Midwifery 123 (2023) 103704

Contents lists available at ScienceDirect

Midwifery

journal homepage: www.elsevier.com/locate/midw

Review Article

Maternal residential area effects on preterm birth, low birth weight and caesarean section in Australia: A systematic review

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ARTICLE INFO

Article history:
Received 7 June 2022
Revised 11 March 2023
Accepted 26 April 2023

Keywords:
Pregnancy outcome
Birth outcome
Preterm birth
Low birth weight
Cesarian section

ABSTRACT

Introduction: In Australia, area of residence is an important health policy focus and has been suggested as a key risk factor for preterm birth (PTB), low birth weight (LBW) and cesarian section (CS) due to its influence on socioeconomic status, access to health services, and its relationship with medical conditions**.** However, there is inconsistent evidence about the relationship of maternal residential areas (rural and urban areas) with PTB, LBW, and CS. Synthesising the evidence on the issue will help to identify the relationships and mechanisms for underlying inequality and potential interventions to reduce such inequalities in pregnancy outcomes (PTB, LBW and CS) in rural and remote areas.
Methods: Electronic databases, including MEDLINE, Embase, CINAHL, and Maternity & Infant Care, were systematically searched for peer-reviewed studies which were conducted in Australia and compared PTB, LBW or CS by maternal area of residence. Articles were appraised for quality using JBI critical appraisal tools.
Results: Ten articles met the eligibility criteria. Women who lived in rural and remote areas had higher rates of PTB and LBW and lower rate of CS compared to their urban and city counterparts. Two articles fulfilled JBI's critical appraisal checklist for observational studies. Compared to women living in urban and city areas, women living in rural and remote areas were also more likely to give birth at a younger age (<20 years) and have chronic diseases such as hypertension and diabetes. They were also less likely to have higher levels of completing university degree education, private health insurance and births in private hospitals.
Conclusions: Addressing the high rate of pre-existing and/or gestational hypertension and diabetes, limited access of health services and a shortage of experienced health staff in remote and rural areas are keys to early identification and intervention of risk factors of PTB, LBW, and CS.

Introduction

In epidemiological research in Australia, geographic location often acts as a proxy for health service access (AIHW, 2020). With more than a third (35%) of the population living in regional and remote places (AUstralia, 2018) area of residence is a major health policy focus. Differences by area on socioeconomic status, poor health outcomes, and timely access of quality health services are all considerations for health policy development (AIHW, 2020; Australian Government, 2012). Compared to urban and city areas, in remote and rural areas, health services availability and access are less likely and there is both a shortage and high turnover of health professionals (AIHW, 2020; Wakerman et al., 2019). For example, the estimated number of services per capita in very remote areas (3.6) was about half that of per capita services in major cities (6.3) (AIHW, 2020). Compared to women living in major cities, women living in remote or very remote locations are more likely to travel to another city or town hospital with an appropriate level of care to give birth (65.9% vs 13.8%) (Hennegan et al., 2014), have a high rate of out of hospital births (4.2% vs 0.7%)

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https://doi.org/10.1016/j.midw.2023.103704

(Steenkamp et al., 2012), have lower access to private hospitals during child birth (28.7% vs 46.1%), have less access to specialist obstetric care during birth (59.2% vs 69.7%), and have later antenatal care initiation (antenatal appointment by 18 weeks of pregnancy [37.4% vs 71%]) (Hennegan et al., 2014). Compared to major cities, rural and remote maternal services are less likely to be planned and maintained based on the number of births and service needs, which could be attributed by differences in planning across states and territories. For example, there was a significant difference across state jurisdictions, higher inequitable planning in Queensland and South Australia compared to New South Wales (NSW). Geographical areas with a high proportion of First Nation peoples were also more likely to have inequitable health service planning and maintenance (Rolfe et al., 2017). Poor health service planning and maintenance is associated with lower quality and continuity of service and worse pregnancy outcomes in rural and remote areas (Abdel-Latif et al., 2006; Talukdar et al., 2021; Xu et al., 2014).

In Australia, the birth rate (Graham et al., 2007; Roberts and Algert, 2000; Robson et al., 2006; Steenkamp et al., 2012) is four times greater among rural residents (4.76%) compared to urban residents (1.23%) (NRHA, 2012). In 2019, 8.6% of Australian babies were born preterm, 6.6% of them were born LBW, and 36% were born by CS (AIHW, 2021). Such outcomes represent a public health problem in Australia, with these outcomes relatively increasing by about 10% over the past decade (2009–2019) (AIHW, 2021, 2019). Past research has shown inconsistent associations between PTB, LBW, and CS and area of residence (rural versus urban). For example, some studies found statistically significant relationships (Fox et al., 2019; Robson et al., 2006; Steenkamp et al., 2012; Xu et al., 2014), while others did not find a significant relationship (Graham et al., 2007; Hennegan et al., 2014; Powers et al., 2013). It is acknowledged that there are variations in population, study periods and methods within and between studies, but they are generally comparable and have relatively similar populations and methodologies. For example, a study among 2573 Indigenous women who had a singleton birth registered in the Northern Territory (NT) Midwives' Data Collection had a 2.09 times increased risk of PTB associated with living in a Top End remote area compared to living in urban Central Australia (Steenkamp et al., 2012). However, the risk of PTB was not significantly different between remote and urban newborns in a study among 35,240 Indigenous mothers registered in the National Perinatal Data Collection (Graham et al., 2007). This systematic review will address this knowledge gap and will provide evidence by synthesising the existing literature to determine the quality of the relationship (after adjustment for biopsychosocial factors (Saxbe, 2017) between maternal residential area and pregnancy outcomes (PTB, LBW, and CS). Evidence from the review could motivate change to the existing maternal and child health services and policies (eg need based uniform planning and maintaining of services) (Rolfe et al., 2017). Prior research has indicated biological factors (age, diabetes or hypertension), psychological factors (perceived stress, depression and anxiety) and social factors (educational status, private hospital access, private health insurance) had associations with PTB, LBW, or CS (Bramham et al., 2014; Dahlen et al., 2012; Hoxha et al., 2017; Hure et al., 2017; Ludford et al., 2012; Mohsin et al., 2003; Morgen et al., 2008; O'Leary et al., 2007; Powers et al., 2013; Roberts et al., 2000; Ruiz et al., 2015; Whish-Wilson et al., 2016; Xu et al., 2014; Yu et al., 2017). However, such biopsychosocial factors (Saxbe, 2017) eg medical conditions, health service access, educational status, smoking and private health insurance are not uniformly distributed across maternal residential areas (Abdel-Latif et al., 2006; Fox et al., 2019; Graham et al., 2007; Hennegan et al., 2014; Morgen et al., 2008; Powers et al., 2013; Robson et al., 2006; Xu et al., 2014).

Therefore, as area is a policy focus, a proxy for health service access and pertinent for care (including obstetrics), this systematic review aimed to identify the location in which PTB, LBW and CS are higher and to identify the corresponding distribution of biopsychosocial risk factors that influence such outcomes by maternal residential areas.

Methods

The systematic review was carried out using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline (Moher et al., 2009). Problem identification (defining the outcome and exposure), searching article in a wide range of electronic databases, screening of articles, and result presentations follow the PRISMA protocol (Moher et al., 2009). The study synthesized PTB (birth before 37 weeks of gestation (WHO, 2011)), LBW (birth weight below 2500 gs (WHO, 2011)) and CS (planned and/or emergency CS) which were the main outcomes of the study. In addition, the risk factors of PTB, LBW and CS were assessed (eg maternal age, diabetes, hypertension, educational status, smoking, private hospital access, private health insurance). Maternal residential area was the exposure variable, and it was reviewed per the area definition of each reviewed article. Specifically, three area classification methods were available in this review: RRMA(Rural, Remote and Metropolitan Areas), ARIA(Accessibility/Remoteness Index for Australia) and ARIA+(Accessibility/Remoteness Index for Australia plus) classifications (AIHW, 2004). A summary of each of these area classifications are presented in Table 1. Area classification group of major cities, metropolitan, highly accessible and urban indicates high level of access to services (eg health facility) and goods, while regional, non-metropolitan, remote and rural indicate relative lower access to services (eg health facility) and goods (AIHW, 2004).

Search strategy

A primary search was conducted in MEDLINE, Embase, CINAHL, and Maternity & Infant Care databases. These search terms were used for all databases, and an example article search procedure using MEDLINE is available online in Table S1 as supplementary file. The initial article search was carried out on 28 May 2018 and was updated for new evidence on 15 April 2022. A citation search of articles identified by the primary search was also carried out.

Study selection

All articles were merged using EndNote X9 and all duplicates were removed. Using predefined inclusion and exclusion criteria as described below, further screening was carried out using titles, abstracts, and full text. The study selection process was summarized in the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2009 (Moher et al., 2009) flow diagram in Fig. 1.

Inclusion and exclusion criteria

Articles were included where they were published in peer-reviewed journals with English language, the research was conducted in Australia, and either described or compared PTB, LBW and/or CS by maternal residential areas. Articles published from 2000 or later were included because the current and most used area measurements were developed and adopted around 2000 (eg ARIA in 1997 and ARIA+ in 2001 (AIHW, 2004)). Known biopsychosocial risk factors for PTB, LBW, or CS were synthesised if they were reported across maternal residential areas in the reviewed articles i.e. assessed the relationship between maternal residential

Table 1
The description of area classifications used in the current review.

Area name	Area subdivision	Description
RRMA (Rural, Remote and Metropolitan Areas)	Metropolitan, rural, and remote	The RRMA classification was established in 1994, and uses the Statistical Local Area (SLA) geographic measure. Based on the 1991 census population size in each Statistical Local Area's, RRMA is subdivided in to metropolitan zone (having ≥100,000 population), Rural zone (5000–99,999 population) and Remote zones (<5000 population) (AIHW, 2004).
ARIA (Accessibility/Remoteness Index for Australia)	Highly accessible, accessible, moderately accessible, remote and very remote	The ARIA classification system was established in 1997. ARIA has a continuous measure of remoteness (ARIA index values 0–12), calculated based on the road distance to the closest service centres. ARIA uses four service center categories based on the 1996 census population size: (A) ≥ 250,000, (B) 48,000–249,999, (C) 18,000–47,999 and (D) 5000–17,999 persons. ARIA has five geographic groups based on the ARIA index values: Highly Accessible (0–1.84), Accessible (>1.84–3.51), Moderately Accessible (>3.51–5.80), Remote (>5.80–9.08), Very Remote (>9.08–12) (AIHW, 2004).
ARIA+ (Accessibility/Remoteness Index for Australia plus)	Major cities, inner regional, outer regional, remote and very remote	ARIA+ was established in 2001 and it is similar to ARIA with some differences e.g., ARIA+ index values are 0–15, calculated based on distance to five service centers i.e. with an additional services center (E) having 1000–4999 persons compared to ARIA. ARIA+ has five geographic groups based on the ARIA+ index values: Major Cities (0–0.2), Inner Regional (>0.2–2.4), Outer Regional (>2.4–5.92), Remote (>5.92–10.53), Very Remote (>10.53–15) (AIHW, 2004).

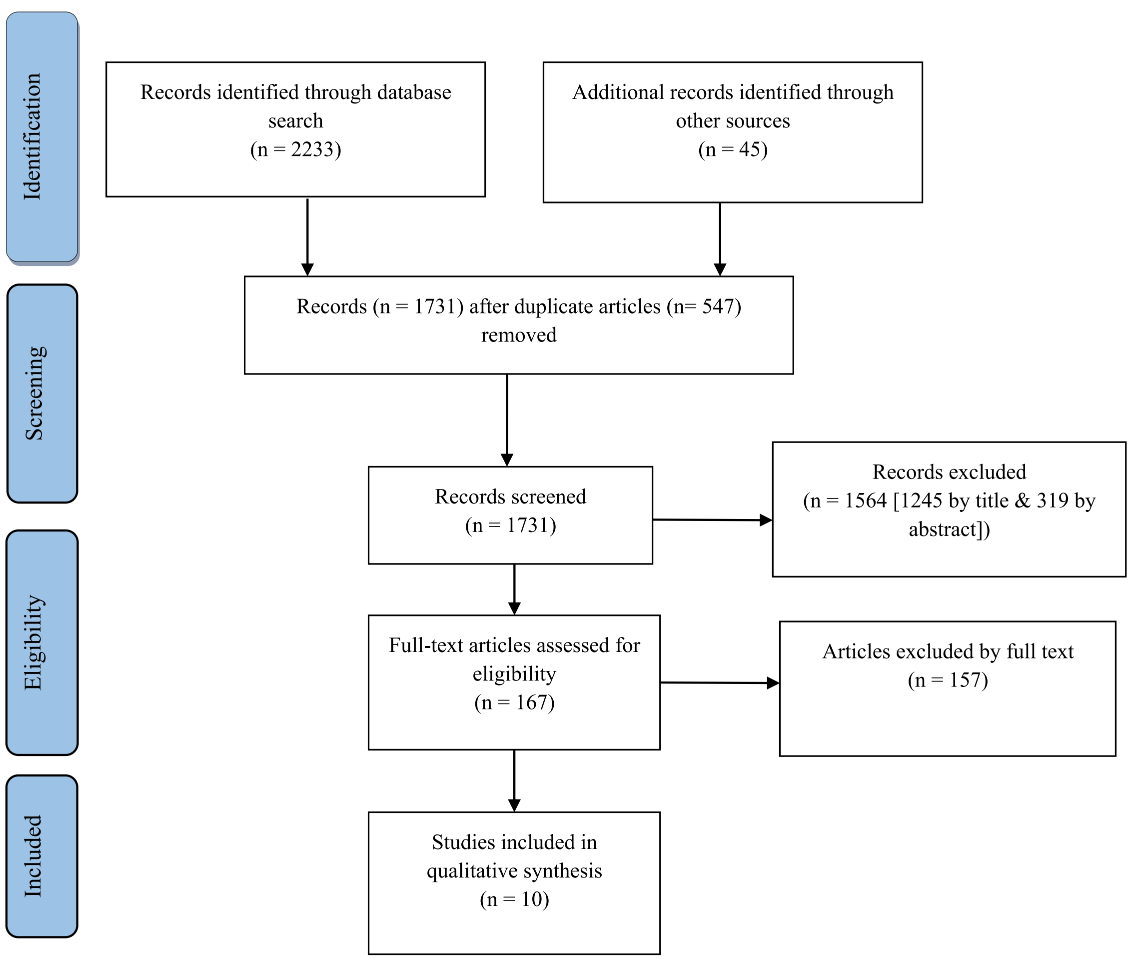

Fig. 1. Summary of the selection process of studies, using PRISMA 2009 Flow Diagram. Australia (2000–2022).

areas and PTB, LBW, and/or CS. Editorial comments on the original articles, duplicate publications of the same study (study reported many variables of interest were selected), conference abstracts, reviews, mass-media publications based on an original article, and case-reports or case-series studies were excluded.

Quality appraisal

The quality of articles was appraised using the JBI critical appraisal for systematic review of observational study designs (Moola et al., 2017). Two authors independently appraised

Table 2
Summary of the studies by study area, study design, study population and maternal residential areas classifications standard, Australia (2000–2022).

ID	Study area	Sample size and population	Maternal residential area classification	Main finding	Factors compared by maternal residential areas [a]
Graham et al., 2007	National	35,240 Indigenous mothers (women of Aboriginal and/or Torres Strait Islander descent) registered in the National Perinatal Data Collection	ARIA+	- PTB was slightly higher in remote areas than major cities but the variation was not significant (aOR=1.02, 95% CI: 0.94–1.11) - LBW was 1.09 times (aOR, 95% CI:1.01–1.19) more likely among newborns born in remote areas compared to newborns born in cities.	- maternal age - chronic or gestational forms of diabetes or hypertension - smoking during or before pregnancy
Xu et al., 2014	National	393,450 singleton births registered in the National Perinatal Data Collection between 2007 and 2009	ARIA+	- PTB was 1.13 times (aOR, 95% CI:1.01–1.27) more likely among very remote newborns compared to major city counterparts	- not measured
Powers et al., 2013	National	5886 primiparous women who had a singleton birth and participated in the Australian Longitudinal Study on Women's Health	ARIA+	- CS rate was lower in non-metropolitan newborns compared to metropolitan newborns, yet this variation was not significant (planned CS [aOR=0.85; 95% CI: 0.70–1.03], un-planned CS [aOR=0.96; 95% CI: 0.83–1.12]).	- maternal age - educational status - private health insurance
Abdel-Latif et al., 2006	NSW and ACT	2654 newborns born before 32 weeks of gestation and consecutively admitted to NICUs	ARIA	- The rate of CS was lower in rural areas compared to urban areas ($p<0.001$)	- maternal age
Burns et al., 2011	NSW	404,152 singleton births recorded in Midwives' Data Collection and used for comparing area variations	ARIA+	- The rate of PTB was higher among regional/remote newborns (18.7%) compared to major metropolitan newborns (15.9%)	- maternal age - smoking during pregnancy
Robson et al., 2006	NSW	21,880 teenage women who had a singleton birth and registered in the Midwives' Data Collection	ARIA	- Birth before 32 weeks of gestation was 3.37 times (aOR, 95%CI: 1.54–7.36) more likely in very remote areas compared to highly accessible areas - The rate of LBW was higher in remote areas - CS birth rate was higher in remote areas	- maternal age - chronic or gestational forms diabetes and hypertension - smoking during pregnancy - private hospital access
Roberts et al., 2000	NSW	694,779 births registered in NSW Midwives' Data Collection	RRMA	- The risk of PTB was lower for non-Indigenous women who live in other rural areas (aOR=0.92, $p = 0.002$) compared to their metropolitan counterparts	- maternal age - medical complications during pregnancy - smoking during pregnancy

(continued on next page)

Table 2 (*continued*)

ID	Study area	Sample size and population	Maternal residential area classification	Main finding	Factors compared by maternal residential areas [a]
Fox et al., 2019	Queensland	189,811 births recorded in the Queensland Perinatal Data Collection	ARIA+	- The rate of CS was lower (eg 30.7% in very remote area versus 35.7% in major city) in remote areas ($p = 0.001$) compared to city areas.	- Not measured
Hennegan et al., 2014	Queensland	7055 women with singleton live birth, registered in the Queensland Registry of Births, Deaths and Marriages and responded to a postnatal survey	ARIA+	- The rate of PTB was not consistently decreased/increased across area - The rate of LBW was not consistently decreased/increased across area - There was no statistical variation of CS procedure across area.	- Gestational diabetes - Gestational hypertension - educational status - private hospital access
Steenkamp et al., 2012	NT	2573 Indigenous women who had a singleton birth registered in the Midwives' Data Collection	Not stated (remote versus urban)	- The odds of PTB were 2.09 times more likely among Indigenous women living in a Top End remote area compared to women living in urban Central Australia. - The rate of LBW did not significantly vary ($p = 0.061$) between remote newborns (10.9%) and urban newborns (8.6%) - The rate of CS was significantly ($p = 0.027$) higher among remote newborns (25.1%) than among urban newborns (21.2%).	- maternal age - diabetes (chronic/gestational) - smoking during pregnancy - out-of-hospital births

ID is first author name and publication year; ARIA: Accessibility/Remoteness Index Australia; ARIA+: Accessibility/Remoteness Index Australia plus; NICU: Neonatal Intensive Care Unit; ACT: Australian Capital Territory; NSW: New South Wales; NT: Northern Territory; RRMA: Rural, Remote and Metropolitan Areas; PTB: preterm birth; LBW: low birth weight; CS: cesarian section.

[a] The risk factors that are associated with Preterm birth, low birth weight and cesarian section and described/compared by area.

the quality of the included articles and differences during quality assessment were discussed until a consensus was reached (Moola et al., 2017).

Data analysis

The data extraction tool was developed by two independent authors. Data included authors, maternal residential area, study design, sample size, residential status, and outcomes (PTB, LBW and/or CS). In addition, data included risk factors of the outcomes under the biopsychosocial framework (Saxbe, 2017) which included maternal age, chronic diseases (diabetes, hypertension), educational status, smoking, private hospital birth, and private health insurance. The summary of data from each study was narrated and presented in tables.

Results

A total of 2278 articles, comprising 2233 articles from the database search and 45 articles from citation search were identified (Fig. 1). After excluding 547 duplicates, the remaining articles (1731) were screened by title where 1245 articles were excluded. Of 486 articles screened by abstract, 319 were excluded and the remaining 167 articles were reviewed as full text. Ten articles were included in the final review (Fig. 1). For each specific outcome, seven or less articles were eligible for the final review: PTB (7 articles), LBW (4 articles), and CS (6 articles).

Most studies were carried out using a cross-sectional analysis of an administrative database (eg the Perinatal Data Collection), except one study that was conducted using a prospective community-based cohort (Powers et al., 2013). Six studies used the ARIA+ classification standard. Only three of the studies were carried out at the national level. The article details regarding study population, area classification, outcome main findings and the list of included risk factors examined in relation to the outcomes are summarized in Table 2. Only two studies fulfilled eight of the critical criteria of JBI critical appraisal checklist for observational studies (Moola et al., 2017). However, due to a low number of articles, all articles, regardless of quality, were included in the review (Table 3). A detailed review of each outcome (PTB, LBW, and CS) and the risk factors of the outcomes are presented in the section below.

Table 3
Critical appraisal results for cross-sectional studies included in the narrative review, Australia (2000–2022).

Checklist questions and response (yes/no)	ID Xu et al., 2014	Hennegan et al., 2014[a]	Graham et al., 2007	Roberts et al., 2000	Powers et al., 2013	Steenkamp et al., 2012	Fox et al., 2019	Burns et al., 2011	Robson et al., 2006[b]	Abdel-Latif ME, et al. 2006
Were the criteria for inclusion in the sample clearly defined?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Were the study subjects and the setting described in detail?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the exposure measured in a valid and reliable way?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Were objective, standard criteria used for measurement of the condition?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were confounding factors identified?	Yes[C1]	Yes[C2]	Yes[C3]	Yes[C4]	Yes[C5]	Yes[C6]	Yes[C7]	No	No	No
Were strategies to deal with confounding factors stated?	Yes	Yes	No	No	No	Yes	Yes	No	No	No
Were the outcomes measured in a valid and reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was appropriate statistical analysis used?	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	No

[a] article appraised in terms of cesarian section outcome.
[b] article appraised in terms of low birth weight and cesarian section outcomes.
[C1] adjusted confounders during association were women's age, parity, essential hypertension, hypertensive disorders during pregnancy, chronic diabetes, gestational diabetes, country of birth, smoking status during pregnancy, socioeconomic index for areas, health insurance type, remoteness, epilepsy, and antepartum hemorrhage.
[C2] adjusted confounders during association were women's age, facility type (public/private), socioeconomic index for areas.
[C3] adjusted confounders during association were age, parity, diabetes or hypertension and smoking status during pregnancy.
[C4] adjusted confounders during association were women age, parity, smoking status during pregnancy and medical and obstetric complications.
[C5] adjusted confounders during association were women's age and private health insurance.
[C6] the association of area with PTB was adjusted for women's age, first parity, status of ≥4 pregnancies, diabetes, smoking or alcohol use during pregnancy.
[C7] adjusted confounders during association were age, body mass index, pre-existing health conditions, complications during prior pregnancy, complications during current pregnancy, area-based socioeconomic deprivation, smoking, and distance to health institution.

Preterm birth

Of the seven reviewed studies, three showed a significantly increased risk of PTB in rural and remote maternal residential areas compared to urban and city areas (Robson et al., 2006; Steenkamp et al., 2012; Xu et al., 2014). In a national study with a subgroup analysis for naturally conceived 381,345 births, PTB was more likely among babies born in very remote maternal residential areas (aOR=1.13, 95% CI:1.01–1.27) compared to major cities (Xu et al., 2014). Babies born in the remote Top End of the Northern Territory had twice the risk of PTB (aOR 2.09; 95% CI: 1.20–3.64) compared to their urban central Australian counterparts (Steenkamp et al., 2012). In a national study among Indigenous women, the rate of PTB was slightly higher in remote newborns (14.6%) compared to their city-born counterparts (14.0%), yet this variation was not significant in the adjusted model (aOR=1.02, 95% CI: 0.94–1.11) (Graham et al., 2007).

In a Queensland study, the rate of PTB did not statistically differ across maternal residential areas (5.9% remote/very remote, 7.2% inner-regional, 8.0% outer regional and 7.6% major city) (Hennegan et al., 2014). In this study, the smaller ratio of women living in remote/very remote areas (170 of 7055 participants) and the low response rate for the self-completed survey (35.3%) compared to studies that reported a higher rate of PTB in rural and remote areas (Robson et al., 2006; Xu et al., 2014) could be one reason for the variation of the rate estimate.

In New South Wales (NSW), the risk of PTB was lower in remote maternal residential areas for both Indigenous women and non-Indigenous women. However, after adjustment, the variation was only significant (aOR=0.92, $p = 0.002$) for Indigenous women living in other rural areas compared to metropolitan areas (Roberts and Algert, 2000). The variation of the results in this study (Roberts and Algert, 2000) compared to other studies that reported a higher rate of PTB in remote maternal residential areas (Robson et al., 2006; Steenkamp et al., 2012; Xu et al., 2014)could be due to the different analysis strategies (separate analysis for Indigenous women and non-Indigenous women), and variation of area measurement accuracy/reliability (Roberts and Algert, 2000). Key findings of the included studies about PTB and areas are summarized in Table 2.

Low birth weight

Of the four reviewed studies, two studies found a significantly higher rate of LBW among babies born in rural and remote areas compared to urban and city areas (Graham et al., 2007; Robson et al., 2006). In a national study among Indigenous mothers ($n = 35{,}240$), LBW was 1.09 times (aOR, 95% CI: 1.01–1.19) more likely among remote newborns compared to their city-born counterparts (Graham et al., 2007). In a NSW-based retrospective study of 21,880 women, the rate of LBW was higher in very remote areas (22.3%) compared to highly accessible areas (urban areas closer to health facilities) (7.2%) (Robson et al., 2006). In a retrospective study of Indigenous births in the Northern Territory (887 in a remote areas and 1686 in an urban area), while the rate of LBW was higher in the remote area (10.9%) than in the urban areas (8.6%), this variation was not significant (p = 0.061) (Steenkamp et al., 2012). Among 7055 births who identified retrospectively in Queensland, the rate of LBW was not significantly varied across maternal residential areas (3.7% remote/very remote, 4.5% inner-regional, 5.1% outer regional and 4.8% major city) (Hennegan et al., 2014). In this study, the number of women living in remote/very remote areas (170) were comparatively smaller, data were collected using a self-report survey and the response rate was low (35.3%) compared to studies which reported a higher rate of LBW (Graham et al., 2007; Robson et al., 2006). Key findings of the included studies about LBW by area are summarized in Table 2.

Cesarian section birth

Of the six reviewed studies, two indicated a significantly lower rate of CS in remote areas compared to urban areas (Abdel-Latif et al., 2006; Fox et al., 2019). In Queensland, CS birth was significantly lower (p<0.001) in remote or regional maternal residential areas (30.7%−32.7%) compared to major cities (35.7%). Compared to major cities, the risk of CS for inner-regional women decreased by 4% (aOR=0.96; 95% CI: 0.93–0.99) (Fox et al., 2019). In a national study, the CS birth rate was lower in non-metropolitan newborns (planned section birth [7.9%]) compared to metropolitan newborns (planned section birth [11.1%]), yet this variation was not significant in the adjusted model (Powers et al., 2013). In Queensland, there was a lower rate of planned CS birth in remote areas (19.2% in remote/very remote vs 22.3% in major city). Unplanned CS was not significantly differed across maternal residential areas (12.6% in remote/very remote vs 12.8% in major city). The overall CS birth rate did not show strong variations across maternal residential areas. For example, compared to major cities, the risk in remote/very remote areas was not strong (aOR=0.98; 95% CI: 0.69–1.40). One of the reasons for the absence of the association could be due to the study not using spontaneous vaginal births as a reference but instead using all vaginal births including assisted vaginal births, as the reference category (Hennegan et al., 2014).

The rate of CS was significantly higher (p = 0.027) among remote newborns (25.1%) compared to urban babies (21.2%) born of Indigenous women living in the Northern Territory (Steenkamp et al., 2012). In NSW, a study among teenage mothers found a greater rate of CS birth in other areas (11.6%−15.5%) compared to highly accessible maternal residential areas (urban areas closer to health facilities) (11.2%) (Robson et al., 2006). The studies that reported a higher rate of CS in remote maternal residential areas compared to highly accessible areas could not be representative of the general population and the studies were of relatively low quality (Robson et al., 2006; Steenkamp et al., 2012). For example, the NSW study was based on teenage mothers, and the sample size for very remote (n = 94) and remote (n = 311) areas was smaller compared to highly accessible areas (15,091) (Robson et al., 2006). Studies in Queensland and NSW and ACT that reported a lower rate of CS in rural areas compared to urban areas generally used a representative population and were of relatively good quality (Abdel-Latif et al., 2006; Fox et al., 2019). Key findings of the included studies are summarized in Table 2.

The relation between maternal residential areas and risk factors of adverse pregnancy outcomes

This section presents the relationship between maternal residential areas and risk factors for PTB, LBW, or CS, organized according to the biopsychosocial framework (Saxbe, 2017). Of the reviewed studies, eight described (ranged from one factor to seven factors) or compared the risk factors of the outcomes (PTB, LBW, or CS) by maternal residential areas while the remaining two studies did not have such information. The studies showed the variation in maternal age, medical conditions (hypertension, diabetes), educational status, smoking, private hospital birth, and private health insurance availability across maternal residential areas. The adjustment of each risk factor is presented in Table 3. Key findings regarding the relationship between maternal area of residence and risk factors for PTB, LBW, or CS are summarized in Table 4.

Biological factors

Younger maternal age (<20 years) was associated with an increased risk of PTB and LBW. In addition, advanced maternal age was related to PTB, LBW, and CS (Ludford et al., 2012; Mohsin et al., 2003). Studies included in the current review showed that the proportion of younger mothers was higher in remote areas compared to urban areas (Abdel-Latif et al., 2006; Burns et al., 2011; Graham et al., 2007; Hennegan et al., 2014; Powers et al., 2013; Robson et al., 2006; Steenkamp et al., 2012). Nationally, there was significant variation in women's age at birth by area (p <0.001). Compared to women living in metropolitan areas, women living in non-metropolitan areas gave birth at a younger age, eg the proportion of women aged 16–19 years was higher in non-metropolitan areas (5.9%) than in metropolitan areas (2.2%) (Powers et al., 2013). Other studies at the national level (Graham et al., 2007), Northern Territory (Steenkamp et al., 2012), NSW (Abdel-Latif et al., 2006; Burns et al., 2011; Roberts and Algert, 2000; Robson et al., 2006), and Queensland (Hennegan et al., 2014) also showed that women living in remote areas gave birth at a younger age compared to their urban counterparts.

Medical conditions (eg diabetes (Bramham et al., 2014; O'Leary et al., 2007; Whish-Wilson et al., 2016; Xu et al., 2014; Yu et al., 2017), hypertension (Bramham et al., 2014; Hure et al., 2017; Mohsin et al., 2003)) were associated with a greater risk of PTB, LBW or CS. Such conditions were more prevalent in rural and remote maternal residential areas compared to urban and city areas (Graham et al., 2007; Hennegan et al., 2014; Roberts and Algert, 2000; Robson et al., 2006; Steenkamp et al., 2012). Nationally, there was a significantly higher (p <0.001) proportion of mothers with pre-existing and/or hypertension and/or diabetes across remoteness (eg 13.0% in remote areas vs 10.8% in city areas) (Graham et al., 2007). In Queensland, the proportion of women with gestational diabetes was higher in remote areas (eg 10.2% in remote areas vs 7.2% in major cities).

Social factors

Lower educational status was related to higher risk of PTB and LBW (Morgen et al., 2008; Ruiz et al., 2015). Compared to women living in urban and city areas, women living in rural and remote areas had a lower educational status. Nationally, higher educational achievement was significantly decreased in remote areas (p <0.001). For example, the proportion of women with university degrees was lower in non-metropolitan areas (24.7%) than in metropolitan areas (46.5%) (Powers et al., 2013). In Queensland, high school qualification status was significantly (p <0.001) lower in remote areas (eg 89.3% in remote areas vs 91.6% in major cities).

Smoking during pregnancy is associated with greater risk of PTB and LBW (Pereira et al., 2017; Shah and Bracken, 2000). In a national study, smoking was significantly different across maternal residential area (P<0.01). The proportion of women who smoked before and/or during pregnancy was higher in regional areas (57.0%) compared to city areas (51.5%) (Graham et al., 2007).

Table 4
The relationship between maternal residential area of residence and known risk factors of adverse pregnancy outcomes, review of published studies, Australia (2000–2022).

Article	Factors reported by maternal residential areas categories Age	Chronic conditions	Educational and smoking status	Health service access related factors
Hennegan et al., 2014	There was a significant variation of women's age during childbirth by area (p <0.001). The proportion of younger women (eg <25 years) were higher in remote areas, i.e. remote and very remote (22.8%), outer regional (15.6%), inner regional (17.8%), major city (11.5%). While the proportion of women in the older age group (eg ≥35) was lower in remote areas, i.e. remote and very remote (18.6%), outer regional (21.2%), inner regional (19.0%), major city (25.4%).	The rate of gestational diabetes was higher across rurality, i.e. remote and very remote (10.2%), outer regional (7.9%), inner regional (7.8%), major city (7.2%). Gestational hypertension was also higher across rurality, i.e. remote and very remote (9%), outer regional (9.7%), inner regional (10.1%), major city (8.7%). However, the variation was not strong for either gestational diabetes (p = 0.423) or gestational hypertension (p = 0.389).	High school qualification status was significantly (p<0.001) lower across rurality, i.e. remote and very remote (89.3%), outer regional (89.6%), inner regional (85.2%), major city (91.6%).	The rate of births in private hospitals was lower in remote areas (p<0.001), i.e. remote and very remote (28.7%), outer regional 34.0%), inner regional (33.3%), major city (46.1%).
Steenkamp et al., 2012	The mean age of Indigenous women living in rural areas (23 years) was lower than in their urban (24.9 years) counterparts (p <0.001). A higher proportion of women living in rural areas gave birth when they were <20 years (31.1%) compared to their urban counterparts (19.8%) (p<0.001). However, the proportion of women who gave birth at an older age (≥35 years) was lower in remote areas (5.3%) than in urban areas (7.1%) (p = 0.062).	The prevalence of diabetes (pre-existing/gestational diabetes) was slightly higher (although non-significant, p = 0.948) among Indigenous women living in rural areas (12.7%) compared to their urban counterparts (12.5%).	Smoking during pregnancy was not significantly differed between remote and urban residents of Indigenous women in Northern Territory e.g. smoking at first antennal care visit was 47.5% in remote areas versus 51.2% in urban areas (P = 0.076).	The proportion of out-of-hospital births were significantly higher (p <0.001) among Indigenous women living in rural areas (4.2%) compared to their urban counterparts (0.7%).
Robson et al., 2006	The proportion of women who gave birth at a younger age (<16 years) was higher in remote areas: very remote (6.4%), remote (5.8%), moderately accessible (3.9%), accessible (3.6%), highly accessible (3.2%).	The prevalence of medical conditions among women living in accessible areas (0.7%) or moderately accessible areas (0.8%) was higher than women living in highly accessible areas (0.6%).	The frequency of smoking per day in the second half of pregnancy was higher in rural and remote areas compared to highly accessible areas e.g. >10 cigarette smoking per day was 37.2% in very remote areas, 28.3% in remote areas, 24.4% in moderately accessible areas, 21.7% in accessible areas and 16.7% in highly accessible areas.	Compared to women living in highly accessible areas (1.5%), women living in accessible areas (0.4%) or moderately accessible areas (0.3%) had lower access to private hospitals.
Graham et al., 2007	Women's age at birth significantly varied across area (p <0.01). The proportion of younger women (<20 years) was higher across rurality: remote (25.9%), regional (21.4%), and city (19.9%). However, for women aged ≥40 years, it was lower in remote (1.0%) or regional (1.0%) areas compared to their city (1.5%) counterparts.	The proportion of diabetes or hypertension varied significantly across area (p<0.01). It was higher among women in remote (13.0%) or regional (10.9%) areas compared to cities (10.8%).	Among Indigenous women, smoking status significantly (P<0.01) varied across maternal residential areas. The proportion of women who smoked before and/or during pregnancy by regional area was 51.3% in remote, 57.0% in regional and 51.5% in the city area.	
Roberts et al., 2000	The proportion of women who gave birth at a younger age (<20 years) increased across rurality i.e. remote areas (11.8%), other rural areas (7.2%), small rural areas (7.9%), large rural areas (7.9%), metropolitan areas (4.5%). However, the proportion of older women (≥35 years) decreased across rurality, i.e. remote areas (6.7%), other rural areas (10.4%), small rural areas (9.7%), large rural areas (9.7%), metropolitan areas (13.8%).	The rate of medical complications during pregnancy was higher in remote areas (2.5%) compared to metropolitan areas (1.9%), while the figure was lower in other areas: other rural areas (1.2%), small rural areas (1.4%), large rural areas (1%).	The frequency of smoking per day in the second half of pregnancy was higher in rural and remote areas compared to metropolitan areas, e.g. smoking >10 cigarettes per day was 21.9% in remote areas, 15.4% in other rural areas, 14.9% in the small rural center, 15.4% in Large rural center and 9% in metropolitan areas.	
Powers et al., 2013	There was significant variation in women's age by area (p <0.001). The proportion of women who gave birth at a younger age (eg 16–19 years) was higher in non-metropolitan areas (5.9%) than metropolitan areas (2.2%), while the proportion of older women (30–36 years) was lower in non-metropolitan areas (21.5%) than in metropolitan areas (39.8%).		Higher educational achievement significantly decreased across rurality (p<0.001). For example, the proportion of university degrees was lower among women in non-metropolitan areas (24.7%) compared to their metropolitan area counterparts (46.5%).	Having private health insurance was significantly lower (p <0.001) among women living in non-metropolitan areas (45.0%) than women living in metropolitan areas (66.1%).

(continued on next page)

Table 4 (*continued*)

Article	Factors reported by maternal residential areas categories Age	Chronic conditions	Educational and smoking status	Health service access related factors
Burns et al., 2011	Women (without an alcohol-related admission) who gave birth when they were <20 years had a high proportion in regional/remote areas (5.7%) compared to metropolitan areas (3.0%), but the proportion for women aged 40–49 years was lower in regional/remote areas (3.7%) compared to metropolitan areas (7.4%).		The rate of smoking during pregnancy among women not having alcohol-related admission was twice higher for those living in regional and rural areas (21.7%) compared to metropolitan counterparts (10.6%).	
Abdel-Latif et al., 2006	The mean age of women at birth was significantly lower in rural areas (27.4 years) than in urban areas (29.5 years) (p <0.001). The proportion of women who gave birth when they were <20 years was higher in rural areas (10.4%) than in urban areas (4.7%) (p<0.001), while the proportion for women aged ≥35 years was lower in rural areas (13.5%) than in urban areas (21.5%) (p <0.001).			

Similarly, the proportion of smoking during pregnancy was more than double in rural and remote areas of NSW (Burns et al., 2011; Roberts and Algert, 2000) compared to urban areas. For instance, over one fifth (21.9%) of women living in remote areas reported smoking more than10 cigarettes per day in the second half of pregnancy, while the figure was 9% for women living in metropolitan areas (Roberts and Algert, 2000).

Private health insurance availability (Hoxha et al., 2017; O'Leary et al., 2007; Powers et al., 2013) and private hospital births (Dahlen et al., 2012; Roberts et al., 2000) were related to increased CS birth. Compared to women living in urban and city areas, women living in rural and remote areas had lower private health insurance availability. Nationally, private health insurance was significantly lower (p <0.001) among women living in non-metropolitan areas (45.0%) than in metropolitan areas (66.1%) (Powers et al., 2013). Women who live in remote areas were less likely to give birth in private hospitals (Hennegan et al., 2014; Robson et al., 2006). In Queensland, there was a significant variation of private hospital births across maternal residential areas (p <0.001). Women living in regional/remote areas had a lower private hospital birth rate (eg 28.7% in remote areas vs 46.1% in major cities) (Table 4) (Hennegan et al., 2014).

Discussion

In this review, ten articles reporting on PTB and/or LBW and/or CS across women's geographic location were included. Compared to women living in urban areas, women living in remote areas had a higher rate of PTB and LBW and a slightly lower rate of CS. Likewise, compared to women living in urban and city areas, women living in rural and remote areas gave birth at a younger age, had a higher rate of chronic disease, smoking during pregnancy and had lower levels of higher education, private health insurance and births in private hospitals. The study synthesized the currently available evidence about the relationship between areas and PTB, LBW and CS and their risk factors. The findings showed variation across different areas and this variation appeared to be due to the complex biopsychosocial factors described across the studies, as well as access to services (Abdel-Latif et al., 2006; Burns et al., 2011; Graham et al., 2007; Hennegan et al., 2014; Powers et al., 2013; Robson et al., 2006; Steenkamp et al., 2012; Xu et al., 2014).

The possible reasons for the relationship of maternal residential areas with PTB, LBW and CS could be the association between maternal residential areas and risk factors for these outcomes, namely, maternal age, chronic diseases, educational status, smoking, private health insurance and private hospitals access (Abdel-Latif et al., 2006; Burns et al., 2011; Graham et al., 2007; Hennegan et al., 2014; Powers et al., 2013; Robson et al., 2006; Steenkamp et al., 2012). The risk factors of PTB, LBW and CS are not uniformly distributed across maternal residential areas (Abdel-Latif et al., 2006; Burns et al., 2011; Graham et al., 2007; Hennegan et al., 2014; Powers et al., 2013; Robson et al., 2006; Steenkamp et al., 2012). In addition, they are related with access to health services and health professionals which are also strongly related to maternal residential areas. Hence, PTB, LBW and CS could vary across maternal residential areas due to delayed identification and poor management (i.e. relatively poor quality and lower continuity of care) of risk factors. Risk factors could be also higher in rural and remote maternal residential areas as a result of lower access to quality perinatal care or speciality care and reduced access to healthcare or specifically transport issues (AIHW, 2020; Australian Government, 2012).

Women living in rural and remote settings have less access to health services or skilled health professionals and have lower socioeconomic status, which are correlated positively with lack of speciality care, birth plan choices (AIHW, 2020; Ronsmans et al., 2004; Wakerman et al., 2019) and women's preference for CS (5%–20%) (Coates et al., 2020; McCourt et al., 2007; Ronsmans et al., 2004). Therefore, the lower rate of CS in rural and remote maternal residential areas could be attributed to lack of health service access and specialist care in their own community and birth plan preferences (AIHW, 2020; Ronsmans et al., 2004; Wakerman et al., 2019) and variations in women's preference for CS (Coates et al., 2020; McCourt et al., 2007) as a result of perceptions of safety, prior birth experience, experience and skill of health providers to perform a CS, cultural and social factors (fear of childbirth, care inadequacy, perceived inequality between women who live in rural and urban areas) (Coates et al., 2020; McCourt et al., 2007).

In rural and remote maternal residential areas, further strengthening the prevention of pre-existing and/or gestational forms of hypertension and diabetes, which are common risk factors of PTB, LBW and CS, could help achieve positive pregnancy outcome (Damus, 2008; WHO, 2020). Preconception care is one of the key periods for pregnancy planning, health promotion, screening and prevention/management of pre-existing and/or gestational hypertension and diabetes. In Australia, preconception care is available (RACGP, 2018) though there is a high rate (40%) of unplanned pregnancy (Rowe et al., 2016). Unplanned pregnancy is 1.4 times more likely among women living in rural and remote areas compared to women living in urban and city areas (Rowe et al., 2016). As a result, many women, especially those living in rural locations may not seek preconception care services.

Women living in rural and remote areas are also less likely (AIHW, 2019) to receive the recommended level of antenatal care (eg less likely to initiate care early before 10 weeks of pregnancy or receive five or more antenatal care visits) (Department, 2019), which is a critical period for management and prevention of pre-existing or gestational forms of hypertension and diabetes. Antenatal care initiation in the first trimester was found to be lower among women living in very remote areas (68.5%) compared to women living in major cities (71.5%). Similarly, five or more antenatal care visits during pregnancy was found lower among women living in very remote areas (91.2%) compared to women living in major cities (94.6%) (AIHW, 2019). Therefore, enhancing antenatal care utilization in rural maternal residential areas is important for preventing PTB, LBW or CS. Prevention of PTB, LBW or CS might also be achieved by expanding access to health services in remote maternal residential area and supporting retention of experienced health professionals. Health facilities could also play a crucial role in the prevention of PTB, LBW and CS through monitoring and evaluating of the implementation of the standardized care, training human resources, resource planning, and information dissemination. Prevention could also be achieved through health professionals who are experienced in clinical skills and health promotion. Community and partners could also benefit the prevention efforts as they help the women to seek and to adhere to the recommended level of care (Tokhi et al., 2018; Waller et al., 2016).

Strength and limitations

We endeavoured to include all peer-reviewed published papers across Australia by searching a wide range of websites using keywords and their Medical Subject Headings. Most of the reviewed studies were based on population-based data and had a large sample size. However, we did not carry out a meta-analysis due to the heterogeneity in definition/grouping used for geographic location across reviewed articles as well as there only being a small number of articles in each outcome e.g. four articles with two different area measures were eligible for LBW outcome. The review for the risk factors of PTB, LBW, or CS was limited to the studies that reported the relationship between maternal residential areas and PTB, LBW, and/or CS. Geographical classification systems have limitations due to using the road distance to service centres. Hence, the maternal residential areas classification will be changed over time when there is a change in construction of a new road or new facility or population size (AIHW, 2004).

Despite ten studies being carried out using population-based data and large sample sizes, the majority were limited to state-level administrative data (Abdel-Latif et al., 2006; Burns et al., 2011; Fox et al., 2019; Hennegan et al., 2014; Roberts and Algert, 2000; Robson et al., 2006; Steenkamp et al., 2012). Administrative data is generally not collected with standardized tools that would ordinarily be used in primary research. In most studies, the relationship between area and PTB, LBW and CS could be confounded because most studies could not account for a comprehensive set of biopsychosocial factors (Engel, 1977; Saxbe, 2017). For example, all studies (Fox et al., 2019; Graham et al., 2007; Hennegan et al., 2014; Powers et al., 2013; Roberts and Algert, 2000; Steenkamp et al., 2012; Xu et al., 2014) did not consider psychological factors such as perceived stress, depression, and anxiety, which have been found to be significantly associated with PTB, LBW or CS in previous research (Lilliecreutz et al., 2016; Nkansah-Amankra et al., 2010; Tandu-Umba et al., 2014). Therefore, studies that are adequately powered and control for a comprehensive set of biopsychosocial factors (including area of residence) are required, in order to provide conclusive evidence regarding not only the relationship between area and PTB, LBW and CS, but also the relative importance of individual risk factors.

Conclusion

The findings of this systematic review suggest that women who live in rural and remote areas are more likely to experience PTB and LBW compared to their urban and city counterparts. Compared to urban areas, in remote areas, women were more likely to be younger at childbirth, smoking during pregnancy and have chronic diseases (eg diabetes and hypertension), while higher educational achievement, private health insurance availability and private hospital birth rates are less prevalent.

CRediT authorship contribution statement

All authors, except GT, participated in drafting the concept and developing the methodology, HMB and GT conducted the article selection and quality appraisal, all authors, except GT wrote the results and discussion parts of the paper, and all authors approved the final draft.

Declaration of Competing Interest

The Author(s) declare(s) that there is no conflict of interest.

Acknowledgements

We would like to extend our thanks to Ms Natalia Soeters and Dr Ryan O'Neill for proofreading and Ms Debbie Booth (senior research librarian) for assisting with article searches for the systematic review. Dr Melissa Harris is supported by an ARC Discovery Early Career Researcher Award (DE190101134).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.midw.2023.103704.

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