NEW ZEALAND RESEARCH

Comparing perinatal outcomes for healthy pregnant women presenting at primary and tertiary settings in South Auckland: A retrospective cohort study

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The original article was published in January 2019 with an error in Table 5. This is a corrected version of the article, re-published March 2025.

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ABSTRACT

Background: Strong evidence supports the premise that many low-risk women and babies experience perinatal outcomes, in a free-standing, midwifery-led, primary level maternity unit (PMU) similar to, or better than, those of an obstetric-led tertiary level maternity hospital (TMH).

Aim: The aim of this study was to identify whether place of birth affected measurable maternal and neonatal outcomes in a low-risk cohort within one New Zealand District Health Board.

Method: We gathered the birth records of a retrospective cohort of low-risk women (n=4,207), who had birthed within two distinct environments, including one TMH and three PMUs. Comparison was made of three maternal outcomes: emergency caesarean section, acute postpartum admission to theatre/high dependency unit/intensive care unit (<12hr post birth) and postpartum haemorrhage (PPH; >500ml). Neonatal outcomes analysed were 5-min Apgar score <7 and acute neonatal admission to neonatal intensive care unit (NICU; <12hr post birth).

Findings: Logistic regression of data revealed statistically significant associations between place of birth and the five perinatal outcomes. Low-risk women giving birth in one of the three PMUs had fewer emergency caesarean sections (OR 0.25, 95% CI, 0.157-0.339), PPHs (OR 0.692, 95% CI, 0.534-0.898), and acute postpartum admissions to theatre (OR 0.201, 95% CI, 0.102-0.398) than women giving birth in the TMH. Babies born to women at a PMU were less likely to experience a 5-min Apgar <7 (OR 0.313, 95% CI, 0.124-0.791) or acute neonatal admission to NICU (OR 0.492, 95% CI, 0.324-0.747) compared to babies of women of similar risk status, born in the TMH.

Conclusion: Low-risk women birthing in PMUs in South Auckland, New Zealand, experienced a significant reduction in morbidity for themselves and their babies.

Keywords: place of birth, primary birthing unit, tertiary maternity hospital, caesarean section, neonatal morbidity, maternal morbidity, transfer rates

INTRODUCTION

In Aotearoa New Zealand (NZ) there are currently 54 freestanding primary level midwife-led maternity units (PMUs) either owned by a District Health Board (DHB) or by non-government organisations (Ministry of Health, 2017). These PMUs offer birthing and postnatal facilities. There are also 18 secondary-level and six tertiary-level obstetric-led maternity hospitals (TMHs) that have specialist obstetric, midwifery, anaesthetic and paediatric services on site (Ministry of Health, 2017). Women in NZ can choose where to give birth. Low-risk women have the options of giving birth in their own home, or in a primary, secondary or tertiary maternity facility. However, access is often an issue as most PMUs are rurally located and many towns and cities with secondary level hospitals have no PMU option. All PMUs, whether private or public, receive government funding for maternity service provision. Self-employed, government funded, Lead Maternity Carer (LMC) midwives provide continuity of care to women irrespective of planned or actual birthplace (Ministry of Health, 2007). This includes intrapartum care in the woman's chosen place of birth, with rostered midwives providing midwifery services in the facilities or in the hospital. It is possible for a private obstetrician to provide primary maternity care as an LMC (at an additional cost to the woman) but if women choose a private obstetrician, a PMU is no longer a birthplace option. At the time of data collection, midwives were the LMC for 93.6% of women nationally (Ministry of Health, 2015) and for all of the participants in this study. Private obstetric care for low-risk women is rare in this low-decile region (accounting for only 0.6% of the low-risk births) and is therefore not included in the analysis. The midwives in this study continued as the primary caregiver whether the woman remained in the PMU or was transferred to the TMH for specialist consultation. Accordingly, differences in outcomes presented relate to birthplace independently of model of care.

BACKGROUND

Despite the number of primary units available in NZ, the proportion of women choosing to birth in a primary unit has been reducing from 15.6% in 2007 (Ministry of Health, 2015) to 9.9% in 2015 (Ministry of Health, 2017). "Safety" is the principle consideration in women's birthplace decision-making, but the way safety is understood differs according to birthplace choice (Grigg, Tracy, Daellenbach, Kensington, & Schmied, 2014). Women choosing the tertiary hospital setting consider access to specialist services/facilities (if needed) was the most important factor, whereas women planning a primary setting identified "closeness to home", "ease of access", the "atmosphere" of the unit and "avoidance of unnecessary intervention" as important (Grigg et al., 2014). The decreasing utilisation of PMUs may be related to the increase in the number of women experiencing intervention (such as induction of labour, labour augmentation, instrumental assisted birth and emergency caesarean section) across the country (Ministry of Health, 2017).

Undertaking a randomised controlled trial for place of birth is problematic due to the inability to blind participants and clinicians and the need to ensure the woman has informed choice. Hollowell et al. (2011) published a prospective cohort study of women (n=64,538) who gave birth between 2008 and 2010 in England. No significant differences were found in the adjusted odds ratios (AORs) of primary outcome (a composite of perinatal mortality and intrapartum related morbidities) for low-risk women who gave birth in a PMU compared with a TMH (AOR 1.22, 95% CI, 0.76-1.96). The researchers concluded that choice of birth place had no effect on perinatal outcomes. However, in the TMH, low-risk women experienced increased rates of intrapartum caesarean section (AOR 0.32, 95% CI, 0.24-0.42) and birth interventions such as augmentation (AOR 0.26, 95% CI, 0.20-0.33), epidural (AOR 0.25, 95% CI, 0.2-0.31), episiotomy (AOR 0.33, 95% CI, 0.28-0.39), transfusion (AOR 0.48, 95% CI, 0.32-0.73), admission to higher level care (AOR 0.32, 95% CI, 0.13-0.84), and third or fourth degree perineal trauma (AOR 0.78, 95% CI, 0.58-1.05). Another component of this research involved a cost analysis which showed that the use of community-based birthing options is less expensive than hospital-based services (Schroeder et al., 2012).

Further prospective, retrospective and population based studies from Denmark (Overgaard, Møller, Fenger-Grøn, Knudsen, & Sandall, 2011), the Netherlands (Wiegerinck et al., 2015), Australia (Homer et al., 2014; Laws, Tracy, & Sullivan, 2010; Monk, Tracy, Foureur, Grigg, & Tracy, 2014), United States of America (Stapleton, Osborne, & Illuzzi, 2013) and NZ (Bailey, 2017; Davis et al., 2011; Grigg et al., 2017) reported significantly fewer obstetric interventions (such as instrumental birth, emergency caesarean section, labour augmentation, episiotomy) for mothers and no difference in neonatal mortality and morbidity for babies, when choosing midwifery-led settings (home and PMU) over obstetric-led hospitals. In contrast, population-based studies from the USA report higher neonatal mortality for babies born at home (Grünebaum et al., 2014; Wax et al., 2010) and a higher prevalence of Apgars of 0 at 5-min and neurological dysfunction in babies born at home or at a PMU (Grünebaum et al., 2014) compared to births at a TMH. Arguably, the lack of an infrastructure supportive of midwifery and midwife-led, free-standing maternity units in America may explain these findings.

The study region, Counties Manukau (CM), forms one of the largest providers of birthing services within Australasia; 14% of all births in NZ are to women residing in this DHB (Jackson, 2011). It has one of the fastest growing populations in NZ with an annual growth rate of 1-2% (Counties Manukau Health, 2016). CM has the second highest number of Māori (after Waikato), the highest number of Pasifika, and the second highest number of Asian people (after Auckland DHB) with a comparatively high birth rate (Winnard, Lee, & Macleod, 2015). Of the approximate 8,500 babies born per year in the region, over 50% are born to Māori or Pasifika mothers (24% and 32% respectively in 2007-2009; Statistics New Zealand, 2018) and more than half of the birthing population for this region resides in the lowest two (9, 10) socio-economic deciles (Counties Manukau Health, 2016).

Counties Manukau District Health Board (CMH) operates a tertiary (full neonatal service) hospital as well as three PMUs. About one-third of all the low-risk women that give birth in this region use one of the three PMUs (Farry, 2015), each of which is located within a 12-40km radius of the TMH. The remaining low-risk births occur at the TMH. Midwives take primary professional responsibility for women with low-risk pregnancies during labour and birth in both the PMU and TMH unit types (Rowe, 2011; Table 1). At the time of data collection, this DHB had lower rates of LMC (community-based or self-employed) midwifery care than other regions, with the DHB providing midwifery primary maternity services (employed or core midwives) for one third of the women (Farry, 2015). To access specialist obstetric or neonatal care from a PMU, the woman or woman and baby transfer (usually via an ambulance) to the TMH with their midwife. All maternity care is fully funded for NZ residents.

Our study's hypotheses

After controlling for age, ethnicity, body mass index (BMI), parity, smoking status, and socio-economic decile, low-risk women giving birth at a PMU will have similar rates of caesarean section, blood loss and maternal postpartum admission to theatre compared with low-risk women giving birth in the TMH. Babies of low-risk women giving birth in a PMU will have similar Apgar scores at 5-minutes and a similar number of acute neonatal admissions to intensive care when compared with babies of low-risk women giving birth in the TMH.

The maternal and neonatal outcome measures in this study are: emergency caesarean section, postpartum haemorrhage (PPH; >500ml), acute maternal postpartum admissions to theatre/high dependency unit (HDU)/intensive care (ICU; within 12 hours of birth), low Apgar (5-min Apgar <7), and acute neonatal admissions to neonatal intensive care (NICU; within 12 hours of birth).

METHODS

This retrospective cohort study compares accurately captured clinical outcomes for well ("low-risk") women giving birth in a TMH with those for women giving birth in PMUs in South Auckland, over a 12-month period. Approval was gained from local DHB and National Health Ethics Committees (expedited review number NTX/12/EXP/078). Data extraction was provided by the region's DHB data managers.

The combined birthing facilities (one TMH and three PMUs) reported 8,063 babies born during the study period. To be defined as low-risk, the woman's pregnancy was at term (37-42 weeks gestation); it was a singleton pregnancy and a cephalic presentation. Exclusion criteria were: women who had had multiple births, had been admitted to hospital during pregnancy or in labour with one or more secondary diagnostic code/s (Table 2), were induced, were >44 years old at time of birth or ≥40 years and nulliparous at time of birth, had a BMI >40kg/m^2 at the time of booking, or who had booked ≤13 days before birth (Figure 1).

Table 1. Place of birth definitions adapted from Rowe (2011)

Term	Definition	Birthplace terms used internationally
Freestanding primary level midwife-led maternity unit (PMU)	A clinical location offering care to women with straightforward pregnancies during labour and birth, with midwives taking primary professional responsibility for care. General practitioners may also be involved in care. During labour and birth, diagnostic and treatment medical services (obstetric, neonatal and anaesthetic) are not immediately available but are located on a separate site if required. Transfer will normally involve a car or ambulance.	Primary unit (NZ) Metropolitan stand-alone primary childbirth unit (Australia) Birth centre (USA)
Tertiary- level obstetric-led maternity hospital (TMH)	Care is provided by a team with obstetricians taking primary responsibility for women at high risk of complications during labour and birth. Midwives offer care to all women (high and low risk) in a TMH and take primary responsibility for women with straightforward pregnancies during labour and birth. Diagnostic and treatment medical services (obstetric, neonatal and anaesthetic) are available on site 24 hours a day.	Tertiary hospital (NZ) Conventional delivery ward (Norway) Hospital labour ward (Australia) Standard care unit (China) Standard delivery ward (Sweden)

Table 2. Diagnostic codes indicating secondary care in pregnancy

Diagnostic code*	*n*
Maternal care due to uterine scar from previous surgery	639
Premature rupture of membranes, onset of labour between 1-7 days later	369
Preterm spontaneous labour with preterm delivery	340
Duration of pregnancy 34-36 completed weeks	339
Maternal care for poor fetal growth	337
Vaginal delivery following previous caesarean section	297
Other specified diseases and conditions complicating pregnancy, childbirth and the puerperium	246
Supervision of pregnancy with other poor reproductive or obstetric history	218
Pre-eclampsia, unspecified	190
Maternal care for excessive fetal growth	189
Oligohydramnios	161
Preterm delivery without spontaneous labour	159
Antepartum haemorrhage, unspecified	139
Diabetes mellitus arising during pregnancy, insulin treated	132
Maternal care for breech presentation	125
Duration of pregnancy 26-33 completed weeks	124
Diabetes mellitus arising during pregnancy, oral hypoglycaemic therapy	122
Gestational (pregnancy-induced) hypertension without significant proteinuria	110
Maternal care for other specified fetal problems	101
Diabetes mellitus arising during pregnancy, other	92
Endocrine, nutritional and metabolic diseases complicating pregnancy, childbirth and the puerperium	82
Diseases of the digestive system complicating pregnancy, childbirth and the puerperium	70
Anaemia complicating childbirth and the puerperium	69
Prophylactic immunotherapy	62
Polyhydramnios	53
Mental disorders & diseases of the nervous system complicating pregnancy, childbirth and the puerperium	44
Other diagnostic codes e.g. rhesus isoimmunisation, thrombocytopenia, cervicalgia	398
Total number of secondary diagnoses	**5,207**
Total number of women excluded	**3,403**

* Diagnostic codes are not mutually exclusive, a total of 3,403 women were excluded for one or more of the above 5,207 secondary diagnoses

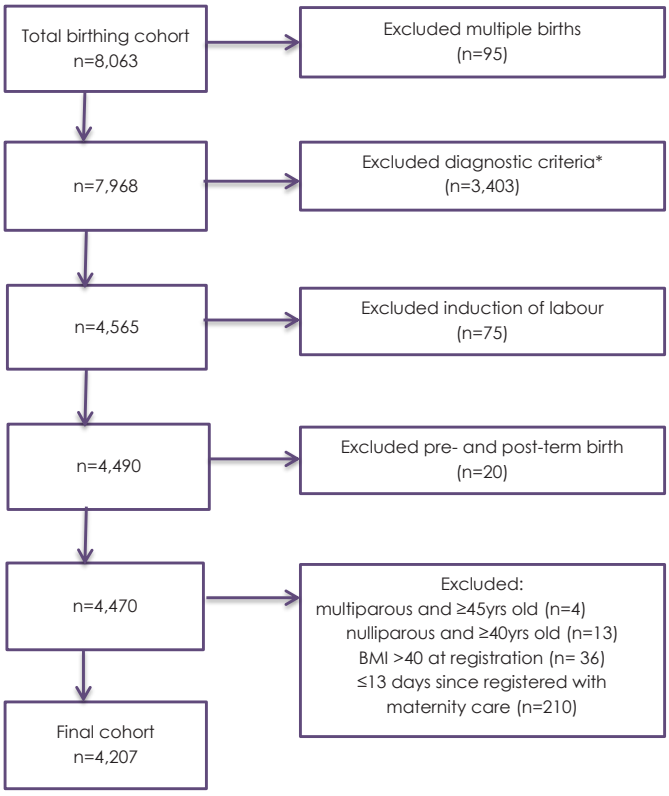
Women's risk status can change at any stage and their risk status on admission in labour is unknown. This fact is acknowledged as a limitation in this study.

Data Extraction

Data were collated from two DHB databases. The first was a local DHB clinical dataset entered in retrospect by non-clinical staff from contemporaneous handwritten records made by clinical staff. The second was a national patient management database updated digitally by non-clinical staff in real time and primarily used for resource allocation.

The integrity and reliability of the data were checked through comparison of the codes applied to each woman's clinical records and actual records by a clinician for a subgroup of 250 women.

The accuracy of each field was measured using the proportion of records for which the database entry matched the clinical notes. Agresti-Coull confidence intervals (CI) of 95% (Agresti & Coull, 1998; Brown, Cai, & DasGupta, 2001) were used. The study was powered to produce a 95 % CI of width no more than 10% under the assumption that the proportion of correct records was 80%. Fields were deemed sufficiently accurate for use if the lower limit of the CI for the proportion of records correct was at 85). If



* See Table 2

Figure 1. Flow chart inclusion/exclusion criteria to identify low risk women

this accuracy was not met, the required information was obtained from the second data source – the national patient management database. Accuracy of this database is likely to be high because it informs contemporaneous availability of beds and is a record of DHB acuity for resource management.

Of the 24 fields captured (Figure 2), five were excluded as the lower limit of the CI for the proportion of records correct was less than 85% (Table 3). Unfortunately, "Intended Place of Birth" could not be determined as women's intentions were not accurately recorded in the local database. This could have offered some insight into women's planned, compared with actual, place of birth. "Birth Site", however, was accurate and used to determine "Place of Birth". "Booking Gestation" was made accurate by subtracting the "Date of Booking" from the "EDB" (Expected Date of Birth) both 90% accurate data fields in the local database. In this way women who were booked into the Healthware database with <13 days left in their pregnancy could be excluded from the cohort as they no longer satisfied the low-risk criteria. This may have erroneously excluded women who were, in fact, "booked" with an LMC in a timely manner and therefore receiving antenatal care, but not booked into the Healthware database by their LMC midwife until their labour was imminent. "Location Changed" and "Changed Reason" were both inaccurate and were replaced by "Transfer Time" and "Transfer Destination" from the patient management database. This information along with "DOB Including Time" allowed intrapartum transfers to be differentiated from postpartum transfers. The data "Acute Maternal Postpartum Admission" and "Neonatal Admission" were also sourced from the national patient management database. Unfortunately, "Third Stage Procedures" did not reach the accuracy criterion and this information was not captured elsewhere, precluding this study from any deeper analysis of differences in third stage management between the sites.

Table 3: Percentage accuracy including 95% CI for 24 variables in national database

National data field	% Accuracy (95% CI)	Accurate, or inaccurate*
Patient details		
Maternal age	97 (0.95, 0.99)	accurate
Ethnicity	93 (0.89, 0.96)	accurate
Suburb	94 (0.92, 0.97)	accurate
Pregnancy details		
LMP date	97 (0.95, 0.99)	accurate
EDB best	98 (0.96, 0.99)	accurate
Gravida	97 (0.95, 0.99)	accurate
Parity	91 (0.88, 0.95)	accurate
Antenatal booking		
Smoking status	91 (0.88, 0.95)	accurate
Booking date	89 (0.86, 0.93)	accurate
Intended place of birth	28 (0.23, 0.34)	inaccurate
Booking gestation	1 (0, 0.02)	inaccurate
Maternal height	97 (0.95, 0.99)	accurate
Maternal weight	95 (0.93, 0.98)	accurate
Labour and birth (mother)		
Birth date	99 (0.98, 1)	accurate
Birth method	97 (0.95, 0.99)	accurate
Location changed	13 (0.09, 0.17)	inaccurate
Changed reason	22 (0.17, 0.27)	inaccurate
Labour and birth (baby)		
DOB (including time)	99 (0.98, 1)	accurate
Birth place	98 (0.96, 0.99)	accurate
Birth outcome	99 (0.98, 1)	accurate
Labour and birth 3rd stage		
Estimated blood loss	98 (0.96, 0.99)	accurate
Third stage procedures	87 (0.83, 0.91)	inaccurate
Baby birth examination		
Apgar 1 min	96 (0.94, 0.98)	accurate
Apgar 5 min	97 (0.95, 0.99)	accurate

* Accurate (lower limit of CI above 85%); inaccurate (upper limit of CI below 85%)

Data Analysis

The inferential statistical analysis was conducted using IBM SPSS version 22.0 using the protocols described by Field (2013) and Pallant (2013). Frequencies were used to describe the characteristics of all eligible healthy women with low-risk pregnancies (n=4,207). Proportions and Pearson's chi-squared tests were used to explore the associations at $p<0.05$ between cross-tabulated variables. Six covariates (parity, smoking status, ethnicity, BMI, socio-economic decile, age) were identified a priori based on their suspected influence on the maternal and neonatal dependent variables (emergency caesarean section, PPH, admission to HDU/ICU/theatre, low Apgar, admission to NICU). These dependent variables were prepared for binary logistic regression by coding all data to dichotomous as per Bagley, White and Golomb (2001). ORs with 95% CIs were calculated for the five perinatal outcomes and shown as unadjusted and adjusted for confounders.

RESULTS

Demographics

Fifty-two percent (n=4,207) of total births in the region during the study period (n=8,063) met the inclusion criteria. Of the 4,207

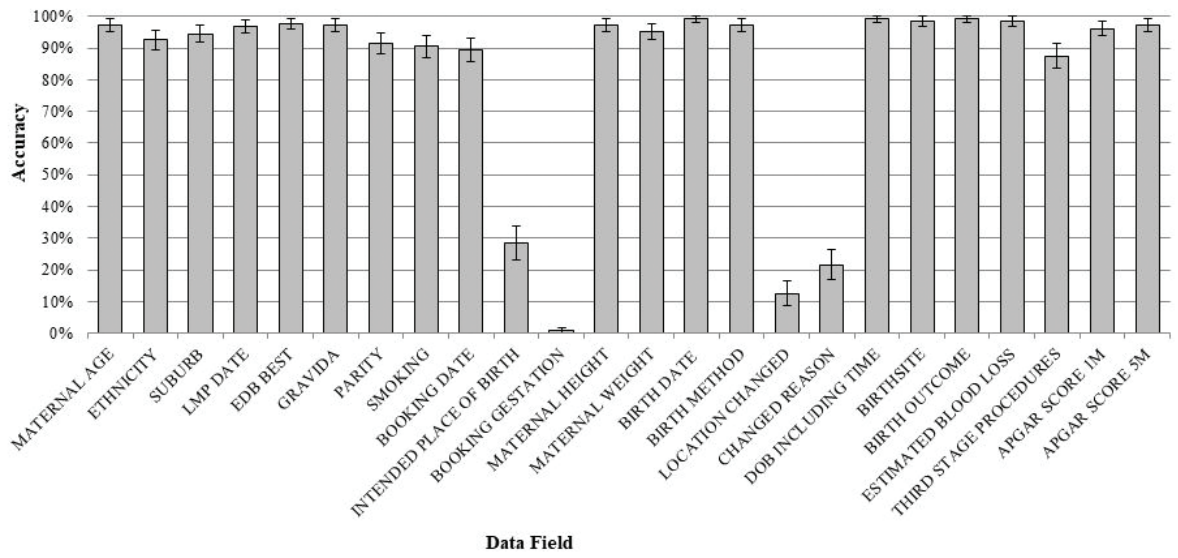


Figure 2. Accuracy assessment of the data fields

women who met the inclusion criteria, 26.5% (n=1,114) gave birth at a PMU and 73.5% (n=3,093) at the TMH. Thirty-nine percent (n=1,206) of those birthing at the TMH were nulliparous, compared to 29% (n=323) of those birthing at a PMU.

The transfer rate from the three PMUs to the TMH was 6.7% for intrapartum (n=75) and 2.6% for immediate (<12h) postpartum women (n=29), making a total transfer rate of 9.3%. There was a statistically significant difference $x^2(3, n=75) = 65.55$, p<.001 between the intrapartum transfer rate of nulliparous women 18% (n=52) compared to multiparous women 3% (n=23). Postpartum transfers were similar between the two groups.

The maternal age, smoking status and parity profile of the PMU and TMH populations was similar. Women giving birth in the PMU were predominantly NZ European (n=421) and Māori (the indigenous people of NZ; n=359), 70% combined; in contrast to the TMH which had a higher proportion of women identifying as Pacific (n=1,348) and Asian (n=509), 60% combined. Women giving birth at one of the PMUs were less likely to have a BMI >35 or be economically deprived. The frequency distributions of the cohort characteristics by Place of Birth are listed in Table 4.

Statistically significant interactions were identified between Place of Birth and the covariates: parity, smoking status, ethnicity, BMI, socio-economic decile, and maternal age. These confounders were adjusted for in the subsequent logistic regression analyses.

Place of Birth

The three maternal (emergency caesarean section, PPH, and acute maternal postpartum admissions) and two neonatal (Apgar and acute neonatal admission) outcomes held statistically significant associations with Place of Birth. The unadjusted and adjusted Odds Ratios (ORs) are shown in Table 5. Low-risk women giving birth at a PMU have one quarter the odds of an emergency caesarean section (aOR 0.224, 95% CI, 0.157-0.339), half the odds of experiencing a PPH (aOR 0.536, 95% CI, 0.424-0.676), and one fifth the odds of being acutely admitted after birth (aOR 0.201, 95% CI, 0.102-0.398) when compared to women birthing in the TMH. Babies of low-risk women giving birth in a PMU have one third the odds of receiving a low Apgar (aOR 0.354, 95% CI, 0.135-0.926) and, correspondingly, have half the odds of being admitted to NICU (aOR 0.571, 95% CI, 0.362-0.902), when compared to babies of low-risk women giving birth in the TMH.

Table 4. Frequency distributions of the cohort covariates for place of birth

Covariate[a]	Place of Birth	PMU n	PMU %	TMH n	TMH %	Pearson's Chi-Square
Parity[b]	Multiparous	753	67.6	1,883	60.9	n=4,207, 15.783 p<0.001
	Nulliparous	361	32.4	1,210	39.1	
	Total	1,114	100.0	3,093	100.0	
Smoking[b]	Yes	207	18.6	486	15.7	n=4,207, 4.899 p=0.027
	No	907	81.4	2,607	84.3	
	Total	1,114	100.0	3,093	100.0	
Ethnicity[b]	Māori	359	32.3	640	20.8	n=4,191, 502.423 p<0.001
	NZ European	421	38.0	457	14.8	
	Pacific	144	13.0	1,348	43.7	
	Asian	113	10.2	509	16.5	
	Other	72	6.5	128	4.1	
	Total	1,109	100.0	3,082	100.0	
BMI[b]	<18	18	1.8	32	1.1	n=3,875, 50.116 p<0.001
	18-24	406	39.8	999	35.0	
	25-29	328	32.1	787	27.6	
	30-34	188	18.4	596	20.9	
	35-40	79	7.8	442	15.4	
	Total	1,019	100.0	2,856	100.0	
Socio-economic decile[b,c]	1-5	368	35.7	487	16.5	n=3,970, 223.550 p<0.001
	6-10	664	64.3	2,451	83.4	
	Total	1,032	100.0	2,938	100.0	
Age[b]	15-24	364	32.6	1,277	41.2	n=4,207, 20.328 p<0.001
	25-34	600	53.9	1,477	47.7	
	35-44[d]	150	13.5	339	11.0	
	Total	1,114	100.0	3,093	100.0	
Model of Care	DHB	397	35.7	1,172	38.0	n=4,198, 1.810 p=0.179
	LMC	715	64.3	1,914	62.0	
	Total	1,112	100.0	3,086	100.0	

[a] n differs for some confounders due to missing data in the original data set

[b] Confounding covariates adjusted for in the logistic regressions presented in Table 5

[c] The higher the decile, the greater the socio-economic deprivation

[d] Only multiparous women were included >40 years of age

Table 5. Effect of place of birth on maternal and neonatal outcomes. Descriptive statistics are listed as n (%) and OR (unadjusted and adjusted) are provided.

Outcome	Occurrence	Place of birth n (%)		Unadjusted[a,b] OR (95% CI)	Adjusted[b] OR (95% CI)
		PMU	TMH		
Maternal					
Emergency caesarean section	No[c]	1,092 (98.2)	2,856 (92.5)	0.224 (0.141-0.356)	0.250 (0.157-0.339)
	Yes	20 (1.8)	233 (7.5)		
Postpartum haemorrhage	No	1,007 (92.2%)	2,481 (87.0%)	0.489 (0.389-0.615)	0.536 (0.424-0.676)
	Yes	85 (7.8%)	371 (13.0%)		
Acute postpartum admission to HDU/ICU/theatre	No	1,105 (99.2%)	2,967 (95.9%)	0.192 (0.097-0.378)	0.201 (0.102-0.398)
	Yes	9 (0.8%)	126 (4.1%)		
Neonatal					
Low Apgar <7 at 5 min	No	1,106 (99.5%)	3,032 (98.5%)	0.298 (0.118-0.752)	0.354 (0.135-0.926)
	Yes	5 (0.5%)	46 (1.5%)		
Neonatal admission to NICU	No	1,087 (97.6%)	2,940 (95.1%)	0.477 (0.315-0.723)	0.571 (0.362-0.902)
	Yes	27 (2.4%)	150 (4.9%)		

a All results were statistically significant at p<0.001

b Adjusted for parity, smoking status, ethnicity, BMI, socio-economic decile, and age, as per Table 4

c This outcome describes vaginal birth inclusive of instrumental birth

When the number of women who required a caesarean section (n=253) was removed from the cohort, the proportion of women experiencing a PPH in the TMH was still statistically significantly higher than the proportion of those who had a PPH and whose Place of Birth was a PMU (OR 0.692, 95% CI, 0.534-0.898). In addition, the non-caesarean section babies born in the TMH remained more likely to be admitted to NICU (OR 0.168, 95% CI, 0.082-0.345).

There were no incidences of maternal or neonatal mortality reported in either cohort.

DISCUSSION

This study found that women giving birth in a freestanding PMU had more favourable clinical outcomes when compared with women giving birth in a TMH. The findings identify statistically significant differences in outcomes dependent on the place of birth, with women giving birth in a freestanding PMU having lower odds of emergency caesarean section, PPH, and acute maternal postpartum admissions to theatre/HDU/ICU, and their babies having lower odds of an Apgar <7 at 5 minutes and of acute neonatal admission to NICU. The associations remained significant after adjustment for known confounding factors (age, ethnicity, decile, BMI, smoking status and parity). For low-risk women giving birth at the TMH, the odds of an emergency caesarean section were four times the odds of women birthing at the PMUs, and the odds of acute maternal postpartum admission to theatre/HDU/ICU were five times the odds of women birthing at the PMUs. This latter finding may reflect the morbidity associated with caesarean (Gregory, Jackson, Korst, & Fridman, 2012) and the increase in prevalence of epidural, episiotomy, and forceps, leading to a higher rate of third and fourth degree tears (Fitzgerald et al., 2007) in the TMH.

The number of women experiencing a PPH was found to be significantly less for PMU births compared with TMH births. This differs from the results in a study undertaken by Davis et al. (2011) which compared outcomes for place of birth. In their study the place of birth was not found to have a significant effect on maternal blood loss. However, their study defined women experiencing a PPH as having a blood loss >1,000ml which they argued to be a clearer indication of morbidity. In our study, a blood loss of more than 500ml was the measure identified to determine PPH. This was because Conner et al. (2015) found that the thresholds most predictive of a clinically significant estimated blood loss were confirmed to be 500ml in a vaginal birth and 1,000ml in a caesarean section, with the median recorded blood loss resulting from a caesarean section being 500ml. To determine if PPH was an interaction of the increased number of emergency caesarean sections observed, we undertook a subgroup analysis in which women whose labours resulted in an emergency caesarean section were removed. We found that the incidence of PPH remained significantly lower when women gave birth at a PMU. Oxytocin augmentation during labour has been shown to increase the risk of PPH (Belghiti et al., 2011; Combs, Murphy, & Laros, 1991; Grotegut, Paglia, Johnson, Thames, & James, 2011; Sheiner, Sarid, Levy, Seidman, & Hallak, 2005; Waterstone, Bewley, & Wolfe, 2001), perhaps by desensitising receptors (Phaneuf et al., 1998; Robinson, Schumann, Zhang, & Young, 2003), thereby impairing oxytocin's post-delivery effects on uterine contractility and increasing the risk of atonic PPH (Magalhaes et al., 2009). Oxytocin augmentation does not occur at PMUs and this may explain the difference in blood loss between the two sites.

The higher rate of neonatal admission of babies of women birthing in the TMH in this study was in agreement with the large Birthplace in England study (Hollowell et al., 2011), two Australian studies (Laws et al., 2010; Monk et al., 2014) and two previous NZ studies (Bailey, 2017; Davis et al., 2011). These findings indicate that routine hospital birth is not safer for babies of low-risk mothers. The higher number of NICU admissions, in the cohort excluding caesarean section, remained significant for women birthing vaginally at the TMH. This agrees with Laws et al. (2010) and Davis et al. (2011), where increased rate of admission to NICU was associated with labour interventions and assisted modes of birth in the TMH settings they studied.

There is no equivalent low-risk national dataset with which to compare and identify the generalisability of our study sample. The demographic findings demonstrate that our sample held

similarities to national maternity data (Ministry of Health, 2017). Age, nulliparity, smoking status, and ethnicity (NZ Māori, Asian and Other) were all within 1-2% of the national/regional maternity data. The proportion of women identifying themselves as NZ European was higher in the national maternity data (48%), than in the current study cohort (20.9%). The proportion of women identifying themselves as Pacific was lower in the National Maternity data (11.2%) than the current study cohort (35.5%). Socio-economic decile is comparable between this study's use of "deprivation decile" and the nationally gathered data reported as "deprivation quintile" according to Atkinson, Salmond and Crampton (2014). The National Report on Maternity (2015) states that 29.8% of NZ birthing women reside in quintile 5 (the lowest quintile in NZ). This study reports 54.2% of the cohort reside in decile 9, 10 (the lowest two deciles). It is possible to conclude that this cohort is more deprived than the national average. The most recent annual report to the National Maternity Quality and Safety Programme also revealed that more than half of the entire Counties Manukau birthing population for this region resides in the lowest two (9, 10) socio-economic deciles (Counties Manukau Health, 2016).

Rates of transfer

The intrapartum and immediate postpartum (within 12 hours of birth) transfer rate was 9.3% (n=104), lower than the 19% (n=6002), 21.9% (n=2,468) and 17.3% (n=70) reported by Bailey (2017), Hollowell et al. (2011) and Grigg et al. (2017), respectively. However, these studies either included maternal and neonatal transfers up to 48 hours (Grigg et al., 2017) or did not define the timeframe (Bailey, 2017; Hollowell et al., 2011). Sixty-nine percent of the transfers were primigravid women. This rate sits between that found by the other two NZ studies which reported a transfer rate of primigravid women of 96.3% (Grigg, Tracy, Tracy, Schmied, & Monk, 2015) and 39% (Bailey, 2017). The latter study may be more relevant as the data are from the same region. However, it may be that the accuracy of manual calculation of data sourced through the national patient management database reveals a more accurate picture of intrapartum transfer. The source of transfer data is not reported by Bailey (2017). The accuracy assessment carried out in this study would suggest that if Healthware data were used they would provide inaccurate figures.

Our study adds to the body of evidence demonstrating that when women give birth in a PMU they have less intervention than when they birth in a TMH. Despite these findings the majority of women continue to choose to birth in a TMH. The notion of informed choice is one of the guiding principles of the midwife-woman partnership in NZ (New Zealand College of Midwives, 2015). Informed choice means that through discussion, education and the sharing of evidence, a woman is able to decide what best serves her needs. To reduce (or at least stabilise) the continually rising rate of caesarean sections, this research suggests that the option of giving birth in a PMU needs to be actively discussed, disseminated and promoted to low-risk women and their support people.

A recent study which surveyed women's wishes around place of birth in Christchurch, NZ, found that perceived risk strongly influenced the woman's decision to birth in a TMH, while a combination of proximity, comfort and avoidance of intervention strongly influenced the woman's decision to birth in a PMU (Grigg et al., 2014). Further research is needed to explore the perception of safety and place of birth as barriers to women choosing a PMU.

In addition to ensuring information is shared with women, there is a need to consider the role of the clinician in decision making. Davis and Homer (2016) recently explored why some midwives use different birthing environments and found "that the culture of the birthplace rather than the physicality is the highest priority" (p.414). It has been suggested that TMHs are structured and function in ways that make childbearing women and midwives change their behaviour. This behaviour difference, termed submissiveness by Fahy and Parratt (2006), is theorised to weaken autonomy for both childbearing women and midwives. Previous NZ research has shown the influence of organisational context on practice (Davis & Walker, 2010; Miller & Skinner, 2012). This is an important issue to consider when looking to support midwives to work in PMUs. Midwives have concerns related to their own professional safety and support needs. The United Kingdom has incorporated changes in their intrapartum care guidelines (National Institute for Health and Clinical Excellence (NICE), 2014) advising health practitioners to offer birth at midwifery-led units to low-risk women. This formal requirement provides implied support for the practitioner to practise in PMUs; however, for midwives who have mostly practised in TMHs, moving to a PMU could be considered challenging. Women, and perhaps midwives, make their choices based on their personal perception of safety and therefore changing these perceptions may be difficult. More research is needed to identify what support structures are needed both for women to utilise, and midwives to facilitate birth in, PMUs.

It may not be advisable to extrapolate these findings to other regions. The freestanding PMUs in this study were relatively busy, with on site midwives present at all times and located within 45 minutes by road from the TMH. Some NZ PMUs are several hours from the hospital and not all have midwives present at all times. Most pregnant women in NZ are under the care of self-employed midwives who have continuous access to obstetric services, facilitating safe and timely consultation and transfer. This requires a strong midwifery infrastructure that may be lacking in other countries.

Strengths and limitations

This study was undertaken in an area of high deprivation, which is associated with poorer outcomes, yet the findings support PMUs as being safer than the TMH for this population. This study involved a rigorous accuracy assessment process which helped to identify and determine the most robust data fields for analysis. In addition, the comprehensive inclusion/exclusion criteria identified a sample of low-risk women. However, only risk factors requiring hospitalisation were captured by the diagnostic codes and therefore there may have been some higher risk women (being managed as outpatients) who were included, leading to potential sample bias. Apart from women's antenatal risk, women's risk status on admission in labour cannot be identified, and this absence of information constitutes another potential source of sample bias. Women with meconium liquor, Group B Strep, fetal heart rate abnormality on home assessment, maternal fever, or long latent phase needing analgesia have all been found to be reasons for a change of plan prior to admission in labour (Grigg, Tracy, Schmied, Monk, & Tracy, 2015). These women would all be admitted to the TMH and their higher risk status would not be identified by the exclusion criteria we used. Another limitation is that the size of the cohort was insufficient to detect rare and severe outcomes in either setting (as there were none). In addition, women's choice is paramount in our model of maternity care and this may have led to differences in philosophy, values and beliefs which also could have had an effect on where women chose to give birth. It is difficult to identify this construct or determine its effect.

CONCLUSIONS

This research found evidence for increased risk of adverse outcomes for low-risk births at an obstetric-led tertiary level maternity hospital (TMH) compared to freestanding primary level midwife-led maternity units (PMUs) in South Auckland, NZ. This research adds to the growing body of international research on freestanding PMUs, confirming them as physically safe places for well women to give birth when midwifery is properly integrated into the maternity system, allowing for the provision of continuity of care across sites and timely referral. The task now is to protect the unique relationship between the TMH and the PMUs of South Auckland and to promote similar models across the country and around the world. This can be achieved by healthcare policy makers and maternity care providers publicly acknowledging the benefits PMUs provide childbearing women and their families. Dissemination and advocation of the findings from this research, along with similar national and international primary maternity unit birthplace literature, are highly recommended.

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