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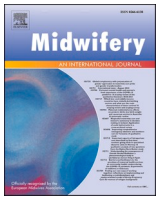

Changes in maternal characteristics and risk of perinatal death among babies born to Aboriginal and/or Torres Strait Islander women in Victoria, Australia: a retrospective cohort study

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ABSTRACT

Problem/Background: The long-standing disproportionate risk of perinatal death for babies born to Aboriginal and/or Torres Strait Islander women reduced in Victoria, Australia from 2008–2016. Identifying the contributing factors to this improvement is crucial to ensuring implementation of effective strategies to continue closing this gap.
Aim: To explore whether changes in key characteristics among Victorian Aboriginal and/or Torres Strait Islander women contributed to reduced perinatal death rates.
Methods: Retrospective population-based cohort study of all births in Victoria from 2000–2019. We calculated relative risk ratios with 95% confidence intervals to determine relationships between maternal characteristics and perinatal death. We performed univariate and multivariate logistic regression to obtain unadjusted and adjusted odds ratios for perinatal death based on maternal Aboriginal and/or Torres Strait Islander status.
Findings: Between 2000–2019 the number of births to Aboriginal and/or Torres Strait Islander women increased and perinatal death rates decreased from 19.7/1000 births to 10.6 /1000 births. Some risk factors for perinatal death, including age younger than 20 years and rural residence, decreased in Aboriginal and/or Torres Strait Islander women between 2000 and 2019, from 19.4% to 8.1% and 67.5% to 55.3% respectively (both p-trend<0.001). Other risk factors for perinatal death stagnated or increased including Body Mass Index ≥35, maternal smoking and low socio-economic status.
Conclusion: Changes in key maternal characteristics may have contributed to improved perinatal death rates among babies of Victorian Aboriginal and/or Torres Strait Islander women. However, these are unlikely to fully explain observed improvements and several stagnant/increasing risk factors may have hindered further improvements.

Statement of significance

Problem/Issue	Babies of Aboriginal and/or Torres Strait Islander women are at disproportionate risk of perinatal death.
What is Already Known	Perinatal death rates for babies born to Aboriginal and/or Torres Strait Islander women reduced in Victoria, Australia from 2008–2016. Potential drivers include efficacy of targeted maternity services and programs, and changes in socio-

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What this Paper Adds	demographic risk factors for perinatal death within the Aboriginal and/or Torres Strait Islander maternal population. Evidence of the role socio-demographic factors play in perinatal outcomes. This informs development of targeted strategies to improve Aboriginal and/or Torres Strait Islander perinatal outcomes.

Background

Babies of Aboriginal and/or Torres Strait Islander women are at disproportionate risk of perinatal death (PND) compared with those of non-Indigenous women (Australian Institute of Health and Welfare 2020, Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021).

National data trends showed little improvement in PND experienced by the overall population between 2001 and 2019 and by Aboriginal and/or Torres Strait Islander women since 2013 (Australian Institute of Health and Welfare 2023). An encouraging decline was seen in Aboriginal and/or Torres Strait Islander PND rates, from 23.1/1000 births in 2001–2003 to 12.6/1000 births in 2017–2019 (Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021) with an apparent equalisation with non-Indigenous PND rates at 9.0/1000 births in the 2014–2016 triennium. This was followed by a clear, though less extreme, divergence of rates in the following triennia (Consultative Council on Obstetric and Paediatric Mortality and Morbidity, 2023).

Despite thorough exploration in consultation with Aboriginal and/or Torres Strait Islander healthcare workers and community leaders we were unable to determine any specific programs, systemic shifts or administrative changes in 2014–2016 that could explain the period of PND rate parity in Victoria. The reason(s) why the rate of Aboriginal and/or Torres Strait Islander PND improved so significantly in Victoria between 2008 and 2016 (Consultative Council on Obstetric and Paediatric Mortality and Morbidity. Victoria's Mothers, Babies and Children report 2016, 2018) are not entirely clear; however several possible and likely inter-connected explanations exist.

Resounding impacts of colonisation, persisting systemic discrimination and racism have been detrimental to the social, economic, cultural and spiritual well-being of many Aboriginal and/or Torres Strait Islander individuals and damaged their trust in authorities and crucial support systems. It is thus no surprise that, like many First Nations populations globally, they experience a greater burden of disease, lower life expectancy and greater social disadvantage (Australian Bureau of Statistics 2016; Australian Government, 2020; Mazel, 2018; Smylie et al., 2010). Given social disadvantage is one of the strongest risk factors for PND (Faulks et al., 2023) this very likely contributes to higher Aboriginal and/or Torres Strait Islander PND rates. Other risk factors for PND such as delayed engagement in antenatal care, smoking during pregnancy, obesity and maternal age younger than 20 (Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021; Ford et al., 2018, Gibberd et al., 2019; Lovett et al., 2017; Panaretto et al., 2006; Thrift and Callaway, 2014) are also influenced by this landscape of social inequity and consequently are more prevalent in Aboriginal and/or Torres Strait Islander women (Ford et al., 2018; Panaretto et al., 2006; Victorian State Government 2017; Wijs et al., 2017). This disparity in exposure to risk factors and access to care, combined with the known higher Aboriginal and/or Torres Strait Islander PND rates, suggests that the socio-economic, geographical and systemic disadvantages faced by this population strongly influence their health outcomes. Given this, there is potential for PND rates to be influenced by changes in the demographics of Aboriginal and/or Torres Strait Islander women.

The ongoing work towards The National Agreement on Closing the Gap targets may explain some PND reduction, specifically those that directly influence perinatal health, notably outcome 1, *people live long and happy lives* which encompasses a specific infant mortality measure, and outcome 2, *babies are born healthy and strong* (Australian Government Productivity commission 2024). Initiatives and actions arising from these targets including expansion of Victorian Aboriginal Community Controlled Health Organisation's (VACCHO) workforce and capabilities, and measures such as Happy Mums, Happy Bubs, aim to improve health outcomes for Aboriginal and/or Torres Strait Islander Australians and as such possess the potential to positively influence PND rates (Australian Government, 2024). Of particular pertinence is the important contribution of targeted and culturally safe maternity services such as the Koori Maternity Services (KMS), established in 2000. The KMS work to support VACCHOs in providing best practice, culturally safe and trauma informed care that is responsive to the individual needs of each woman (Victorian State Government 2017). Despite our inability to directly measure the impact of these services and initiatives in our study we recognise that given the proven impact of such programs on general population and more specifically Aboriginal and/or Torres Strait Islander perinatal outcomes (McLachlan et al., 2024), the presence of these services in Victorian urban areas over the study period may have influenced improved PND rates.

Additionally, these observations may have been influenced by data volatility and diversification within the small Victorian Aboriginal and/or Torres Strait Islander maternal population. The number of Victorians identifying as Aboriginal and/or Torres Strait Islander increased by 25.7 % between the 2011 to the 2016 national census (Australian Bureau of Statistics 2018). Moreover, the number of women giving birth in Victoria identifying as Aboriginal and/or Torres Strait Islander increased 3-fold from 2000–2018 (Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021). Notably the greatest proportion of Aboriginal and/or Torres Strait Islander population growth was seen in non-remote areas (Australian Bureau of Statistics 2018). Regional, remote and rural residents can face barriers to accessing healthcare, financial and education services, with these challenges amplified in geographically larger states than Victoria (Australian Institute of Health and Welfare 2018). The 2016 census outlined advancements in key welfare indicators for Aboriginal and/or Torres Strait Islander Victorians with increases in median weekly income, enrolment rates at all educational levels and professional employment (Australian Bureau of Statistics 2016).

It is possible that through enhanced proficiency of midwives and other health care providers asking and recording Aboriginal and/or Torres Strait Islander status (Australian Institute of Health and Welfare, 2010), expanding access to culturally safe maternity services (McLachlan et al., 2024; Victorian State Government 2017) and an interconnected increased perceived "safety" in self-identifying, a larger and more diverse group of Aboriginal and/or Torres Strait Islander Victorians was being identified. In the context of the connection between social disadvantage and PND, the demographic shift associated with this growth and diversification may also have contributed to explaining the PND trends in Victoria.

In this study we aimed to examine trends in Aboriginal and non-Indigenous PND rates from 2000 to 2019 and explore whether changes in key characteristics among Victorian Aboriginal and/or Torres Strait Islander women could have influenced observed improvements in their perinatal outcomes.

Participants, ethics and methods

This study was undertaken in collaboration with Aboriginal and/or Torres Strait Islander healthcare workers, community leaders and representatives from KMS. This was a retrospective population-based cohort study utilising data from the Victorian Perinatal Data Collection (VPDC) and the perinatal mortality database of the Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM). Legislation requires that details of all births in Victoria at 20 or more weeks' gestation (or with a birthweight of at least 400 g if gestation is not known) are reported to VPDC, and that a detailed report

of all stillbirths and neonatal deaths is submitted to CCOPMM for review and classification of cause of death. Perinatal data are collected by attending midwives and detailed mortality data are collected by attending medical practitioners. The accuracy of the VPDC has been shown to be excellent on most variables (Flood et al., 2017). We assessed all births reported to the VPDC in Victoria from 2000 to 2019. Babies with birthweight less than 150 *g* (e.g. fetus papyraceus) and terminations of pregnancy were excluded. A deidentified dataset was provided for this research.

The primary exposure characteristic of interest was self-reported maternal Aboriginal and/or Torres Strait Islander status, analysed through a binary variable of Aboriginal and/or Torres Strait Islander (Aboriginal, Torres Strait Islander or both) and non-Indigenous. Characteristics and outcomes for babies born to Aboriginal and/or Torres Strait Islander women were compared with those born to non-Indigenous women. The Aboriginal status of the baby was not collected prior to 2009, so Aboriginal babies who have a non-Indigenous mother are included here in the comparison group - babies of non-Indigenous women. Other maternal characteristics of interest were those known to be associated with PND. Maternal residential location was geocoded to provide a precise latitude and longitude, then dichotomised into rural or metropolitan. The geocoding allocated women's addresses to Australian Bureau of Statistics SA1 areas. SA1 defines geographical areas with average populations of 400 and assesses multiple characteristics to calculate the average SES of residents to determine the Index of Relative Social Disadvantage (IRSD). Maternal socio-economic status (SES) was represented as quintiles (Q1 most disadvantaged to Q5 least disadvantaged) of IRSD codes. Maternal Body Mass Index (BMI) was pre-calculated from self-reported maternal height and weight and grouped according to the WHO classification of BMI classes. Maternal age was collapsed into 5-yearly brackets from younger than 20 years to 45 or older. Gestation at first antenatal visit was recoded into four groups ranging from <12 weeks to >/=28 weeks. The <12 weeks group represents the recommended early engagement, based on the Closing the gap measure for target 2, "children are born healthy and strong" (Australian Government Productivity commission 2024) and the WHO recommendations for antenatal care (Jiwani et al., 2020), while >/= 28 weeks represents late engagement by which time key antenatal assessments, interventions and counselling (for example dating and morphology scans, aneuploidy testing, glucose tolerance testing) are recommended to have occurred (World Health Organization, 2016). We included the intermediate groupings for more nuanced analysis. Maternal smoking was identified through a binary variable of not smoking or smoking at all during pregnancy. Maternal age and residential location data was available and analysed from 2000 onwards, whilst data for maternal SES, BMI, smoking status and gestation at first antenatal visit was only available and therefore analysed from 2009 onwards. For this reason, we also computed a time epoch variable for the years 2000–2009 (Epoch 1), and 2010–2019 (Epoch 2).

The principal outcome of interest was PND, classified as either a stillbirth (an infant ≥20 weeks gestation or if gestation unknown, ≥400 *g* birthweight, who shows no signs of life after birth) or a neonatal death (death of a live-born occurring during the first 28 days of life) (Victorian, 2020). The relatively small number of perinatal deaths of babies born to Aboriginal and/or Torres Strait Islander women precluded detailed separate analysis of stillbirths and neonatal deaths.

We excluded cases with missing values from analyses; maternal Aboriginal status (0.4 %), IRSD SA1 codes (3.7 %), Metropolitan/rural residence (2.1 %), BMI (4.0 %), gestation at first antenatal visit (0.6 %), maternal smoking (2.4 %) and maternal age (0.02 %).

Frequencies, percentages and rates of maternal characteristics by maternal Aboriginal and/or Torres Strait Islander status and time epoch were tabulated and compared within each epoch with either the Pearson's chi-square or Fisher's exact test as appropriate.

The association between maternal Aboriginal and/or Torres Strait Islander status and PND was then assessed with logistic regression to obtain unadjusted and adjusted odds of PND over the entire study period. Confounders that were adjusted for were identified a *priori* as being associated with both perinatal mortality and with Aboriginal status, They included maternal IRSD quintile, age, smoking status, BMI, marital status, gestation at first antenatal visit, parity, plurality and birth year of the baby (Australian Institute of Health and Welfare 2020a; 2020b; Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021; Ford et al., 2018; Gibberd et al., 2019; Lawn et al., 2016; Lovett et al., 2017; Panaretto et al., 2006; Thrift and Callaway, 2014; Whish-Wilson et al., 2016; Wijs et al., 2017). Preterm birth was not included due to being on the causal pathway. Rates of PND were then graphed by Aboriginal and/or Torres Strait Islander status in rolling triennia to minimise data volatility.

Lastly, we examined the relationship between each maternal characteristic and PND in the total population of Victorian birthing women. We calculated relative risk ratios (RRR) with 95 % confidence intervals using a favourable reference category (IRSD quintile 5, metropolitan living, BMI 18.5 to <25, gestation less than 12 weeks at first antenatal visit, maternal age of 30 to <35 years, no smoking) for each characteristic. We contrasted the specific PND risk associated with each maternal characteristic with changes over the study period (determined by comparing the prevalence of the characteristic in the first year to the prevalence in the last, and the magnitude and significance of the time trend analysis) to conduct an ecological assessment of the likely impact of these changes. All statistical analyses were performed using IBM SPSS Statistics (Version 24) and Stata 16 (StataCorp. Release 16.). A p-value <0.05, two-tailed, was considered statistically significant.

Ethics approval for the conduct of this project was obtained from Monash University Human Research Ethics Committee on March 3rd, 2021, including a waiver of consent given the data was routinely collected and deidentified.

Results

A total of 1,422,760 women gave birth to 1,446,361 babies during the study period. The number of women identifying as Aboriginal and/or Torres Strait Islander was 15,705 (1.1 %), and Aboriginal status was not recorded for 0.4 % of women. The number of non-Indigenous women rose by 23.6 % (61,099 in 2000 to 75,502 in 2019) and, consistent with census increases in the Aboriginal population, the number of Aboriginal and/or Torres Strait Islander women increased by 197.3 % (376 (0.6 % of all women giving birth) in 2000 to 1118 (1.4 % in 2019) (Fig. 1).

The characteristics of Aboriginal and/or Torres Strait Islander and non-Indigenous women stratified by the two epochs are presented in

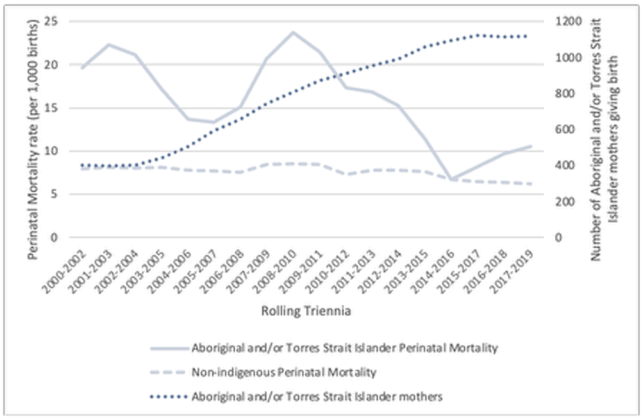

Fig. 1. Perinatal Death rates in Victoria by Aboriginal and/or Torres Strait Islander status in rolling triennia from 2000 to 2019 with the number of Aboriginal and/or Torres Strait Islander mothers giving birth in rolling triennia (on the additional Y axis).

Table 1
Maternal characteristics across two 10-year epochs by Aboriginal and/or Torres Strait Islander status.

		2000 to 2009			2010 to 2019		
		Number of Aboriginal and Torres Strait Islander women (%)	Number of Non-Aboriginal and Torres Strait Islander women (%)	P value	Number of Aboriginal and Torres Strait Islander women (%)	Number of Non-Aboriginal and Torres Strait Islander women (%)	P value
Maternal age (years)	*Younger than 20*	995 (19.3)	17,620 (2.7)	**<0.001**	1150 (11.3)	12,560 (1.7)	**<0.001**
	20 to 24	1564 (29.4)	74,703 (11.5)		2994 (28.8)	73,176 (9.7)	
	25 to 29	1265 (23.7)	172,694 (26.7)		2803 (26.9)	195,238 (26.0)	
	30 to 34	961 (18.1)	234,009 (36.1)		2104 (20.2)	276,918 (36.8)	
	35 to 39	455 (8.1)	125,752 (19.3)		1080 (10.5)	157,761 (21.0)	
	40 to 44	82 (1.4)	23,336 (3.6)		237 (2.3)	34,271 (4.6)	
	45 and older	<5 (0.0)	1013 (0.2)		10 (0.1)	2374 (0.3)	
Marital status	Married/de facto	*2797 (50.4)*	*565,676 (87.0)*		5655 (55.0)	*657,194 (87.3)*	
	Single/widowed/ divorced	*2493 (46.7)*	*82,328 (12.7)*	***<0.001***	4482 (43.2)	*85,928 (11.4)*	<0.001
Maternal residential location	Rural	3089 (66.2)	158,568 (25.0)	**<0.001**	5044 (53.2)	166,220 (22.6)	**<0.001**
	Metropolitan	1658 (33.8)	477,509 (75.0)		4460 (46.8)	570,543 (77.4)	
IRSD quintiles*	Q 1 (most disadvantaged)				4402 (45.9)	140,551 (19.8)	**<0.001**
	Q 2				2165 (22.6)	142,367 (20.0)	
	Q 3				1330 (13.7)	143,019 (20.1)	
	Q 4				983 (10.1)	142,389 (20.0)	
	Q 5 (least disadvantaged)				732 (7.7)	142,830 (20.1)	
Admission status	*Public*	4996 (93.6)	420,896 (64.7)		9879 (95.2)	543,029 (72.3)	
	Private	341 (6.4)	229,448 (35.3)	**<0.001**	482 (4.6)	208,288 (27.7)	<0.001
Parity	Nulliparous	1925 (36.1)	277,492 (42.7)		3754 (36.2)	333,151 (44.3)	
	Parous	3411 (63.9)	372,875 (57.3)	**<0.001**	6622 (63.8)	419,342 (55.8)	<0.001
Maternal Body mass index*	*<18.5*				355 (3.6)	21,247 (3.0)	**<0.001**
	18.5 to <25				3755 (38.9)	355,383 (50.5)	
	25 to <30				2439 (25.3)	184,931 (26.2)	
	30 to <35				1593 (16.5)	83,939 (11.9)	
	≥35				1544 (15.7)	55,525 (7.9)	
Maternal smoking during pregnancy*	*No*				5761 (57.6)	651,243 (90.2)	**<0.001**
	Yes				4223 (42.4)	70,324 (9.8)	
Gestation at first antenatal visit*	*<12 weeks*				4306 (42.0)	402,388 (53.9)	**<0.001**
	13 to 19 weeks				3174 (31.4)	241,952 (32.4)	
	20 to 27 weeks				1600 (15.9)	68,849 (9.2)	
	≥28 weeks				1022 (10.2)	31,850 (4.3)	
Plurality	*Singleton*	5273 (98.8)	638,992 (98.2)		10,240 (98.7)	741,060 (98.6)	
	Multiple	64 (1.2)	11,415 (1.8)	**0.002**	136 (1.3)	11,511 (1.5)	0.087
Gestation at birth (completed weeks)	*20–27*	79 (1.5)	3867 (0.5)		116 (1.1)	4227 (0.6)	
	28–31	75 (1.4)	4251 (0.7)		117 (1.1)	4757 (0.6)	
	32–36	512 (9.6)	36,158 (5.6)	**<0.001**	999 (9.6)	45,912 (6.1)	**<0.001**
	37–41	4585 (86.2)	595,940 (91.9)		989 (87.6)	692,634 (92.0)	
	42+	68 (1.3)	8550 (1.3)		54 (0.5)	4912(0.7)	

*these variables were only available from 2009 onwards and thus only included in the second epoch (2010–2019)
<5: VPDC rules stipulate all cells with a value less than 5 must be recorded as <5 for confidentiality reasons.
IRSD - Index of Relative Socio-Economic Disadvantage.

Table 1. In both epochs, compared with non-Indigenous women, Aboriginal and/or Torres Strait Islander women were more likely to be younger than 20 years of age (henceforth, years), unpartnered, live rurally, be admitted for the birth as a public patient, to have given birth previously and give birth to a preterm baby. For characteristics only available in the second epoch, Aboriginal and/or Torres Strait Islander women were more likely to live in a Q1 (most disadvantaged) and less likely to live in Q5 (least disadvantaged) area. Additionally, they were less likely to have their first antenatal care appointment before 12 weeks' gestation and more likely to have their first antenatal care at greater than 28 weeks' gestation. Moreover, Aboriginal and/or Torres Strait Islander women were more likely than non-Indigenous women to smoke during pregnancy and have a BMI ≥ 30. There were clear shifts in the demographics of Aboriginal and/or Torres Strait Islander women over the study period where in the second epoch compared to the first, fewer Aboriginal and/or Torres Strait Islander women lived rurally, were aged younger than 20 years and were unpartnered, but a greater number were older than 35 years.

PND rates for babies of Aboriginal and/or Torres Strait Islander women decreased from 19.7/1000 births (n=24) in the 2000–2002 triennium to 10.6 /1000 (n=36) in 2017–2019 (p trend=0.0001). For babies of non-Indigenous women, rates decreased from 7.9/1000 (n=1480) to 6.2/1000 (n=1447) (p trend<0.001) over the same period. Aboriginal and/or Torres Strait Islander PND rates equalled those for non-Indigenous women in the 2014–2016 triennium at 6.6/1000 and 6.7/1000 respectively. Excepting this triennium, Aboriginal and/or Torres Strait Islander PND rates were higher across the study period at an average of 15.6/1000 compared to 7.6/1000 in non-Indigenous women. The relative reduction in PND rates was 46.2 % for Aboriginal and/or Torres Strait Islander mothers compared with 21.5 % for non-Indigenous. (Fig. 1)

Babies of Aboriginal and/or Torres Strait Islander women had 39.0 % higher odds of PND compared to non-Indigenous women (95 % CI 1.30–1.49). After adjustment for key socio-demographic characteristics, this disparity reduced to 11.0 % (95 % CI 1.01–1.21). (Table 2)

The relative risks of PND for each characteristic in the whole birthing population along with the trends in each maternal characteristic over the study period are presented in Table 3.

Table 2
Average perinatal death rates and crude and adjusted odds ratios for mortality outcomes by Aboriginal and/or Torres Strait Islander status, births in Victoria 2000–2019.

Outcome	Aboriginal and/or Torres Strait Islander status	Average rate (%) over the study period	Crude odds ratio (95 % confidence interval)	P value	Adjusted odds ratio** (95 % confidence interval)	P value
Perinatal death (per 1000 births)	*Aboriginal and/or Torres Strait Islander*	15.6	1.39 **(1.30–1.49)**	**<0.001**	1.11 **(1.01–1.21)**	**0.024**
	Non-Indigenous	7.6	Reference	-	Reference	-
Neonatal death (per 1000 live births)	*Aboriginal and/or Torres Strait Islander*	6.3	1.52 **(1.36–1.69)**	**<0.001**	1.18 **(1.02–1.37)**	**0.029**
	Non-Indigenous	2.5	Reference	-	Reference	-
Stillbirth (per 1000 births)	*Aboriginal and/or Torres Strait Islander*	9.4	1.46 **(1.31–1.62)**	**<0.001**	1.07 (0.96–1.20)	0.223
	Non-Indigenous	5.1	Reference	-	Reference	-

**Adjusted for maternal IRSD quintile, maternal age, maternal smoking status, maternal BMI, maternal admission status, maternal marital status, gestation at first antenatal visit, parity, plurality and birth year of the baby.

Table 3
Changes in maternal characteristics over the study period for Aboriginal and/or Torres Strait Islander and non-Indigenous women: and relative risk (RR) of perinatal death (PND).

		Aboriginal and/or Torres Strait Islander women			Non-Indigenous women			
		First year of the study period n (%)	Last year of the study period n (%)	P for trend	First year of the study period n (%)	Last year of the study period n (%)	P for trend	RR of PND in the total Victorian birthing population (95 % Confidence interval)
Variables available from 2009								
		2009 n = 830	**2019 n = 1118**		**2009 n = 69,895**	**2019 n = 75,502**		
IRSD quintile	*Q 1 (most disadvantaged)*	304 (47.0)	520 (46.8)	0.581	11,854 (19.7)	14,938 (19.9)	0.258	**1.55 (1.43 - 1.68)**
	Q 2	142 (22.0)	245 (22.0)	0.192	12,010 (20.0)	15,240 (22.3)	0.077	**1.33 (1.22 - 1.45)**
	Q 3	97 (15.0)	160 (14.4)	0.602	12,044 (20.1)	15,380 (20.5)	0.147	**1.19 (1.09 - 1.29)**
	Q 4	**55 (8.5)**	**115 (10.3)**	**0.009**	12,064 (20.1)	14,875 (19.8)	0.728	**1.14 (1.04 - 1.24)**
	Q 5 (Least disadvantaged)	49 (7.6)	72 (6.5)	0.131	12,067 (20.1)	14,719 (19.6)	0.720	*Reference*
Maternal Body Mass Index	*<18.5*	37 (4.8)	37 (3.4)	0.384	1768 (2.9)	1975 (2.7)	0.451	1.16 (0.99 - 1.37)
	18.5 to <25	**313 (40.7)**	**378 (34.8)**	**0.022**	**30,942 (49.9)**	35,888 (48.2)	0.602	*Reference*
	25 to <30	193 (25.1)	280 (25.8)	0.139	16,931 (27.3)	20,565 (27.6)	0.750	**1.18 (1.11 - 1.26)**
	30 to <35	123 (15.1)	189 (17.4)	0.663	7730 (12.5)	9410 (12.7)	0.931	**1.36 (1.25 - 1.48)**
	≥35	**103 (13.4)**	**203 (18.7)**	**0.004**	**4692 (7.6)**	**6572 (8.8)**	**0.032**	**1.58 (1.44 - 1.73)**
Maternal smoking during pregnancy	*No*	*419 (55.8)*	*614 (56.5)*	–	*60,286 (89.0)*	*67,217 (92.4)*	–	*Reference*
	Yes	332 (44.2)	473 (43.5)	0.077	**7436 (11.0)**	**5518 (7.6)**	**0.003**	**1.59 (1.48 - 1.70)**
Gestation at first antenatal visit	*<12 weeks*	**337 (41.8)**	**668 (57.6)**	**0.008**	**39,141 (61.4)**	**52,641 (70.8)**	**0.022**	*Reference*
	13 to 19 weeks	242 (30.0)	247 (27.8)	0.246	18,895 (22.7)	16,930 (22.6)	0.663	**1.11 (1.05 - 1.18)**
	20 to 27 weeks	122 (15.1)	105 (9.2)	0.117	6277 (9.7)	3877 (5.2)	0.059	**2.12 (1.97 - 2.28)**
	≥28 weeks	**106 (13.1)**	**68 (5.4)**	**0.008**	**3645 (6.3)**	**1559 (2.1)**	**0.014**	0.99 (0.87 - 1.14)
Variables available from 2000								
		2000 n = 376	**2019 n = 1118**		**2000 n = 61,099**	**2019 n = 75,502**		
Maternal age	*Younger than 20*	**73 (19.4)**	**90 (8.1)**	**<0.001**	**1937 (3.2)**	**755 (1.0)**	**<0.001**	**2.43 (2.22 - 2.66)**
	20 to 24	112 (29.8)	349 (31.2)	0.865	**7505 (12.3)**	**5965 (7.9)**	**<0.001**	**1.44 (1.36 – 1.53)**
	25 to 29	90 (23.9)	324 (29.0)	**<0.001**	**18,748 (30.7)**	**18,422 (24.4)**	**0.033**	**1.13 (1.08 – 1.19)**
	30 to 34	*68 (18.1)*	*232 (20.8)*	–	*21,198 (34.7)*	*29,521 (39.1)*	–	*Reference*
	35 to 39	**28 (7.4)**	**104 (9.3)**	**0.020**	**9949 (16.3)**	**17,064 (22.6)**	**0.004**	**1.16 (1.10 – 1.22)**
	40 to 44	**5 (1.3)**	**19 (1.7)**	**0.004**	**1701 (2.8)**	**3472 (4.6)**	**<0.001**	**1.50 (1.38 – 1.64)**
	45 and older	0 (0.0)	0 (0.0)	0.087	**61 (0.1)**	**302 (0.4)**	**<0.001**	**2.38 (1.83 – 3.08)**
Maternal residential location	*Rural*	**220 (67.5)**	**565 (55.3)**	**<0.001**	**15,694 (26.2)**	**16,318 (22.0)**	**<0.001**	**1.12 (1.07 - 1.17)**
	Metropolitan	**106 (32.5)**	**457 (44.7)**	**<0.001**	**44,255 (73.8)**	**57,838 (78.0)**	**<0.001**	*Reference*

Primary outcome relative risks were calculated for the total population, trends over time were calculated within each population.
P for trend (p trend) analysis was used to determine the significance of characteristic trends over time.
IRSD - Index of Relative Socio-Economic Disadvantage.

Maternal socio-economic status

The risk of PND increased with increasing disadvantage from lowest risk in Q5 to highest in Q1 (RR 1.55 (95 %CI 1.43–1.68)). Over the study period, the percentage of Aboriginal and/or Torres Strait Islander women living in the most disadvantaged areas remained similar, with almost half (46.8 %) of these women living in Q1. The proportion of non-Indigenous women was equal in each quintile and remained stable.

Maternal body mass index

The risk of PND with BMI followed a J-shaped curve, where a BMI greater than 35 demonstrated a 58.0 % risk increase compared to a BMI between 18.5 and <25. The proportion of Aboriginal and/or Torres Strait Islander women with a BMI between 18.5 to < 25 decreased from 40.7 % in 2009 to 34.8 % in 2019 (p trend=0.022). Conversely, this same period saw an increase in Aboriginal and/or Torres Strait Islander

women with a BMI ≥35 from 13.4 % to 18.7 %. The proportion of non-Indigenous women with a BMI ≥35 also increased.

Maternal smoking during pregnancy

Maternal smoking during pregnancy was associated with a 59.0 % increased risk of PND. While the percentage of non-Indigenous women smoking during pregnancy decreased from 11.0 % to 7.6 % over the 10 years, the proportion of Aboriginal and/or Torres Strait Islander women who smoked during pregnancy did not change significantly during this time, remaining close to 44 %.

Gestation at first antenatal visit

The risk of PND increased with increasing gestation at first antenatal visit, where compared to the lowest risk before 12 weeks, risk increased by 11.0 % at 13 to 19 weeks and by 112.0 % at 20 to 27 weeks. Over the study period the number of Aboriginal and/or Torres Strait Islander women having their first antenatal care appointment before 12 weeks increased from 41.8 % to 57.6 % while first appointment after 28 weeks decreased. Non-Indigenous women's trends mirrored this pattern.

Maternal age

Maternal age younger than 20 years was associated with a 2.4-fold increased risk of PND. The percentage of Aboriginal and/or Torres Strait Islander women who were younger than 20 years when they gave birth halved over the study period. Non-Indigenous women younger than 20 years also decreased. Maternal age of 35 or older was also associated with increasing risk of PND. The percentage of Aboriginal and/or Torres Strait Islander women aged 35 or older increased over the study period.

Maternal residential location

Living rurally was associated with a 12.0 % increased risk of PND comparative to metropolitan living. A decreasing proportion of both Aboriginal and/or Torres Strait Islander and non-Indigenous women lived in rural areas over the study period.

Discussion

Consistent with other Australian jurisdictions, we noted that overall PND rates were significantly higher for the Aboriginal and/or Torres Strait Islander population than for other women in Victoria (Australian Institute of Health and Welfare 2020). Over the study period we observed a decrease in PND rates for babies of both Aboriginal and/or Torres Strait Islander and non-Indigenous women in Victoria, with a greater relative reduction observed for Aboriginal and/or Torres Strait Islander women. We hypothesised that changes in maternal characteristics proven to be risk factors for PND likely contributed to the falling Aboriginal and/or Torres Strait Islander PND rate. In the whole birthing population, we found that socioeconomic disadvantage, BMI <18.5 or ≥25, smoking during pregnancy, late engagement in antenatal care, extremes of maternal age and rural residence were significantly associated with PND. Several factors associated with a lower rate of PND improved for Aboriginal and/or Torres Strait Islander women over time including early engagement in antenatal care, metropolitan residence and fewer women birthing at ages younger than 20 years. This may partly explain the significant reduction in PND observed. However, other factors associated with increased rates of PND remained unchanged or increased including smoking during pregnancy, obesity, maternal age of 35 or older and socio-economic disadvantage, all of which likely contribute to remaining disparities.

The odds ratios for both stillbirth and neonatal death were raised for babies of Aboriginal and/or Torres Strait Islander women. Adjustment for demographic characteristics reduced the magnitude of the odds ratio for each, though the odds ratio for NND for Aboriginal and/or Torres Strait Islander women remained elevated, likely related to preterm birth being a common cause of NND (Australian Institute of Health and Welfare 2020; Consultative Council on Obstetric and Paediatric Mortality and Morbidity, 2023).

We found that women who commenced antenatal care after 12 weeks had a higher risk of PND. Considering this, we observed an increase in the proportion of Aboriginal and/or Torres Strait Islander women commencing antenatal care before 12 weeks. These results mirror current literature and stand as positive trends that may have contributed to the reduction in PND (Australian Institute of Health and Welfare 2020; Consultative Council on Obstetric and Paediatric Mortality and Morbidity. Victoria's Mothers, Babies and Children report 2016, 2018; Panaretto et al., 2006). These results may also suggest an increased perceived safety/accessibility of maternity care and improvement in services, which appears to have continued since our study with further services emerging to facilitate healthcare engagement and support families within the perinatal period. Many of these services are underpinned by Birthing on Country principles (Victorian State Government 2017) and as such are often aligned with the four pillars of the evidence-based RISE framework for establishing and sustaining a culturally and clinically safe Birthing on Country service (Kildea et al., 2019): redesigning health services, investing in workforce, strengthening families and embedding Aboriginal and/or Torres Strait Islander community governance and control (Kildea et al., 2019). Specifically, many of these services harness aspects of this framework to deliver Aboriginal and/or Torres Strait Islander directed caseload midwifery care (McLachlan et al., 2024), heralded as the gold standard of maternity care (Forster et al., 2016; Kildea et al., 2019; McLachlan et al., 2024). Studies have highlighted that caseload midwifery care improved perinatal outcomes such as increased engagement in antenatal care, lower rates of pre-term birth and pregnancy loss before 24 weeks, fewer Neonatal Intensive Care admissions and mothers who reported feeling safer and more supported (Forster et al., 2016; McLachlan et al., 2024). One recent example is the Replanting the Birthing Tree program which aims to address gaps in perinatal care and scale up community co-designed, evidenced-based perinatal care programs to benefit Aboriginal and/or Torres Strait Islander families in the first 2000 days of a baby's life (Chamberlain et al., 2025).

With regards to maternal age two trends require examination. Firstly, the increase in the number of Aboriginal and/or Torres Strait Islander women aged 35 or older giving birth, represents a possible contribution to persisting PND rates given the known higher risk of PND with advancing maternal age beyond 35 years (Elci et al., 2022). Secondly, is the reduction in the proportion of Aboriginal and/or Torres Strait Islander women giving birth before 20 years. Given the risk of PND is higher for women aged under 20 years (Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021; Marino et al., 2016; Steenkamp et al., 2017) this reduction stands as a positive trend that may have contributed to the reduction in PND rates over the study period. We observed an increase in the proportion of Aboriginal and/or Torres Strait Islander women living in metropolitan areas and a decrease in those living rurally. This is unsurprising given the previously described increase in numbers of Aboriginal and/or Torres Strait Islander women and shift to urban living. Mirroring current literature our study observed rural living to be associated with higher risk of PND when compared with metropolitan. This is likely influenced by the known disparity in access to appropriate healthcare services, where in the context of greater access to all levels of maternity and general healthcare (Australian Institute of Health and Welfare 2018), this urban shift may have contributed to the reduction in PND rates observed. However, there are notable reasons why residential location and by extension the physical, social and cultural context within which women are birthing must be examined with greater nuance.

Firstly, birthing on Country holds great significance to many

Aboriginal and/or Torres Strait Islander people, often forming the foundations of cultural and spiritual identity, facilitating healing from intergenerational trauma and fostering connection with people and the environment (Kildea et al., 2019). The term Country represents connection not only to sovereign lands and the environment but also history, culture, spirituality and community. Accordingly, birthing on Country does not necessarily pertain to the physical place of birthing but instead represents giving birth in a setting that upholds cultural safety, self-determination, and connection to heritage, kin, and land (Kildea et al., 2019). Lack of access to culturally safe care services and supports, regardless of geographical location, can disrupt these essential connections, negatively impacting spiritual wellbeing, cultural identity, and community ties (Ganesharajah, 2009). As such, when considering access to safe birthing for Aboriginal and/or Torres Strait Islander women, geographical location alone is an incomplete metric, instead exploration of access to a culturally, spiritually and clinically safe birth should be undertaken. Birthing on Country services recognise and aim to address the various systemic, geographical and socio-economic barriers women face in accessing appropriate care. Programs aligned with this vision — such as those informed by the RISE framework and exemplified by initiatives like the Koori Maternity Service (KMS) — have been established in urban maternity centres across Victoria. These community-led models provide holistic, culturally safe care and have been shown to significantly improve perinatal outcomes (McLachlan et al., 2024). Such findings demonstrate that creating culturally enriching birthing environments is both feasible and effective in urban settings. As such it can be posited that through expansion of these targeted services the healthcare system could appropriately support this growing urban Aboriginal and/or Torres Strait Islander population. Notably, current models have not yet been effectively implemented in regional and rural areas (McLachlan et al., 2024). Ensuring translatability into non-urban settings stands as a clear imperative for further investment and action given, despite the noted urban shift, a comparatively greater proportion of Aboriginal and/or Torres Strait Islander women still reside in these areas.

Secondly, current literature has highlighted significant socio-demographic improvements such as increased income and employment for urban Aboriginal and/or Torres Strait Islander individuals, with little improvements for those living rurally (Australian Bureau of Statistics 2018). Although these improvements are encouraging, the primarily metropolitan increase in the small Aboriginal and/or Torres Strait Islander population in Victoria may leave data vulnerable to being overwhelmingly influenced by a healthier and wealthier metropolitan cohort. This may result in a failure to represent those most disadvantaged and vulnerable. In future studies it is important to consider stratification by residential location for accurate measurement of outcomes for all Aboriginal and/or Torres Strait Islander Victorians (Consultative Council on Obstetric and Paediatric Mortality and Morbidity, 2023).

We saw no great change in SES and observed that the risk of PND increased with increasing socio-economic disadvantage. There was no change to the near half (46.8 %) of Aboriginal and/or Torres Strait Islander birthing women living in the most disadvantaged quintile (Q1), with the highest risk of PND. Not only is current literature unanimous in reporting an increased risk of PND with lower socio-economic status, many studies link socio-economic disadvantage with younger maternal age and high-risk pregnancy behaviours such as inadequate antenatal care, maternal smoking, alcohol consumption and substance use, all of which further increase the risk of adverse perinatal outcomes (Australian Institute of Health and Welfare 2020; Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021; Gibberd et al., 2019). As such, the near stagnant socio-economic profile of Aboriginal and/or Torres Strait Islander women with continued high proportions of women in quintile 1 may have hindered further improvements in PND.

We observed an increase in the proportion of Aboriginal and/or Torres Strait Islander women with a BMI of 35 or more and a reduction in those with a BMI between 18.5 and 25. This is unsurprising, given that we also saw an increase (albeit smaller) in maternal obesity in non-Indigenous women, and Australia Bureau of Statistics reports a Victoria-wide trend of increasing BMI (Australian Bureau of Statistics 2018). Our results parallelled current literature demonstrating a higher risk of PND with increasing BMI (Australian Institute of Health and Welfare 2020; Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2019; Lawn et al., 2016; Wijs et al., 2017; Yao et al., 2014). Given this risk profile, these Aboriginal and/or Torres Strait Islander maternal BMI trends may have hindered further improvements in PND over the study period.

Aboriginal and/or Torres Strait Islander maternal smoking rates were considerably higher than those seen in non-Indigenous women, and they did not decrease over the study period. Smoking during pregnancy is a well-established risk factor for PND and our results replicated this (Ford et al., 2018; Gibberd et al., 2019; McInerney et al., 2019; Panaretto et al., 2006; Whish-Wilson et al., 2016; Wijs et al., 2017). High rates of maternal smoking likely limited improvements in PND rates during the study period. Further, there was likely compounding risk of PND resulting from higher rates of interconnected risk factors such as rurality and low SES. Several promising approaches to supporting Aboriginal and/or Torres Strait Islander women to stop smoking in pregnancy have been implemented in recent years. These include the Stronger Bubba Born program, which is a culturally adapted version of the Safer Baby Bundle and includes resources about smoking cessation (Stuart-Butler et al., 2023). The now national iSISTAQUIT smoking cessation program collaborates with KMS, State Health Services, general practitioners, midwives and communities to encourage and support Aboriginal and/or Torres Strait Islander women to quit smoking through direct support for women and in training Healthcare professionals to provide best practice care (Gould et al., 2023). Furthermore, the national Tackling Indigenous Smoking Program has developed a Resource and Information Centre, National Best Practice Unit and multiple local teams to work with organisations to facilitate the use of best practice and continually gather and analyse data to evaluate current initiatives and inform future funding and programs (Tackling Indigenous Smoking Program, 2023). Promisingly and likely influenced by the above initiatives, since our study there has been progress in Victoria, with smoking during pregnancy decreasing from 41.3 % in 2020 to 38.0 % in 2021 for Aboriginal/or Torres Strait Islander women (Consultative Council on Obstetric and Paediatric Mortality and Morbidity, 2023).

Finally, despite the significant improvement in Victorian Aboriginal and/or Torres Strait Islander PND rates observed, we cannot ignore the enduring disparity in PND rates that exists between babies born to Aboriginal and/or Torres Strait Islander women and those to non-Indigenous women. Regarding this disparity, the influence of persisting socio-economic, health and systemic disadvantage is undeniable and illustrated by several of our findings. Aboriginal and/or Torres Strait Islander Australians continue to experience lower life expectancy, represent a disproportionate amount of Australia's burden of disease and experience poorer general and perinatal health outcomes (Australian Institute of Health and Welfare 2020; Australian Government Productivity commission 2024; Consultative Council on Obstetric and Paediatric Mortality and Morbidity 2021; Mazel, 2018). Similar disparities exist for First Nations populations in Canada, New Zealand and the United States, highlighting the need to address these issues on a national and global scale (Smylie et al., 2010). These health inequalities are often rooted in the impacts of colonialism and can persist through racism, systemic discrimination, damaged relationships with authorities and a lack of targeted support. In this context, it is not surprising that established socio-demographic risk factors for PND and barriers to maternity care disproportionately affect Aboriginal and/or Torres Strait Islander women (Panaretto et al., 2006; Victorian State Government 2017; Wijs et al., 2017), likely strongly contributing to the disparate PND rates observed. Such barriers include a lack of trust in authorities

and government-run systems, geographical isolation and often associated paucity of culturally safe birthing services, higher rates of socio-economic disadvantage, greater risk of poor health literacy and lack of cultural support and acceptance (Australian Bureau of Statistics 2018, Australian Institute of Health and Welfare 2018; National Indigenous Australians Agency, 2020). This was highlighted by our regression results displaying significant reductions in the risk of PND after adjustment for key socio-demographic characteristics, illustrating that these identified maternal characteristics (likely along with others not available in our dataset) were primary drivers of the differences in PND rates between the Aboriginal and/or Torres Strait Islander and non-Indigenous population. This key understanding underpins the importance of ongoing data collection and research focusing on the influence of maternal socio-demographic risk factors for PND.

Study strengths and limitations

This is a population-based study utilising the validated and high accuracy VPDC database to include the entire population of Aboriginal and/or Torres Strait Islander women birthing in Victoria. Consequently, our results are free of selection bias and are generalisable to women within Victoria and potentially to similar First Nations populations elsewhere in Australia and beyond. Several important variables (BMI, initiation of antenatal care, smoking in pregnancy, detailed socio-economic coding) were added to VPDC during the study period. This is the first time they have been used to examine PND differences between Aboriginal and/or Torres Strait Islander and non-Indigenous women.

The primary limitation of this study was the size of the Aboriginal and/or Torres Strait Islander population in Victoria, limited further by the assessment of a rare outcome. The small number of Aboriginal and/or Torres Strait Islander PNDs made quantification of trends in PND stratified by characteristic over time unfeasible. Instead, we took an ecological approach using population level data to illustrate which characteristics increase and decrease the risk of PND. Ideally, stillbirth and neonatal death could have been investigated separately, but the small number of cases precluded this. Some aetiological factors differ between stillbirth and neonatal death, but the maternal characteristics considered here are risk factors for both types of death. Finally, we acknowledge that although the dataset allowed us to examine several key risk factors for PND, there are other important factors that influence PND that we could not analyse such as antenatal education, lack of transport, insecure housing, alcohol and substance use.

Conclusion

The consistently higher PND rates for babies born to Aboriginal and/or Torres Strait Islander women are a tragedy, reflective of pervasive intergenerational health and social disadvantage. Aboriginal and/or Torres Strait Islander women remain disadvantaged compared to non-Indigenous women with the trends observed in BMI, smoking and SES likely limiting improvements in perinatal outcomes. However, there was a significant reduction in Victorian Aboriginal and/or Torres Strait Islander PND rates, with positive trends in several socio-demographic characteristics likely contributing to this, alongside innovative models of maternity care including caseload midwifery and models underpinned by Birthing on Country principles. These improvements exemplify the potential for advancements, and highlight areas that deserve continued support, while those potentially limiting factors stand as targets for enhanced research, funding and collaboration. This study provides further insight into the evolving socio-demographic landscape of the Victorian Aboriginal and/or Torres Strait Islander maternal population, and the influence of key maternal characteristics on PND which enable midwives and other maternity carers to identify women who need enhanced support, for example assistance to quit smoking, referral for assistance with housing and income. Understanding these factors is integral in informing ongoing development of collaborative, targeted and effective interventions and services, building on established cultural knowledge and community connections, to improve Aboriginal and/or Torres Strait Islander perinatal outcomes.

CRediT authorship contribution statement

Sophie KC Nunn: Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Tanya Farrell:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **Catherine Chamberlain:** Writing – review & editing, Supervision. **Tracey Zakazakaarcher:** Writing – review & editing, Conceptualization. **Euan M Wallace:** Writing – review & editing, Supervision, Conceptualization. **Miranda L Davies-Tuck:** Writing – review & editing, Supervision, Methodology. **Mary-Ann Davey:** Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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