonatal outcomes [6], was completed on April 11, 2018, provided 139 full text articles for review (Fig. 1) and resulted in 23 cohort studies that met our predefined inclusion criteria for a systematic review of intended place of birth. Two of these studies [9,10] were excluded because they reported on data duplicated in other included studies. Three studies were excluded because they did not report on maternal interventions or outcomes [11–13]. Of 18 studies eligible for systematic review of maternal interventions or outcomes, two provided no data either published or from study authors that could be included in a meta-analysis [14,15]. Thus, the meta-analyses included 16 original cohort studies published between 1996 and 2017 that reported maternal interventions or outcomes for ~500,000 intended home births (Table 2). The precise number of births varies by analysis depending on the inclusion of one or the other of the large Dutch

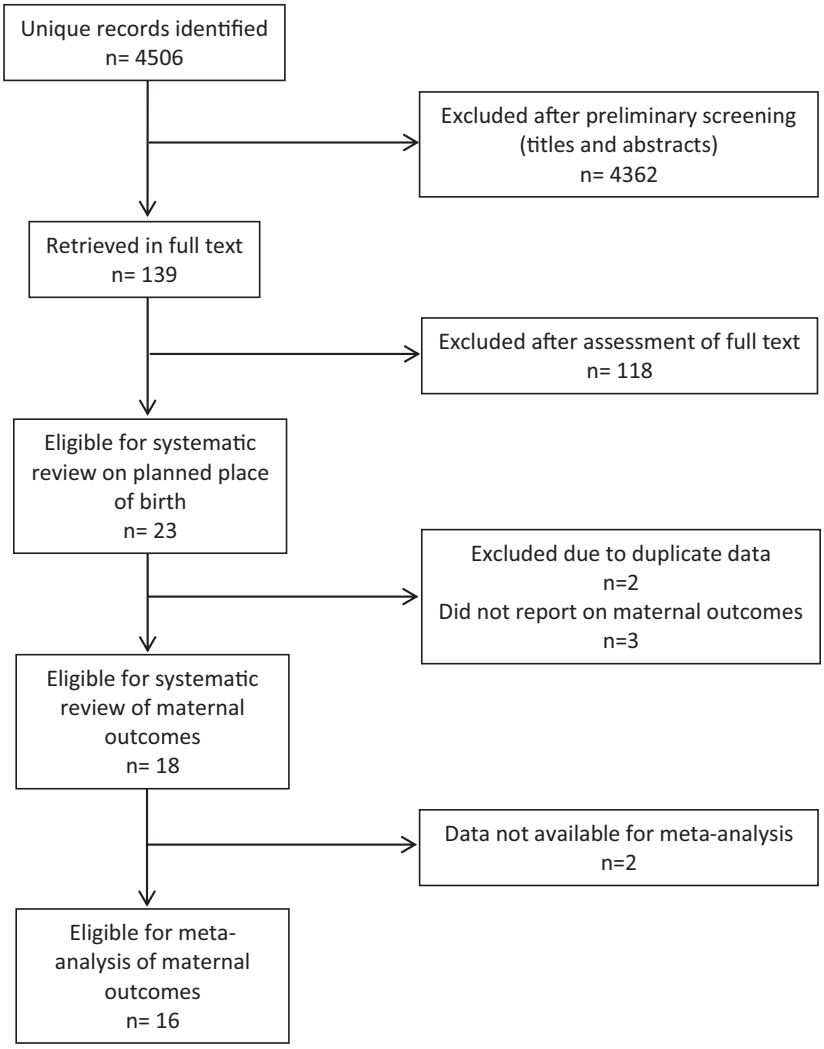

Fig. 1. Flow diagram of study selection.

papers where there is likely considerable overlap of the data [16–18]. No randomised trials were found that included the outcomes of interest. A table of primary research studies excluded from this review can be found in Appendix 1.

Four included studies had more than one comparator group [19–22]. For the study by the Birthplace in England Collaborative Group, because all the women included were low obstetrical risk, we combined outcomes of the midwifery alongside unit (an in-hospital birthing unit) and the obstetrical unit [19]. For a variety of reasons the multiple hospital comparison groups in Janssen et al.'s studies could not be combined therefore we used the physician-attended hospital comparison group [20,21]. For Davis et al., we used the primary unit comparison group [22].

The 18 studies included in the systematic review (16 included in the meta-analyses) described here took place in nine settings, which are illustrated in Table 1. Fifteen studies took place in six settings where midwives attending home birth were considered to be well-integrated into the healthcare system (The Netherlands, England, Iceland, Canada, USA, New Zealand) [14,16–29]. Three studies took place in three settings where midwives attending home birth were considered to be less well-integrated into the healthcare system (Norway, Sweden, Japan) [15,30,31] as described elsewhere [7]. A pragmatic study design was used by nine studies [14,15,20,21,26–30], and the other nine studies included only those women who met local standards for home birth [16–19,22–25,31]. Two studies [23,24] rated 4 out of a possible 9 for quality on the Newcastle Ottawa Scale for Cohort Studies (NOS) while the remainder were given scores greater than 6. The I^2 results ranged from 0 to 97.4% (see Tables 3, 4 and 5). Inverted funnel plots were created to assess for reporting bias across studies for our primary outcome (published previously), one for each strata of analysis, resulting in five plots [6]. However, plots with fewer than ten studies are difficult to interpret and the largest of our plots included only seven studies [32].

No maternal deaths were reported in either group among the nearly 50,000 women included in the six studies that explicitly reported this outcome. Women in well integrated settings who intended to give birth at home compared with those planning a hospital birth were >40% less likely to give birth by caesarean section (6 studies, OR 0.58, 95% CI, 0.44 to 0.71); >50% less likely to have an operative vaginal birth (5 studies, OR 0.42, 95% CI, 0.23 to 0.76); 70% less likely to use epidural analgesia (6 studies OR 0.30, 95% CI, 0.24 to 0.38); 55% less likely to have an episiotomy (6 studies, OR 0.45 95% CI, 0.28, 0.73); >40% less likely to experience a 3rd or 4th degree perineal tear (5 studies, OR 0.57, 95% CI, 0.43 to 0.75) and >60% less likely to receive oxytocin augmentation of labour (6 studies, OR 0.37, 95% CI, 0.26 to 0.51). Adverse maternal outcomes were also less frequent among those intending to give birth at home with: >75% fewer reporting maternal infection (2 studies, OR 0.23, 95% CI, 0.15 to 0.35) and >30% fewer reporting postpartum haemorrhage (7 studies, OR 0.66, 95% CI, 0.54 to 0.80). However, the pooled estimate for 2 studies analysed separately due their use of risk ratios showed no difference in the risk of postpartum haemorrhage (2 studies, RR 1.30, 95% CI, 0.79 to 2.13).

We found a similar pattern of findings among nulliparous and multiparous women in well-integrated settings. Nulliparae who intended to give birth at home when labour began were ~30% less likely to give birth by caesarean section; (9 studies, OR 0.71, 95% CI, 0.62 to 0.81); ~25% less likely to have an operative vaginal birth (8 studies, OR 0.74, 95% CI, 0.64 to 0.85); ~50% less likely to use epidural analgesia (4 studies OR 0.51, 95% CI, 0.35 to 0.74); 25% less likely to have an episiotomy (8 studies, OR 0.75 95% CI, 0.64, 0.87); and >35% less likely to receive oxytocin augmentation of labour (5 studies, OR 0.63, 95% CI, 0.47 to 0.86). No difference was found in the odds of experiencing a 3rd or 4th degree perineal tear (5 studies, OR 1.39, 95% CI, 0.67 to 2.92). The odds of experiencing postpartum haemorrhage was not different among nulliparous women who intended to give birth at home compared to those intending to give birth in hospital (9 studies, OR 0.95, 95% CI, 0.87 to 1.05).

Multiparous women were ~60% less likely to give birth by caesarean section; (8 studies, OR 0.41, 95% CI, 0.26 to 0.65); 60% less likely to have an operative vaginal birth (7 studies, OR 0.40, 95% CI, 0.28 to 0.57); 75% less likely to use epidural analgesia (3 studies OR 0.25, 95% CI, 0.22 to 0.28); >50% less likely to have an episiotomy (7 studies, OR 0.47 95% CI, 0.35, 0.62); 45% less likely to have 3rd or 4th degree perineal tear (4 studies, OR 0.55, 95% CI, 0.37 to 0.84) and >65% less likely to receive oxytocin augmentation of labour (4 studies, OR 0.32, 95% CI, 0.16 to 0.63). The odds of experiencing postpartum haemorrhage was decreased by 40% among multiparous women who intended to give birth at home compared to those intending to give birth in hospital (8 studies, OR 0.60, 95% CI, 0.50 to 0.72).

4. Discussion

This study compared outcomes among low risk women who began labour planning to give birth at home with those who planned to birth in hospital and found that, overall, those who planned to give birth at home were less likely to experience any of the intrapartum interventions studied (caesarean section, operative vaginal birth, epidural analgesia, episiotomy, and oxytocin augmentation). They were also less likely to suffer a 3rd or 4th degree perineal tear, maternal

Table 1
Studies eligible for systematic review of maternal interventions and outcomes, stratified by degree of integration of home birth within the health care system and by study design.

		Type of integration into health system	
		Well-integrated	Less well-integrated
STUDY DESIGN	**Pragmatic (all women who intend home birth)**	Halfdandottir 2015 [29] Hutton 2009 [26] Hutton 2015 [27] Janssen 2002 [20] Janssen 2009 [21] van der Kooy 2017 [14] Wiegers 1996 [28]	Blix 2012 [30] Lindgren 2008 [15]
	Within standards (only women who meet criteria for birth at home)	Bolton 2016 [16] Birthplace in England Collaborative Group 2011 [19] Davis 2011 [22] de Jonge 2013 [17] Hermus 2017 [18] Miller 2012 [24] Nove 2012 [25] Pang 2002 [23]	Hiraizumi 2013 [31]

Table 2
Description of included studies.

Study	Data source & Time period	Method of accounting for parity	NOS Quality Score	Methods	Sample size	Setting	Outcomes Reported	Author questionnaire completed
Blix et al. 2012 [30]	Home: Midwife's register, telephone interview, and midwife's birth protocols Hospital: Medical birth registry of Norway (MBRN) 1990–2007	Stratified	6	Pragmatic Retrospective cohort study	1631 home 16,310 hospital	Norway (Midwives less well-integrated)	1, 3–5, 8, **11, 12, 15–18**	yes
Birthplace in England Collaborative Group, 2011 [19]	Home: All NHS Trusts that provide home birth services OU: Random sample of 36 obstetric units within the NHS ALU: All NHS hospitals that have an alongside unit Data collection forms designed for this study 2008–2010	Stratified and adjusted	7	Within standards Prospective cohort study 4 groups: Obstetric Unit, Alongside Midwifery Unit, Free-standing birth centre, Home	16,840 home 16,710 ALU 19,706 OU 11,282 FSU Combined ALU and OU for comparison group	England (Midwives well-integrated)	1, 2, 4, 8, 9, **11, 12, 14–18**	yes
Bolten et al. 2016 [16]	DELIVER Study, recruited from 20 midwifery practices 2009–2011	Stratified	6	Within standards Prospective cohort study	2050 home 1445 hospital	Netherlands (Midwives well-integrated)	**11, 12, 14, 16–18**	yes
Davis et al. 2011 [22]	Midwifery Maternity Provider Organization Database 2006–2007	Adjusted	8	Within standards Retrospective cohort study	1830 home Primary unit 2877 Secondary hospital 7380 Tertiary hospital 4123 Used primary unit comparison group	New Zealand (Midwives well-integrated)	8, 9, **11, 14, 16, 18**	no
de Jonge et al. 2013 [17]	LEMMoN Study database, National Perinatal database I, National Perinatal database II, National Neonatal Register 2004–2006	Stratified	8	Within standards Prospective cohort study	92,333 home 54,419 hospital	Netherlands (Midwives well-integrated)	**11**	yes
de Jonge et al. 2014 [11]	National Perinatal database I, National Perinatal database II, National Neonatal Register 2000–2009	Stratified	7	Within standards Retrospective cohort study	466,112 home 276,958 hospital 2000–2009	Netherlands (Midwives well-integrated)	1, 2, 4, 5, 8, 9 No maternal outcomes	yes
Halfdansdottir et al. 2015 [29]	Icelandic electronic birth registry and original midwife and doctor records extracted by study author using a	Matched and Stratified	7	Pragmatic + Within standards Retrospective cohort study	307 home 921 hospital	Iceland (Midwives well-integrated)	1, 3, 4, 6, 8–**11, 14–18**	yes

(*continued on next page*)

Table 2 (*Continued*)

Study	Data source & Time period	Method of accounting for parity	NOS Quality Score	Methods	Sample size	Setting	Outcomes Reported	Author questionnaire completed
	structured item list. 2005–2009							
Hermus et al. 2017 [18]	Midwifery practices using case report form developed for the study and linked with the Netherlands Perinatal Registry (Perined) 2013	Stratified	6	Within standards Prospective cohort study	1086 home 701 hospital	Netherlands (Midwives well-integrated)	1, 3, 4, 9, **10–12, 14–18**	yes
Hiraizumi et al. 2013 [31]	Japanese Red Cross Katsushika Maternity Hospital database 2007–2011	Presumed matched, equal proportion in groups by parity	7	Within standards Retrospective cohort study	168 home 123 hospital	Japan (Midwives less well-integrated)	8, **11–14, 17, 18**	no
Homer et al. 2014 [13]	5 datasets in New South Wales. NSW Perinatal data collection NSW admitted patient data collection NSW register of congenital conditions NSW registry of births, deaths, and marriages Australian Bureau of Statistics 2000–2008	Stratified	7	Within standards Retrospective cohort study	735 home 221,284 hospital 2000–2008	Australia (Midwives less well-integrated)	1, 2, 4 No maternal outcomes	yes
Hutton et al. 2009 [26]	Ontario Midwifery Program dataset 2003–2006	Matched, Stratified	8	Pragmatic Retrospective cohort study	6692 home 6692 hospital 2003–2006	Ontario, Canada (Midwives well-integrated)	1–3, 5, 6, 8, 9, **10–12, 14–18**	yes
Hutton et al. 2015 [27]	Ontario Midwifery Program dataset 2006–2009	Matched, Stratified	8	Pragmatic Retrospective cohort study	11,493 home 11,493 hospital	Ontario, Canada (Midwives well-integrated)	1–6, 8, **10–12, 14–18**	yes
Janssen et al. 2002 [20]	Home: Home Birth Demonstration Project Hosp: British Columbia Perinatal Database Registry 1998–1999	Matched, Adjusted	6	Pragmatic Prospective and Retrospective cohort study	862 home 571 MW comparison 743 MD comparison Used MD comparison group	British Columbia, Canada (Midwives well-integrated)	1, 2, 6–8, **11–18**	yes
Janssen et al. 2009 [21]	Home: BC Perinatal Database Registry + Rosters submitted to the College of Midwives of BC Hosp: BC Perinatal Database Registry 2000–2004	Matched, Adjusted	6	Pragmatic Retrospective cohort study	2899 home 4752 MW comparison 5331 MD comparison Used MD Comparison group	British Columbia, Canada (Midwives well-integrated)	1, 2, 4, 6–8, **10–18**	yes
Lindgren et al. 2008 [15]	Home: Home birth midwives reports, linked to Swedish Medical Birth Register Hosp: Swedish Medical	Adjusted	6	Pragmatic Retrospective cohort study	897 home 11,341 hospital	Sweden (Midwives less well-integrated)	1, 2, 4, **10–12, 16, 18**	yes

(*continued on next page*)

Table 2 (*Continued*)

Study	Data source & Time period	Method of accounting for parity	NOS Quality Score	Methods	Sample size	Setting	Outcomes Reported	Author questionnaire completed
	Birth Register 1992–2004							
Miller et al. 2012 [24]	Midwives who chose to participate and report on their most recent nulliparous births. Not reported	Restricted to nulliparous	4	Within standards Retrospective cohort study	109 home 116 hospital	New Zealand (Midwives well-integrated)	**11, 12, 14–18**	yes
Nove et al. 2012 [25]	St. Mary's Maternity Information System 1988–2000	Adjusted	8	Within standards Retrospective cohort study	5998 home 267,874 hospital	England (Midwives well-integrated)	**11**	yes
Pang et al. 2002 [23]	Washington State birth certificate data 1989–1996	Adjusted, Stratified	4	Within standards Retrospective cohort study	6133 home 10,593 hospital	Washington state, USA (Midwives less well-integrated	1, 3, **11** Data not available for meta-analysis	no
van der Kooy et al. 2011 [12]	Netherlands Perinatal Registry 2000–2007	Adjusted	7	Pragmatic Retrospective cohort study	402,912 home 219,105 hospital	Netherlands (Midwives well-integrated)	1, 2, 4 No maternal outcomes	yes
van der Kooy et al. 2017 [14]	Netherlands Perinatal Registry 2000–2007	Adjusted		Pragmatic Retrospective cohort study	402,912 home 219,105 hospital	Netherlands (Midwives well-integrated)	1, **18** Data not available for meta-analysis	yes
Wiegers et al. 1996 [28]	Questionnaires and the Birth Notification System 1990–1993	Stratified	6	Pragmatic Prospective and Retrospective cohort study	1140 home 696 hospital	Netherlands (Midwives well-integrated)	1, 3, 4, 9, **11, 16–18**	yes

Outcomes reported by included studies are listed in the table as follows. Outcomes reported in this manuscript are **bolded and underlined** in the table.
1. Any perinatal or neonatal mortality.
2. Perinatal or neonatal mortality excluding malformations.
3. Perinatal or neonatal mortality including malformations.
4. Any perinatal mortality.
5. Any neonatal mortality.
6. Neonatal Resuscitation.
7. Apgar <7 at 1 min.
8. Apgar <7 at 5 min.
9. Admission to NICU.
10. Maternal mortality.
11. Postpartum hemorrhage.
12. 3rd or 4th degree tear.
13. Maternal infection.
14. Oxytocin augmentation.
15. Epidural.
16. Episiotomy.
17. Assisted vaginal delivery.
18. Caesarean section.

Table 3
Summary of perinatal interventions and maternal outcomes meta-analyses findings for nulliparous women.

Outcome (by strata)	No. of Studies	OR	95% CI	I^2
Caesarean section				
(Well integrated settings)	9 [16,18,19,21,24,26–29]	0.71	0.62, 0.81	54.8%
(Less well integrated)	1 [30]	0.79	0.49, 1.26	n/a
Operative Vaginal Birth				
(Well integrated settings)	8 [16,18,19,24,26–29]	0.74	0.64, 0.85	57.1%
(Less well integrated)	1 [30]	0.35	0.22, 0.54	n/a
Epidural analgesia				
(Well integrated settings)	4 [18,19,24,29]	0.51	0.35, 0.74	74.9%
(Less well integrated)	1 [30]	0.19	0.12, 0.29	n/a
Episiotomy				
(Well integrated settings)	8 [16,18,19,24,26–29]	0.75	0.64, 0.87	71.8%
(Less well integrated)	1 [30]	0.84	0.62, 1.15	n/a
3rd or 4th degree perineal tear				
(Well integrated settings)	5 [16,18,19,24,27]	1.39	0.67, 2.92	94%
(Less well integrated)	1 [30]	0.22	0.08, 0.60	n/a
Oxytocin Augmentation				
(Well integrated settings)	5 [16,18,19,24,29]	0.63	0.47, 0.86	82.7%
(Less well integrated settings)	0			
Maternal Infection				
(Well integrated settings)	This data is not available by parity.			
(Less well integrated)				
Postpartum haemorrhage				
(Well integrated settings)	9 [16–19,24,26–29]	0.95	0.87, 1.05	7.5%
(Less well integrated)	1 [30]	0.69	0.46, 1.03	n/a

infection or postpartum haemorrhage. No cases of maternal mortality were reported in either study group. Although it is well known that rare but serious events associated with birthing may occur regardless of setting, we saw no evidence of such events in our sample of nearly one million women. Findings were comparable for multiparous women and in settings where care was well-integrated, as well as less well-integrated, into the health care system. Results among women giving birth for the first time were similar with the exception of 3rd or 4th degree tears, where no difference was found between groups. These findings are congruent with the primary neonatal outcomes of this meta-analysis, published earlier, which reported no increase in perinatal or neonatal mortality or morbidity among neonates when birth was planned at home compared to hospital [6].

Table 4
Summary of perinatal interventions and maternal outcomes meta-analyses findings for multiparous women.

Outcome (by strata)	No. of Studies	OR	95% CI	I^2
Caesarean section				
(Well integrated settings)	8 [16,18,19,21,26–29]	0.41	0.26, 0.65	88.8%
(Less well integrated)	1 [30]	0.52	0.29, 0.94	n/a
Operative Vaginal Birth				
(Well integrated settings)	7 [16,18,19,26–29]	0.40	028, 0.57	70.8%
(Less well integrated)	1 [30]	0.26	0.12, 0.56	n/a
Epidural analgesia				
(Well integrated settings)	3 [18,19,29]	0.25	0.22, 0.28	0%
(Less well integrated)	1 [30]	0.09	0.05, 0.17	n/a
Episiotomy				
(Well integrated settings)	7 [16,18,19,26–29]	0.47	0.35, 0.62	81.3%
(Less well integrated)	1 [30]	0.45	0.29, 0.71	n/a
3rd or 4th degree perineal tear				
(Well integrated settings)	4 [16,18,19,27]	0.55	0.37, 0.84	63.3%
(Less well integrated)	1 [30]	0.28	0.11, 0.68	n/a
Oxytocin Augmentation				
(Well integrated settings)	4 [16,18,19,29]	0.32	0.16, 0.63	93.0%
(Less well integrated)	0			
Maternal Infection				
(Well integrated settings)	THIS DATA IS NOT AVAILABLE BY PARITY.			
(Less well integrated)				
Postpartum haemorrhage				
(Well integrated settings)	8 [16–19,26–29]	0.60	0.50, 0.72	51.5%
(Less well integrated)	1 [30]	0.28	0.18, 0.42	n/a

Table 5
Summary of perinatal interventions and maternal outcomes meta-analyses findings for all women after accounting for parity.

Outcome (by strata)	No. of Studies	OR	95% CI	I^2
Caesarean section				
(Well integrated settings)	6 [19–21,26,27,29]	0.58	0.44, 0.71	91.7%
(Less well integrated)	1 [31]	0.98	0.21, 4.44	n/a
Operative Vaginal Birth*				
(Well integrated settings)	5 [20,21,26,27,29]	0.42	0.23, 0.76	96.8%
(Less well integrated)	1 [31]	0.72	0.23, 2.30	n/a
Epidural analgesia				
(Well integrated settings)	6 [19–21,26,27,29]	0.30	0.24, 0.38	93.5%
(Less well integrated)	0			
Episiotomy†				
(Well integrated settings)	6 [19–21,26,27,29]	0.45	0.28, 0.73	97.4%
(Less well integrated)	0			
3rd or 4th degree perineal tear‡				
(Well integrated settings)	5 [19–21,26,27]	0.57	0.43, 0.75	78.5%
(Less well integrated)	1 [31]	2.21	0.09, 54.76	n/a
Oxytocin Augmentation				
(Well integrated settings)	6 [19–21,26,27,29]	0.37	0.26, 0.51	96.4%
(Less well integrated)	1 [31]	1.33	0.57, 3.13	n/a
Maternal Infection				
(Well integrated settings)	2 [20,21]	0.23	0.15, 0.35	0%
(Less well integrated)	1 [31]	1.10	0.18, 6.68	n/a
Postpartum haemorrhage§				
(Well integrated settings - OR)	7 [19–21,25–27,29]	0.66	0.54, 0.80	61.3%
(Well integrated settings - RR)	2 [22,23]	1.30	0.79, 2.13	58.4%
(Less well integrated)	1 [31]	1.05	0.39, 2.84	n/a

Notes:.
* 2 studies reported only Risk Ratios and could not be included in the meta-analyses of operative vaginal birth: Davis 2011 (RR 0.86 (95% CI, 0.60 to 1.24)) and Lindgren 2008 (RR 0.40 (95% CI, 0.2 to 0.7)); [15,22].
† 2 studies reported only Risk Ratios and could not be included in the meta-analyses of episiotomy: Davis 2011 (RR 0.57 (95%CI, 0.40 to 0.82)) and Lindgren 2008 (RR 0.1 (95%CI, 0.0 to 0.2)); [15,22].
‡ Lindgren 2008 reported only a Risk Ratio and could not be included in the meta-analyses of perineal tear: (RR 0.2 (95%CI, 0.0 to 0.7)); [15].
§ Lindgren 2008 reported only a Risk Ratio and could not be included in the meta-analyses of postpartum haemorrhage: (RR 0.5 (95%CI, 0.2 to 1.0)); [15].

Multiple factors may explain the decreased rate of perinatal interventions and maternal morbidity among those who planned to give birth at home observed in this study. Women self-select to plan home birth and are likely to carefully evaluate their risk status. It is probable that careful screening by midwives helps ensure that clients who plan to give birth at home are good candidates to do so. The majority of studies that we were able to include in these analyses came from settings where home birth care was well-integrated into health services. In these situations, labouring women or their newborn infants can move to more intensive health services with maximum efficiency and thus have access to the interventions studied, when needed. However, those planning to birth at home may be committed to birthing without intervention, which in turn makes them less likely to experience the interventions studied. In some settings, it is also possible that planned place of birth is associated with factors such as ethnicity, socioeconomic status or education, which may confound the relationship with birth interventions and maternal outcomes. All of the included studies reported baseline characteristics, however, not consistently. Therefore, despite individual study approaches to ensure a comparable low-risk comparison group, women planning home birth may simply be at lower risk of interventions and complications. Regardless of why the decreases exist, the magnitude of effect and the remarkable consistency of the findings do much to support home as a choice of birthplace. However, readers need to interpret the safety of home birth within their particular context because of the variation in how well home birth care providers are integrated into the health care system as well as variation in the ease of transfer to hospital, which may not be uniform across and even within settings.

In order to reduce potential bias, this study included all relevant studies and addressed differences in study design by stratifying results. Because we found no important differences in results among studies that included all home births ('pragmatic' design) and those that included only those that met local standards for homebirth ('within standards' design), we report these findings together. Although studies using a pragmatic design could in theory include home births that fall outside of standards, in practice, most likely adhere to standards. Thus, while the study questions in these designs are somewhat different, the cohorts studied and resulting event rates are quite similar.

We set out to consider births in settings where home birth care is a well-integrated service within the health system and those where it is less well integrated. We found many fewer studies that met the latter definition possibly because those settings may be less able to collect home birth outcome data. Due to the paucity of studies in less well-integrated settings, caution should be used in generalising our findings to such settings.

When results show considerable heterogeneity among included studies, as ours do for most outcomes, it can be concluded that effect size varies between studies, either due to methodological diversity or a true variation in intervention effect. In this situation it is prudent to consider potential causes of heterogeneity and whether study differences are of a magnitude that does not support combining outcomes. In our study, variation found between studies might arise from differences in practice between study settings resulting in higher or lower rates of key variables among studies. For example, epidurals may be more or less available dependent on setting. Another source of variation may lie with the type of care provider in the control groups: in some studies women in control groups were attended by midwives, in others by obstetricians or by family physicians and in some by a mix of care providers. It is possible that care provider preference may influence women's preferences and or use of interventions. An additional source of variance in outcome may arise from variation in outcome definitions, for example postpartum haemorrhage. Despite the varied definitions between studies, a constant definition was used within each study, making it is useful to combine findings; but this potentially contributes to greater variation in point estimates between studies. We used the random effects approach to combine the effect sizes among studies to reflect these potential differences in study populations. Despite I^2 values being above 50% indicating substantial heterogeneity and thus variance in point estimates between studies, because findings of individual studies all favoured the same group, we can be confident in the outcomes.

As pointed out in a Cochrane review, randomised controlled trials comparing outcomes for home and hospital birth are not feasible, both because women are unlikely to enroll in such studies and because a very large sample size would be required to measure the infrequent outcomes. They instead recommended that a systematic review and meta-analyses of high-quality cohort studies be conducted to evaluate outcomes of intended home birth [4]. Continued efforts to monitor home birth outcomes using quality cohort studies may be warranted, although one author has called for studies on safety of hospital births [33]. Our study is the first systematic review and meta-analyses of high quality cohort studies reporting on maternal perinatal and postpartum outcomes to use a peer-reviewed, prepublished, registered protocol [5]. We included only those studies that met our *a priori* defined inclusion and exclusion criteria, used an inclusive strategy with regards to study question design, and stratified results according to parity and whether home birth was well integrated within the study setting health care system. Earlier systematic reviews report similar findings, however their sample sizes are much smaller as a result of very limited inclusion criteria and their findings are less precise [34,35]. In addition, because known effect modifiers such as parity are not accounted for, their findings are less accurate and prone to bias.

In conclusion, the findings from this report, along with our prior study reporting infant outcomes, provide important information to families, health care providers and policy makers. The findings indicate that home birth is safe for low-risk women in settings where home birth care is well-integrated into the local health care system, and who begin labour with a plan to give birth at home.

Declaration of Competing Interest

We declare no competing interests.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2020.100319.

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