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Risk factors for preterm, low birthweight and small for gestational age births among Aboriginal women from remote communities in Northern Australia

Sue V. Kildea[a,b,*], Yu Gao[a,b], Margaret Rolfe[c], Jacqueline Boyle[d], Sally Tracy[e], Lesley M. Barclay[c]

[a] School of Nursing, Midwifery and Social Work, The University of Queensland, Brisbane, Qld 4010, Australia
[b] Mater Research Institute — The University of Queensland, Brisbane, Qld 4101, Australia
[c] University Centre for Rural Health North Coast, Sydney Medical School, University of Sydney, Lismore, NSW 2480, Australia
[d] Monash Centre for Health Research and Implementation, School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia
[e] School of Nursing, University of Sydney, Sydney, NSW 2050, Australia

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ABSTRACT

Objective: To identify the risk factors for preterm birth, low birthweight and small for gestational age babies among remote-dwelling Aboriginal women.
Methods: The study included 713 singleton births from two large remote Aboriginal communities in Northern Territory, Australia in 2004–2006 (retrospective cohort) and 2009–2011 (prospective cohort). Demographic, pregnancy characteristics, labour and birth outcomes were described. Multivariate logistic regression analysis was conducted and adjusted odds ratios were reported.
Results: The preterm birth rate was 19.4%, low birthweight rate was 17.4% and small for gestational age rate was 16.3%. Risk factors for preterm birth were teenage motherhood, previous preterm birth, smoker status not recorded, inadequate antenatal visits, having pregnancy-induced hypertension, antepartum haemorrhage or placental complications. After adjusting for gender and birth gestation, the only significant risk factor for low birthweight was first time mother. The only significant risk factor for small for gestational age baby was women having their first baby.
Conclusions: Rates of these events are high and have changed little over time. Some risk factors are modifiable and treatable but need early, high quality, culturally responsive women centred care delivered in the remote communities themselves. A different approach is recommended.

Statement of significance

Problem or Issue

Australian Aboriginal population has significantly higher rate of preterm birth, low birthweight and small for gestational age birth, especially in rural and remote areas.

What is Already Known

Risk factors of preterm births, low birthweight and small for gestational age births include social and demographic factors and medical factors.

What this Paper Adds

Compared to non-Aboriginal women or Aboriginal women in urban areas, similar risk factors for these events were identified in the remote dwelling Aboriginal women.

* Corresponding author at: Level 1, Aubigny Place, Raymond Terrace, South Brisbane, QLD 4101, Australia.
E-mail address: sue.kildea@mater.uq.edu.au (S.V. Kildea).

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1. Introduction

Preterm births (PTB) and low birthweight (LBW) are associated with neonatal morbidity, lifetime disability[1]; diabetes, cardiovascular and renal disease in adulthood[2]; and high social and economic costs.[1] In Australia, over the last 20 years the PTB rate has increased from 6.8% in 1991 to 8.6% in 2013 and LBW rate has seen little change remaining at 6% over this time.[3,4] The LBW rate varies geographically from 6.3% for mothers living in major cities to 10.6% in very remote areas.[4]

The risk factors for PTB and LBW are similar, including social and demographic factors such as ethnicity, socioeconomic status, maternal education, maternal smoking, nutritional status, domestic violence, substance abuse, low or high body mass index (BMI) and maternal age.[1,5–9] Medical factors include sexual and urinary tract infections (STI/UTI), chronic conditions (e.g. diabetes, hypertension) and placental abnormalities; and fetal conditions such as multiple pregnancies, fetal death in utero, intrauterine growth restriction (IUGR) and congenital anomalies.[1,6,7,10]

There is significant disparity between Aboriginal and non-Aboriginal Australians for these outcomes: PTB (14.3% vs. 8.3%) and LBW (11.8% vs. 6.0%)[11]; and the risk factors for example: teenage pregnancy (18.6% vs 3.0%), smoking in pregnancy (48.1% vs 10.7%) and living in remote areas (24.1% vs. 1.8%).[11,12] Aboriginal mothers are also more likely to attend antenatal care later in pregnancy and receive less antenatal visit than non-Aboriginal mothers.[4]

A few Australian studies have reported risk factors for PTB and LBW among Aboriginal women from regional and urban areas.[13,14] However, about a third of Aboriginal births are to women who live in remote/very remote areas.[12] Pregnancy and birth characteristics and outcomes differ from those occurring in urban, rural and remote areas.[12,15] In 2007, the authors were awarded an Australian National Health and Medical Research Council (NHMRC) grant aiming to improve outcomes for Aboriginal women and infants living in two remote communities in Northern Territory (NT), Australia. Key results are reported elsewhere[16,17] however, we found that PTB and LBW rates were some of the highest in Australia, which urged us to investigate the risk factors for PTB, LBW and small for gestational age (SGA) births for women in our study. We have used the international literature to shape health service recommendations.

The NT of Australia is a large sparsely populated jurisdiction, with approximately 4000 babies born annually. Of these, approximately 1400 (34%) are born to Aboriginal women.[18] In NT, two-thirds of Aboriginal women live in remote areas (62%) compared with 5% of non-Aboriginal mothers. The study sites included the Health Centres (HCs) in two large remote Aboriginal communities outside of major towns (population 2200–2600), each located approximately 500 km from the regional centre and NT capital, Darwin. The index of socio–economic disadvantage rates these communities (on income, education, employment, single parent, no car, overcrowding, language ability) as being in the lowest 2% of all communities in Australia.[19] The third study site, the regional hospital, is the main public hospital servicing these communities and provides tertiary level care including a Special Care Nursery (18 cots), a neonatal intensive care (NICU) (five ventilated cots) and a birth centre. A private operator provides an aero-medical retrieval service for remote communities. Currently most district health boards in Australia do not support local birthing services for women in remote areas, despite the many consultations undertaken with Aboriginal women who state the importance of being able to give birth on their own lands (birth on country).[20] Instead, pregnant women from remote communities are separated from their families at around 38 weeks gestation and transferred to hospitals in larger regional centres via a commercial flight to await birth. The Patient Assistance Transport Scheme provides funding for airfares and accommodation. Relocation to await giving birth is mandatory (no other choice offered) and often occurs at an earlier gestational age for women with identified risk factors in pregnancy.

In this study preterm births were defined as births greater than 20 completed weeks gestation (or ≥400 g birthweight) and <37 completed weeks gestation. Low birthweight babies include both live born and still born babies whose birthweight was below 2500 grams and who were >20 completed weeks gestation or ≥400 g birthweight. Small-for-gestational age (SGA) was defined as infants with a birthweight below the 10th percentile for gestational age according to the latest Australian national birthweight percentiles standard and differed by infant gender.[21] We have reported the perinatal mortality rate using the Australian definition[11] and the definition used in the Cochrane Review of midwifery models of care[22] to enable international comparisons.

2. Participants

All Aboriginal women from the two study communities who gave birth to a singleton baby at a gestation ≥20 weeks or birth weight ≥400 g from 1 January, 2004 to 31 December, 2006 (Cohort 1, retrospective) or during September 2009 to 30 June, 2011 (Cohort 2, prospective) at the regional hospital, in transit to hospital, in their resident community or a hostel were included in the study. Cohort 2 included some additional women who received care through the new model and lived in some of the smaller nearby communities (n = 74). In total, 713 births were included for analysis from Cohort 1 (n = 408) and Cohort 2 (n = 305).

3. Ethics

Ethics approval was granted on 10th September, 2007 from the Human Research Ethics Committee (HREC) of the NT Department of Health and Families and Menzies School of Health Research (09/37).

4. Methods

A full description of the study design, data collection and other clinical and health economic evaluation findings from the study have been reported.[17,23–28] In brief, the study was conducted in two purposively selected remote Aboriginal communities both of approximately 500 km from the regional centre. Although only one hour flight time to the regional centre, a priority one evacuation can take more than four hours to transfer women to the regional centre. Roads to both communities are cut off in wet season for many months. The study included a retrospective cohort (Cohort 1) and a prospective cohort (Cohort 2) following the implementation of a culturally enhanced Midwifery Group Practice (MGP) consisting of midwives, Strong Women Workers, Aboriginal Health Workers and student midwives working in a team in the regional centre. In both cohorts early antenatal care (ANC) was provided at the local HCs by resident midwives, nurses, doctors and Aboriginal health workers (AHWs). Specialist outreach obstetricians visited 3–4 times a year. The HCs opened Monday–Friday 8–5pm and offered on call services after hours. Women with identified risks in pregnancy were seen by the resident doctor, a specialist outreach obstetrician or transferred to Darwin for specialist appointments. Implementation of the MGP team program provided continuity of midwifery care and culturally responsive care for Cohort 2 women at any time they came in to the regional centre during pregnancy, from when they transferred to await the birth, during the intrapartum period and during the postnatal period until they boarded a flight home. This initiative aimed to improve care in the regional setting but had minimal ability to impact on care in the remote setting.

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4.1. Data collection

The study cohorts were constructed through manual review and data linkage of records in the remote community HCs and the regional hospital. Data was collected using paper based forms for both the mother and infant and then manually entered into a specifically designed Access ([TM]Microsoft Corporation) database.

Risk factors in this population were identified from the literature and considered in this study including: maternal and pregnancy characteristics and pregnancy complications (Table 1).

Table 1
Maternal and infant characteristics and outcomes for 713 Indigenous Australian singleton births from remote communities in the Northern Territory, 2004–2006 and 2009–2010.

Description of variable	n	%	Total
Maternal characteristics			
Age (years)			
Age <20 years	185	28.3	654
Age >35 years	40	6.1	654
Primipara	224	31.4	713
Smoking in pregnancy	287	58.0	495
Drinks alcohol	22	4.9	446
Pregnancy characteristics			
Previous preterm	144	20.2	713
Previous caesarean section	132	18.5	713
Previous neonatal deaths	22	3.1	713
Previous stillbirths	21	3.0	713
Inadequate antenatal care	118	17.1	690
Pregnancy complications			
Anaemia	422	59.2	713
Diabetes	54	7.6	713
Urine tract infection	283	43.7	648
Sexually transmitted infections	146	22.5	649
Pregnancy induced hypertension	48	6.7	713
Cardiac conditions	99	13.9	713
Antepartum haemorrhage and/or placental complications	35	4.9	713
Labour and birth outcomes			
Onset of labour			712
Spontaneous	560	78.7	
Induced	84	11.8	
No labour	68	9.6	
Birth place			712
Hospital	639	89.7	
Community Health Centre	57	8.0	
Other	16	2.3	
Birth mode			712
Non-instrumental vaginal birth	486	68.3	
Instrumental vaginal birth	47	6.6	
Caesarean section	179	25.1	
Preterm	138	19.4	712
Gestation age at birth			712
Extremely preterm (20–27 weeks)	14	2.0	
Very preterm (28–31 weeks)	24	3.4	
Moderate to late preterm (32–36 weeks)	100	14.0	
Term (≥37 weeks)	574	80.6	
Low birth weight	123	17.4	709
Birth weight			709
<1000 g	16	2.3	
1000–1499 g	15	2.1	
1500–2499 g	92	13.0	
2500–3999 g	558	78.7	
≥4000 g	28	4.0	
Small for gestational age	113	16.3	693
Neonatal admission	217	31.4	691
Perinatal mortality rate (per 1000 births) (Australian NPESU definition)[a]			
Stillbirth (≥400 g, or ≥20 weeks)	7 (9.8 per 1000 births)		
Neonatal death (up to 28 days)	6 (8.4 per 1000 births)		
Perinatal mortality rate (per 1000 births) (Cochrane definition)[b]			
Stillbirth (≥24 weeks)	5 (7.1 per 1000 births)		
Neonatal deaths (up to 28 days)	4 (5.6 per 1000 births)		

Notes: cardiac condition including maternal rheumatic heart disease and other cardiac diseases.
Placental complications including placenta abruption, placenta previa.
Sexually Transmitted Infection including chlamydia, gonorrhea, trichomonas, syphilis.
[a] Australian NPESU definition includes births of at least 20 weeks gestation or at least 400 g birthweight.
[b] Cochrane definition includes birth of at least 24 weeks gestation.

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Because the total number of antenatal visits is confounded by gestational weeks (i.e. the longer the duration of the pregnancy the more antenatal care visits a mother is likely to attend), in this study we created a new variable 'Recommended antenatal visits (based on schedule)' to assess antenatal care according to the birth gestation. When birth gestation was between 20 and 31 weeks, women with two or more visits; or when birth gestation was 32 weeks or more, women with five or more visits were treated as having adequate visits.[29]

4.2. Data analysis

There were a small number of missing data for preterm, LBW and SGA births (<3%). Mother's smoking status was poorly recorded with over a third missing data, which were not imputed in analysis. Instead we treated them as a third category — smoking not recorded (Table 1). There were 647 (91%) women had at least one ultrasound during pregnancy.

The effect of each risk factor on PTB, LBW and SGA was investigated by univariate analysis; chi-square tests were used for contingency tables and two-sample *t* tests for continuous variables. The risk factors included in the PTB and LBW univariate models were: model of care, infant gender, maternal age, parity, marital status, previous preterm, previous caesarean section, previous neonatal death or stillbirth, smoking, urinary tract infection, sexually transmitted infection, anaemia, cardiac disease, pregnancy-induced hypertension, antepartum haemorrhage or placenta complications and antenatal visits. The LBW univariate model was also adjusted for infant gestation at birth. The SGA univariate model excluded gestation at birth and infant gender but included all the other risk factors of PTB described above. Multivariate logistic regression analysis was conducted to identify significant risk factors of PTB, LBW and SGA births. Any variables with a p-value < 0.10 in univariate analysis were included in the multivariate logistic regression model. The non-significant variables were removed manually in a stepwise manner until all risk factors were significant. Unadjusted odds ratios (ORs) and adjusted OR (AORs) with 95% confidence intervals (95% CI) were reported. All analysis was conducted using Stata 12.0. Statistical significance for all other analyses was set at $p < 0.05$. The area under the receiver operating characteristic curve (AUC) was used to describe model performance: poor discrimination (when AUC < 0.7), acceptable discrimination (0.7–0.8), excellent discrimination (>0.8).[30]

5. Results

5.1. Mothers

A number of women had characteristics that placed them at high-risk of these outcomes: 28.3% (n = 185) were teenage mothers (n = 53: 28.7% of whom were multiparous) and 31.4% (n = 224) were first time mothers. About 20% (n = 144) of the sample had a previous PTB and 18.5% (n = 132) had previously had a caesarean section. The burden of disease in this population was high: 59.2% (n = 422) women had anaemia (60.9%, n = 257 had recorded treatment), 13.9% had cardiac conditions (maternal rheumatic heart disease or other cardiac disease), 7.6% had diabetes, 43.7% had a urine tract infection (31.4%, n = 89 with recorded treatment), 22.5% had a sexually transmitted infection (chlamydia, gonorrhea, trichomonas or syphilis) and 5% had an antepartum haemorrhage or placental complication (for example placenta praevia).

5.2. Infants

Ten percent (n = 73) of the studied babies were born out of hospital: 8.0% (n = 57, with 27 PTB) in community health centres and 2.2% (n = 16, two were PTB) in other places such as in transit to hospital, at hostels or at home. There were 13 perinatal deaths (10 of which were PTB), with a perinatal mortality rate of 18.2 per 1000 births (Australian definition[4]) but this reduced to 12.6 per 1000 when using the Cochrane definition[22] (6/9 perinatal deaths were PTB), four at the very early range of viability (≥20 to <24 weeks) (Table 1). The mean birthweight was 2989 g (95% CI 2939–3040) with 17.4% identified as having LBW. The median gestation was 38 weeks, range 20–42 weeks (IQR 37–39). The PTB rate was 19.4% (n = 138) with a non-significant reduction between Cohorts (n = 84, 20.6% vs 54, 17.7% p = 0.335). Although twins were excluded for the analysis presented in this paper, when twins were included, the overall PTB rate was 20.5% (20.8% in Cohort 1 vs 20.3% in Cohort 2). The PTB rate for live born infants was 18.7% (n = 132): 81 (20.0%) in Cohort 1 and 51 (16.9%) in Cohort 2 (p = 0.303). The

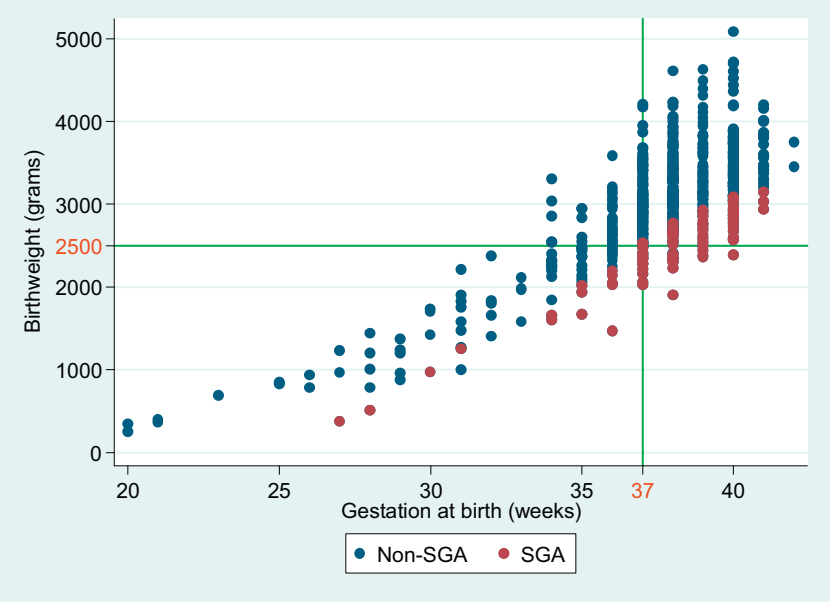

Fig. 1. Scatter plot of birthweight and gestation at birth by small for gestational age status.

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overall LBW rate was 17.4% (17.3% in Cohort 1 vs 16.8% in Cohort 2) Thirty-two LBW babies were term. One hundred and thirteen (16.3%) babies were small for their gestational age: 16.8% in Cohort 1 and 15.6% in Cohort 2. Of the 113 SGA babies, 16 were preterm and 45 had LBW (Fig. 1).

Of the 138 PTB, 14 (10%) were 20–27 weeks gestation, 24 (17%) were 28–31 weeks and 100 (72%) were 32–36 weeks (Table 1). Of the 100 moderate to late PTB, over half (53.0%) were born at 36 weeks (Fig. 1). One hundred and nineteen (86.2%) PTB had spontaneous labour, seven (5.1%) had induction and 11 (8.0%) had no labour established before birth. Over a third (n = 217) of all infants were admitted to neonatal intensive care (Table 1).

The majority of PTBs (n = 96, 72.7%) and 81.0% (n = 98) of LBW infants were admitted to the neonatal nursery, however, the rate of admission for SGA babies was 42.7% (n = 47).

5.3. Risk factors for preterm birth, low birthweight and small for gestational age

The clinical redesign of MGP in Cohort 2 did not significantly reduce the odds of being PTB (OR = 0.83, $p = 0.335$), LBW (OR = 0.94 $p = 0.754$) or SGA (OR = 0.91 $p = 0.666$) therefore it was not included in the final models.

The significant risk factors for PTB from univariate (Supplement Table 5) or multivariate logistic models were being a female baby, maternal age younger than 20, with a history of previous preterm birth, inadequate antenatal visits, smoking status not recorded and having a pregnancy complicated with pregnancy-induced hypertension, antepartum haemorrhage or placental complications. Anaemia was the only factor that appeared to offer a protective effect, but this is possibly a surrogate marker for improved antenatal care once anaemia was detected. When women's smoking status was not recorded, their odds of having a PTB were 3 times higher than non-smokers (Table 2). The area under the receiver operating characteristics curve (AUC) was 0.74 which indicates the model's ability to predict PTB is modest.

Table 2
Risk factor for preterm birth for 622 Indigenous Australian singleton births from remote communities in the Northern Territory, 2004–2006 and 2009–2010.

Risk factor	Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	*p*-Value
Infant gender			
Male	Reference	Reference	1
Female	1.62 (1.10, 2.37)	1.74 (1.12, 2.69)	**0.013**
Maternal age			
Under 20	1.45 (0.96, 2.18)	1.69 (1.04, 2.76)	**0.034**
20–34	Reference	Reference	1
35 and over	1.35 (0.64, 2.85)	1.43 (0.61, 3.34)	0.406
Previous preterm			
No	Reference	Reference	1
Yes	2.22 (1.47–3.37)	2.07 (1.26, 3.41)	**0.004**
Smoking status			
No	Reference	Reference	**1**
Yes	0.86 (0.52–1.42)	1.00 (0.58, 1.74)	0.995
Not recorded	2.25 (1.41–3.61)	3.35 (1.90, 5.89)	<**0.001**
Recommended antenatal visits (based on schedule)			
No	2.61 (1.68–4.05)	2.16 (1.27, 3.42)	**0.004**
Yes	Reference	Reference	1
Anemia			
No	Reference	Reference	1
Yes	0.61 (0.42–0.88)	0.51 (0.33, 0.80)	**0.003**
Pregnancy-induced hypertension			
No	Reference	Reference	
Yes	1.80 (0.94–3.45)	2.08 (0.98, 4.43)	0.057
Antepartum haemorrhage and/or placental complication			
No	Reference	Reference	1
Yes	3.38 (1.68–6.80)	5.59 (2.49, 12.56)	<**0.001**

Areas under the ROC curve for preterm model: 0.7370.

Table 3
Risk factor for low birthweight for 689 Indigenous Australian singleton births from remote communities in the Northern Territory, 2004–2006 and 2009–2010.

Risk factor	Odds ratio (95% CI)	Adjusted odds ratio (95% CI)	*p*-Value
Infant gender			
Male	Reference	Reference	1
Female	1.88 (1.26, 2.82)	2.10 (1.17, 3.78)	**0.013**
Parity			
Multiparous	Reference	Reference	1
Primiparous	1.79 (1.20–2.67)	3.06 (1.68, 5.58)	<**0.001**
Gestation at birth	0.36 (0.30, 0.44)	0.35 (0.28, 0.43)	<**0.001**

Areas under the ROC curve for low birthweight model: 0.9254.

Table 4
Risk factor for small for gestational age for 635 Indigenous Australian singleton births from remote communities in the Northern Territory, 2004–2006 and 2009–2010.

Risk factor	Odds ratio (95% CI)	Adjusted odds ratio (95% CI)	*p*-Value
Parity			
Multiparous	Reference	Reference	
Primiparous	1.89 (1.25, 2.86)	1.89 (1.25, 2.86)	**0.002**

Areas under the ROC curve for preterm model: 0.5728.

The results from univariate and multivariate analysis showed that the significant risk factor for LBW was first time mothers and being a female baby. Maternal age under 20 and smoking were not significant risk factors for LBW in the multivariate model (Table 3). The AUC was 0.93 which suggest that this model has an excellent ability to predict LBW.

Multivariate logistic regression analysis showed that being a first time mother significantly increased risk of SGA birth, however, the model did not have a good ability to predict an SGA birth (AUC = 0.57) (Table 4).

6. Discussion

Preterm birth (19.4%), LBW (17.4%) and SGA rates (16.3%) were unacceptably high in these Aboriginal communities and need urgent attention. The rates are possibly the highest rates in Australia,[11] are also high by international standards,[1] and were higher than those reported in the general Darwin region (their sample had 76.7% of Aboriginal babies which included women from these communities) more than 20 years ago (liveborn singletons had PTB: 7.4% and LBW 13.9%).[31] Even though remoteness is a known independent risk factor for poorer outcomes in the NT and regional differences have been identified[12] this study highlights the importance of community/regional specific reporting to enable targeted strategies where they are needed most.

When looking at socioeconomic disadvantage these communities are in the lowest 2% of all communities in Australia, thus it was not surprising that we found high rates of teenage mothers (28.3%). Comparison with other studies is difficult due to different data completeness, however similar to some studies we found teenage mothers were 1.6 times more likely to have a PTB.[32,33]

Adequate, high quality antenatal care has been shown to improve birth outcomes in general, particularly for PTB and LBW.[34] Not having recommended antenatal visits was associated with PTB in this and other studies.[35,36] It is clear that measuring the adequacy of antenatal care by number of visits is not enough to identify quality of care for example management of identified risk factors such as STIs, UTIs, anaemia, diabetes, hypertension, and smoking. Additionally it does not highlight the missing data which we assume means women also missed opportunities for

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treatment, referral and health promoting activities and may have had delayed care.[37] In this study over a third of women's smoking status was not recorded. Our study did not find smoking was a significant risk factor, most likely because of missing data, as it has been consistently reported as a risk factor in other studies.[13,31,38] Over a third of our women's smoking status was not recorded (mostly in Cohort 1), this in itself was a risk factor for PTB, and was more likely to reflect inadequate care, rather than poor documentation. Continuous quality improvement in antenatal care in Australia in Primary Health Care Centres with predominantly Aboriginal women has been shown to improve completeness of antenatal records and quality of care[39] but was not operating in these communities at the time of the study. We understand it is now. Earlier results from our study reported significant challenges to the delivery of high quality care in these remote communities.[16,40] Nulliparous women were more likely to have a LBW and SGA birth, consistent with other studies.[38,41] One explanation of second and third children being heavier than the first is that the first pregnancy matures the uterus, improving uterine conditions resulting in better placenta development and fetal nutrition.[41]

Women having a previous PTB birth were at increased risk for preterm,[42] and they were more than twice as likely to have PTB than women who did not have a previous PTB. It is not clear why this occurs but generally the risk of PTB is believed to be inversely related to the previous gestational age.[43] The association between pregnancy-induced hypertension and PTB was marginally significant in our study whereas a larger Queensland study in Indigenous women found it to be a more important predictor (AOR: 4.6)[35] as did Sayer and Powers' study in Darwin 20 years ago (AOR: 12.7).[31]

It should be feasible to plan for prevention more actively than what currently happens. Quality antenatal models of care providing social and financial support for pregnant women, particularly disadvantaged/at-risk population groups, have been associated with reducing PTB and LBW rates.[1] One program, established in the NT in 1991 to address PTB/LBW, is the Strong Women, Strong Babies, Strong Culture program.[44] A recent evaluation found that although the program was still recognised as a 'flagship program,' there were substantial challenges in its provision and sustainability impeding it from reaching its potential.[45] This program was not operating in one of our study settings and had been reduced from its former size in the other. Although the new model of care had employed one Strong Women Worker she had links to one community only and was mostly situated in the regional setting. Strengthening this program in these communities' may likely help address the high rates of PTB/LBW. High rates of poverty are a hallmark of these communities and financial support for at risk pregnant women has not been trailed. Financial incentives and support to encourage smoking cessation has also been shown to work in other populations[46–48] and could be tested in this setting, although this would need to be a family centred approach.

When any of these risk factors are noted in antenatal women in these communities (eg. teenage mother, previous PTB, smoking in pregnancy, first baby) women should be immediately referred for multidisciplinary case management, whereby a plan is developed and regularly reviewed, and incorporates explanations and discussions with the women, in her first language with support from the Strong Women or other cultural advisors. Most clinicians do not speak the local languages and women may speak two or three languages before learning English. Thus the role of interpreters is important yet poor utilisation of interpreter services, and profound and pervasive inadequacies in communication and health education, have been reported across the NT and are likely to be contributing to these outcomes.[49,50] A greater use of telehealth in this environment should be explored.

Midwife-led continuity models of care have shown a reduction in PTB (of 24%),[22] including for at risk groups like teenagers[51] through early engagement with women in pregnancy and providing opportunities' for early health and social support interventions that impact positively on birth outcomes.[51] Indeed this was one of the drivers for the intervention (the clinical redesign) that was developed through the introduction of the MGP, however we found it mainly impacted services and care provision in the regional hospital around the time of birth (which was also a priority of the project) but the team had limited ability to impact on early engagement or early intervention which may have been a contributing reason to why we did not see a difference in PTB between the cohorts. Further research is needed to adapt these models, and an appropriate clinical governance structure to flow into the remote communities where women reside during the entire antenatal period.

At the beginning of our project the women themselves asked for the return of birthing services to enable them to Birth on Country.[52] They felt this would help to address the stress and disadvantage they experienced by being removed from family, community and country for birth. A 'Birth on Country' service model has been described as one that is community based and governed; incorporates traditional practice; recognises the connection with land and country; incorporates a holistic definition of health; values both indigenous and non-indigenous ways of knowing, learning and risk assessment; and service delivery that is culturally competent and developed by, or with, Indigenous people.[28,53] The National Maternity Service Plan[54] recommended this service model be established and evaluated in several sites in Australia and these remote communities do have the birthing numbers to sustain such services. It would likely engage women early and drive health promoting behaviour as women strive to ensure they are healthy enough to stay and birth on country in a low risk unit (as it has done in remote Inuit communities)[26,55]. It would also require a health service commitment to fulltime experienced midwives being onsite 24/7 every day of the year. This alone would impact on the availability of ANC, with our study finding that at times, the single community midwife was absent for several weeks at a time with not backfill.[17] The high burden of disease evident in our data would see many women still being advised to birth in the higher level services. However, you would expect this proportion to reduce over time as the birthing on country model works as a complex, protective intervention,as it has been shown to do in the remote Inuit communities.[56]

7. Study limitations

Some important variables were either not routinely collected at both time points (BMI) or had a substantial amount of missing data (smoking). Twenty three (3.2%) women's antenatal records were missing and of the 690 women with available records, 17.1% (n = 118) did not have adequate antenatal visits per recommendations. About a third of women's smoking and drinking history was not recorded. One hundred and seventy seven (81.1%) of the missing records occurred in Cohort 1 before the MGP was introduced and the rate of missing records dropped significantly to 18.8% (n = 41) in Cohort 2. Of the women with complete records, 58.0% (n = 287) were smokers but only 4.9% drank alcohol. Sixty two (28.4%) women who did not have their smoking status recorded had inadequate antenatal visits which was 2–3 times higher than non-smokers (9.1%) and recorded smokers (12.9%). It suggests that women whose smoking status was not recorded had poorer antenatal care than women with smoking status recorded.

The scatter plot identified a number of babies who were documented as being preterm without LBW. We also found that the majority of women (60%) either did not have their first antenatal

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care or ultrasound scan in the first trimester. This could mean that the estimation and measurement of gestational age was not as accurate as birth weight measurements, especially evident in the later preterm gestational ages of 35–36 weeks.

8. Conclusion

This study highlights high rates of PTB, LBW and SGA alongside high rates of risk factors, some of which are modifiable or treatable with high quality, early, culturally responsive, woman-centred care. Targeted strategies are urgently needed and must be developed with, and delivered in, the remote communities themselves. The lack of progress over the last 20 years must not be allowed to continue.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

Author's contributor statement

Professor Sue Kildea designed the study and drafted the manuscript. Dr. Yu Gao conducted analysis, assisted with writing up the final manuscript. Dr. Margaret Rolfe and Dr Jacqueline Bolye assisted with data analysis. Professor Sally Tracy and Professor Lesley Barclay provided significant comments on the manuscript.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.wombi.2017.03.003.

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