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RESEARCH ARTICLE

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Perinatal outcomes of socially disadvantaged women in Australia: A population-based retrospective cohort study

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Abstract

Objective: To examine the perinatal outcomes of women who experience social disadvantage using population-based perinatal data collected between 1999 and 2016.

Design: Population-based, retrospective cohort study.

Setting: Victoria, Australia.

Population or Sample: A total of 1 188 872 singleton births were included.

Methods: Cohort study using routinely collected perinatal data. Multiple logistic regression was performed to determine associations between social disadvantage and adverse maternal and neonatal outcomes with confidence limits set at 99%. Time-trend analysis for perinatal outcomes was performed in relation to area-level disadvantage measures.

Main Outcome Measures: Incidence of maternal admission to intensive care unit (ICU), postpartum haemorrhage (PPH) and caesarean section, perinatal mortality, preterm birth, low birthweight (LBW), and admission to special care nursery/neonatal intensive care unit (SCN/NICU).

Results: Social disadvantage was associated with higher odds of adverse perinatal outcomes. Disadvantaged women were more likely to be admitted to ICU, have a PPH or experience perinatal mortality (stillbirth or neonatal death) and their neonates were more likely to be admitted to SCN/NICU, be born preterm and be LBW. A persistent social gradient existed across time for the most disadvantaged women for all outcomes except caesarean section.

Conclusions: Social disadvantage has a marked negative impact on perinatal outcomes. This aligns with national and international evidence regarding the impact of disadvantage. Strategies that improve access to, and reduce fragmentation in, maternity care in addition to initiatives that address the social determinants of health may contribute to improving perinatal outcomes for socially disadvantaged women.

KEYWORDS

deprivation, disadvantage, low birthweight, maternal intensive care unit admission, perinatal outcomes, preterm birth, stillbirth

1 | INTRODUCTION

Social disadvantage is associated with poorer perinatal outcomes. Disadvantage is a multi-faceted concept and is more complex than poverty as a single construct.[1] In 2013, a Productivity Commission Staff Working Paper on *Deep and Persistent Disadvantage in Australia* acknowledged that there is a 'high personal cost from disadvantage' with impact

This article includes Author Insights, a video abstract available at: https://drive.google.com/file/d/1oZ1ZrWmd1fZuifYZ6zdkq7tYHOE8pyjC/view?usp=sharing.

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being felt financially, socially, emotionally, educationally and physiologically through poorer health outcomes for both adults and children.[1] This is reflected in the research looking at disadvantage and perinatal outcomes, with a documented association existing between the experience of disadvantage, health behaviours and health outcomes.[2–5] Living in areas of high deprivation,[1,6] rural residency,[1,7] adolescent pregnancy[8–11] and being unpartnered[9,12] are all associated with social disadvantage. Other factors associated with disadvantage and deprivation that can further impact adversely on women's health and well-being include smoking,[4] obesity (body mass index [BMI] ≥30 kg/m^2)[13–16] or being underweight (BMI <18.5 kg/m^2).[13,17]

Disadvantaged women are consistently overrepresented in the data for adverse maternal and neonatal outcomes such as maternal admission to intensive care unit (ICU),[18] postpartum haemorrhage (PPH),[19] preterm birth, low birthweight[9,20] and stillbirth.[21–23] Deprivation,[20] stress[24,25] and low engagement with pregnancy care[26,27] contribute to these outcomes. In addition, disadvantaged women have more difficulty accessing care,[26] are less likely to receive adequate care, and have less capacity to connect with the healthcare system.[28]

Social determinants of health that contribute to poorer maternal and neonatal outcomes include lower levels of education, poverty, ethnicity,[29] area-based socio-economic indicators,[30] young maternal age,[2] obesity,[31] smoking[32] and rurality or remoteness.[33,34] The authors are not aware of any studies that have analysed both population-based data exploring multiple key social determinants individually and associated perinatal outcomes that demonstrate the impact of disadvantage not only for the mother but also for the fetus or neonate over a long period of time (18 years). The aim of this study was to explore the association between social disadvantage and perinatal outcomes using population-based routinely collected perinatal data (1 188 872 births) collected between 1999 and 2016 in Victoria, Australia. We hypothesised that women living in Australia who experience disadvantage have worse perinatal outcomes than women who are not disadvantaged. By determining which components of disadvantage impact on perinatal outcomes we hope to enable targeted interventions to be developed to address these. The term 'perinatal' is defined in this study as 'occurring in the period shortly before or after birth (usually up to 28 days after)'.[35]

2 | METHODS

This paper presents perinatal outcomes for socially disadvantaged women who gave birth to singleton infants in Victoria between 1999 and 2016 using population-based data.

2.1 | Study design and data source

Individual level de-identified data were obtained from the Victorian Perinatal Data Collection (VPDC), a population-based surveillance system used to regularly collect and collate data from all birthing services across Victoria, Australia. Data collection items are standardised across all health services. A core outcome set has not been used for this study. The definition of a birth by the VPDC is 'any birth or stillbirth that is required to be registered under the Births, Deaths and Marriages Registration Act 1996, defined as any birth greater than 20 weeks or, if gestation unknown, the birthweight was more than 400 g.'[36] The total sample consisted of 1 188 872 singleton births. Data were de-identified before access by the research team. The use of the VPDC data was approved by the Consultative Council on Obstetric and Paediatric Mortality and Morbidity, Victoria. Our study was granted ethical approval by the La Trobe University Human Ethics committee (reference S17/150). There was no patient or consumer involvement in the development or application of this study.

2.1.1 | Inclusion criteria

Births were included in this study if they were singleton births (n = 1 188 872) that occurred in Victoria between 1999 and 2016.

2.1.2 | Exclusion criteria

The original sample consisted of 1 273 404 births. Multiple births (3.3%; n = 41 862) and those involving congenital anomalies (3.5%; n = 44 594) (both the mother and the baby) were excluded from the study. The VPDC data manual[37] defines congenital anomaly as: 'any congenital abnormality detected before birth, at birth or days later. This includes structural, functional, genetic, chromosomal and biochemical anomalies in either a live born or stillborn baby. These anomalies may be multiple or isolated. Other anomalies that include neoplasms, metabolic and haematological conditions should also be reported'.[37] As data collection for the VPDC ceases at discharge from the birth hospital/service, this would be the latest determination of congenital anomalies for reporting. This is documented in the data set as 'reportable congenital anomaly present' or 'no reportable congenital anomaly present'.

2.2 | Variables

2.2.1 | Exposure measures

Social indicators available in the VPDC data set were residential postcode, partner status, and maternal age. Given that, inherently, there are limitations to the social 'picture' that routinely collected data can provide, we also used smoking during pregnancy and being underweight or obese as proxy measures of social disadvantage due to the high rates of these health factors in disadvantaged communities.[14,38,39] More specifically, BMI was explored using the WHO classifications: BMI <18.5 kg/m^2 (underweight), BMI 18.5–29.9 kg/m^2 (normal weight/

pre-obesity), BMI 30–34.9 kg/m^2 (Obesity Class I), BMI 35–39.9 kg/m^2 (Obesity Class II) and BMI >40 kg/m^2 (Obesity Class III).[40]

Maternal age data were continuous variables trichotomised to produce three age groups: 14–19 years, 20–35 years and over 35 years. Partner status was dichotomised to partnered (including married or de facto) and unpartnered (single, divorced, widowed or separated). Data for smoking after 20 weeks of gestation were collected as the number of cigarettes smoked daily, which was dichotomised to smoking (1–99 per day) or non-smoking (zero). The Socio-economic Indexes for Areas (SEIFA) was used to apply area level measures of disadvantage[41] using the Index of Relative Socio-economic Disadvantage (IRSD), which is primarily concerned with variables associated with disadvantage. Typically, a low score indicates that a postcode area has a high number of low-income families, many people working in unskilled occupations and low levels of education.[41] Similarly, we used the Australian Statistical Geography Standard Remoteness Structure[42] to determine rurality/remoteness by grouping areas into five classes of remoteness with respect to relative accessibility of services. The five classes were major cities, inner regional, outer regional, remote and very remote. For the purpose of this study, inner regional, outer regional, remote and very remote were considered a 'rural and remote', which aligns with the Australian Institute of Health & Welfare classifications.[43]

2.2.2 | Maternal outcomes

Maternal outcomes included maternal admission to ICU, caesarean birth of any type (i.e. emergency caesarean or elective caesarean), PPH (defined as blood loss more than 500 mL), labour type (spontaneous or induced) and perineal status. Labour type and perineal status were not reported because there was no statistically significant difference between the disadvantaged and non-disadvantaged cohorts.

2.2.3 | Neonatal outcomes

Neonatal outcomes included preterm birth (babies born before 37 completed weeks of gestation), perinatal mortality (here defined as death occurring before or during labour and/or birth (stillbirth), up to 28 days after birth (neonatal death) where gestational age is 20 or more completed weeks of gestation or with a birthweight of at least 400 g),[44] low birthweight (LBW; birthweight less than 2500 g), admission to special care nursery/neonatal intensive care unit (SCN/NICU) and an Apgar score at 5 minutes of less than 7. Based on existing evidence that the Apgar score lacks adequate interrater reliability and results may not be generalisable,[45] the research team removed this outcome variable from analysis.

2.2.4 | Confounders

All covariates were examined as possible confounders based on their potential to impact on maternal and neonatal outcomes as described in the literature.[9,17,22,35,46] Similarly, other confounders were adjusted for based on their known impact on maternal and neonatal outcomes. These included maternal medical conditions (pre-existing diabetes mellitus,[47] gestational diabetes mellitus,[48] hypertension,[49] pre-eclampsia,[50] eclampsia[51]), country of birth[52] (dichotomised as 'Australia [and territories]' and 'other'), birth type (dichotomised as 'caesarean birth – any type' [including elective or emergency caesarean] and 'vaginal birth – any type' [including normal vaginal or instrumental]), gestation (dichotomised as 'greater than or equal to 37 weeks' or 'preterm') and parity[53] (dichotomised as 'nullipara' and 'multipara').

2.3 | Data cleaning

The raw data were provided by VPDC in Microsoft Excel[54] format. Initial data cleaning was carried out in Microsoft Excel. Variables were reviewed for collection period and accuracy in data entry. Variables were considered by the research team with respect to ranges that were feasible based on accepted parameters within the literature and data items outside these ranges were set to missing and subsequently excluded from the analyses. The data were then imported into Stata (version 16) (StataCorp, College Station, TX, USA) for analysis.

2.3.1 | Missing data

In this study, missing data were less than 0.1% for postcode; less than 0.2% for date of birth (maternal), country of birth, parity, birth status, birth type and gestational age; less than 1% for partner status and birthweight; 1.4% for maternal admission to ICU and neonatal admission to SCN/NICU; 5.8% for smoking after 20 weeks and 9.5% for body mass index measures (maternal height and weight). Women with missing variable values in the regression model were excluded from the data analysis in Stata.

2.4 | Data analysis

Descriptive statistics were calculated first for all exposure and outcome variables, with number and percentage used for categorical variables and mean and standard deviation (SD) used for continuous variables. Rare adverse event prevalence (perinatal mortality and maternal admission to ICU) has been reported using two decimal places whereas other variables have been reported using one. Bivariate analysis followed for each component considered to demonstrate disadvantage – age, partner status, BMI, smoking status,

socio-economic area, rurality – and perinatal outcomes to examine the associations between maternal characteristics and perinatal outcomes. Bivariate logistic regression was conducted to estimate crude odds ratios (cOR) and a 99% CI with the level of significance set at a p value less than 0.001, to account for multiple comparisons, was applied. A 99% CI was considered appropriate given the size of the data set. Adjusted odds ratios (aOR) for the disadvantage variables were calculated using multiple regression for each outcome variable adjusting for covariates and confounders. Adjusted models included maternal age, parity, partner status, IRSD, rurality, plurality, smoking, country of birth, maternal medical conditions, birth type, BMI and gestation. Time-trend analysis was performed using crude annual rates for each outcome variable to examine trends over the study period (1999–2016) by quintiles of area level disadvantage.

Although the VPDC has been collecting data since the mid-1990s, data items have changed over time in response to surveillance requirements driven by clinical policy or risk. Some variables, such as postcode, age and partner status, were consistently collected throughout the data set period (1999–2016), but some variables, such as smoking after 20 weeks of gestation, maternal height/weight and blood loss at delivery, were not routinely collected until 2009. For this reason, the period studied varies according to variables being analysed. Notations regarding collection period for data items have been included in tables where variables have not been consistently collected over time.

3 | RESULTS

3.1 | Maternal characteristics

The population comprised 1 188 872 singleton births in Victoria between January 1999 and December 2016. Maternal characteristics are outlined in Table 1. All eligible women who gave birth in Victoria during this time were included in the study. The mean maternal age was 30.6 years (±5.36 SD, range 14–60 years), mean gestational age at birth was 39.0 weeks (±1.93 SD) and 70.7% of women were born in Australia. Women aged less than 20 years at the time of the birth comprised 2.5% of this cohort and 12.6% of women were unpartnered. Area-level disadvantage indices indicated that 31.4% were in the two most disadvantaged quintiles (SEIFA) and 32.1% of women were living in rural or remote areas. Almost one-fifth of women (19.2%) had a BMI of at least 30 kg/m^2 (Obese)[40] and 3.0% were underweight (BMI <18.5 kg/m^2). Additionally, 6.1% of women smoked after 20 weeks during their pregnancy.

3.2 | Maternal outcomes

Women in this cohort who were admitted to ICU during the period 1999–2016 equated to 0.9%. After adjusting for covariates, maternal medical conditions (pre-existing diabetes mellitus, gestational diabetes mellitus, hypertension, pre-eclampsia, eclampsia), country of birth and birth type, there was an association between living in a disadvantaged area, rurality, and maternal admission to ICU (Table 2). PPH occurred in 14.6% of all births. Women who were underweight or smokers were less likely to experience PPH and women who were unpartnered, obese (all classes) or living in rural or disadvantaged areas were more likely to experience PPH. There was an association between obesity and increased odds of caesarean section (Table 2). A clear gradient was demonstrated in relation to the impact of obesity, with increasing obesity classification associated with increasingly poor outcomes – particularly caesarean birth and PPH. Similarly, a clear gradient was evident with respect to increasing area level disadvantage and increasing rates of maternal admission to ICU and PPH.

3.3 | Neonatal outcomes

The perinatal mortality rate in this cohort was 0.6% (Table 3). Women aged less than 20 years and who lived in the most disadvantaged areas had increased odds of perinatal mortality. The preterm birth rate in the population studied was 6.0% (Table 3). Women who were unpartnered, were aged over 35 years, had a low BMI, smoked and lived in the most disadvantaged areas demonstrated higher odds of preterm birth. Almost one in seven (13.4%) babies were admitted to the SCN/NICU (Table 3). This was consistently higher across all disadvantage variables with a stronger association for women living in the most disadvantaged or rural areas, and women who smoked, had a high BMI, were over 35 years and unpartnered. Overall, 4.8% of babies in the population studied were LBW. For women experiencing disadvantage, higher odds of LBW were seen, particularly for women who were unpartnered, were underweight, smoked or lived in disadvantaged areas (with a clear gradient effect between the most disadvantaged and the least disadvantaged groups). Women who were obese and lived in rural areas were less likely to have an LBW baby.

3.4 | Time-trend analysis

Time-trend analysis demonstrates a persistent gap between the most and least disadvantaged groups over time for all outcomes. Prevalence was calculated on unadjusted, crude annual rates of the outcome for women living in the first and fifth IRSD quintiles (Figure 1).

We found that a persistent, widening gap existed between the most and least disadvantaged groups for maternal admission to ICU and PPH with a general upward trend in rates overall across the time period. Similarly, caesarean section rates have consistently increased over time. There has been a decrease in perinatal mortality between 1999 and 2016 but a persistent variance existed

TABLE 1 Whole population demographics and perinatal outcome data.

Characteristics	*n*	%
All women	1 188 872	100
Maternal age (range 14–60 years; *n* = 1 186 896); mean 30.6 (±5.36) years		
14–19 years	29 938	2.5
20–30 years	534 841	45.1
31–40 years	591 446	49.8
41–60 years	30 671	2.6
Country of birth (*n* = 1 188 872)		
Australia (and territories)	840 071	70.7
Other	348 801	29.3
Partner status (*n* = 1 178 708)		
Partnered	1 030 277	87.4
Unpartnered	148 431	12.6
Gestation at birth (range 20–43 weeks; *n* = 1 186 594); mean 39.0 (±1.93) weeks		
<37 weeks	70 641	6.0
37+ weeks	1 115 953	94.0
Parity (*n* = 1 187 182)		
Nullipara	511 900	43.1
Multipara	675 282	56.9
BMI[a] (range 16–48 kg/m^2) (*n* = 518 253); mean 25.74 (±5.39) kg/m^2		
BMI <18.5 Underweight	15 367	3.0
BMI 18.5–29.9 Non-obese	403 588	77.9
BMI 30–34.9 Obese Class I	61 746	11.9
BMI 35–39.9 Obese Class II	25 235	4.9
BMI ≥40 Obese Class III	12 317	2.4
Plurality (*n* = 1 271 780) before application of exclusion criteria		
Singleton	1 229 838	96.7
Multiple	41 862	3.3
Smoking after gestational age 20 weeks[a] (*n* = 473 343)		
No smoking at all after gestational age 20 weeks	444 518	93.9
Smoking during pregnancy after 20 weeks of gestation	28 825	6.1
SEIFA (*n* = 1 186 799) (Index of relative disadvantage IRSD)		
1st Quintile (Most disadvantaged)	183 351	15.5
2nd Quintile	188 749	15.9
3rd Quintile	241 453	20.3
4th Quintile	265 554	22.4
5th Quintile (Least disadvantaged)	307 692	25.9
Remoteness Index (*n* = 1 188 263)		
Major cities	805 657	67.7
Inner regional	291 637	24.5
Outer regional	88 027	7.4
Remote	2499	0.2
Very remote	443	0.04
Maternal outcomes		
Admission to ICU (*n* = 1 171 885)		
Not admitted	1 161 050	99.1
Admitted to ICU	10 835	0.92
Blood loss[a] (*n* = 563 172); mean 381.25 (±297.59) mL		
Normal EBL (<500 mL)	480 790	85.4
PPH: 500–1000 mL	57 895	10.3
PPH: 1000–2000 mL	22 366	4.0
PPH: >2000 mL	2121	0.4
Labour type (*n* = 1 186 893)		
Spontaneous	444 858	37.5
Induced (Medical &/or Surgical) or augmented	540 126	45.5
No labour	201 909	17.0
Method of birth (*n* = 1 187 113)		
Vaginal birth – non-instrumental	669 035	56.4
Forceps	78 581	6.6
Vacuum extraction	87 157	7.3
Planned caesarean – no labour	174 040	14.7
Unplanned caesarean – labour	132 300	11.1
Planned caesarean – labour	9386	0.8
Unplanned caesarean – no labour	34 210	2.9
Breech	2404	0.2
Neonatal outcomes		
Birthweight (n = 1 185 244); mean 3399.02 (±556.19) g		
BW: 401–2500 g (LBW)	57 059	4.8
BW: 2501–4000 g	988 533	83.4
BW: >4000 g	139 652	11.8
Admission to SCN/NICU (*n* = 1 171 461)		
No admission	1 014 678	86.6
Admitted SCN	146 668	12.5
Admitted NICU	10 115	0.9
Birth status (*n* = 1 187 315)		
Neonatal death	1858	0.16
Livebirth	1 180 175	99.4
Stillbirth	5282	0.44
Congenital anomalies (*n* = 1 265 561) before application of exclusion criteria		
No congenital anomalies	1 220 967	96.5
Congenital anomalies	44 594	3.5

[a]Data items only collected from 2009.

between the most and least disadvantaged groups. Preterm birth, admission to SCN/NICU and LBW rates increased only marginally with a persistent disparity existing between the most and least disadvantaged groups. As the

TABLE 2 Association between maternal disadvantage and maternal outcomes in Victoria, 1999–2016.

Maternal outcomes									
	Admission to ICU			PPH			Caesarean birth – Any type		
Maternal characteristics	*n* (%)	cOR (99%CI)	aOR (99% CI)[a]	*n* (%)	cOR (99% CI)	aOR (99% CI)[a]	*n* (%)	cOR (99% CI)	aOR (99% CI)[a]
Prevalence in whole population	10 835 (0.92)			82 382 (14.6)			349 936 (29.5)		
Maternal age									
<20 years	315 (1.07)	1.21 (1.04, 1.40)	0.96 (0.75, 1.22)	1625 (13.7)	0.92 (0.86, 0.99)	0.86 (0.79, 0.94)*	4483 (15.0)	0.46 (0.44, 0.48)*	0.54 (0.50, 0.58)*
20–35 years	8226 (0.89)	Ref	Ref	64 453 (14.7)	Ref	Ref	259 697 (27.6)	Ref	Ref
35+ years	2286 (1.07)	1.21 (1.14, 1.29)*	1.09 (1.00, 1.19)	16 272 (14.5)	0.99 (0.96, 1.01)	1.00 (0.97, 1.03)	85 665 (39.6)	1.72 (1.70, 1.74)*	1.74 (1.70, 1.78)*
Partner status									
Partnered	9019 (0.89)	Ref	Ref	70 557 (14.5)	Ref	Ref	311 358 (30.2)	Ref	Ref
Unpartnered	1675 (1.14)	1.28 (1.20, 1.38)*	1.15 (1.04, 1.28)	10 581 (15.7)	1.10 (1.07, 1.13)*	1.14 (1.10, 1.19)*	36 148 (24.4)	0.74 (0.73, 0.76)*	0.83 (0.81, 0.86)*
BMI (kg/m^2)									
BMI <18.5 Underweight	176 (1.15)	0.89 (0.75, 1.08)	0.96 (0.78, 1.20)	1773 (11.7)	0.82 (0.76, 0.87)*	0.80 (0.74, 0.86)*	3441 (22.4)	0.69 (0.65, 0.72)*	0.71 (0.67, 0.75)*
BMI 18.5–30 Non-obese	5162 (1.28)	Ref	Ref	55 515 (13.9)	Ref	Ref	119 394 (29.6)	Ref	Ref
BMI 30.1–34.9 Obese Class I	981 (1.59)	1.25 (1.14, 1.36)*	1.04 (0.94, 1.16)	10 227 (16.8)	1.25 (1.21, 1.28)*	1.23 (1.19, 1.27)*	24 109 (39.1)	1.53 (1.49, 1.56)*	1.58 (1.54, 1.62)*
BMI 35–39.9 Obese Class II	486 (1.93)	1.52 (1.34, 1.72)*	1.15 (1.00, 1.32)	4757 (19.1)	1.46 (1.40, 1.52)*	1.42 (1.35, 1.49)*	10 977 (43.5)	1.83 (1.77, 1.90)*	1.90 (1.82, 1.97)*
BMI ≥40 Obese Class III	262 (2.13)	1.67 (1.42, 1.97)*	1.09 (0.90, 1.31)	2601 (21.4)	1.68 (1.59, 1.78)*	1.55 (1.45, 1.65)*	5897 (47.9)	2.19 (2.09, 2.29)*	2.30 (2.18, 2.43)*
Smoking after gestational age 20 weeks									
No smoking	6052 (1.36)	Ref	Ref	65 869 (15.0)	Ref	Ref	143 052 (32.2)	Ref	Ref
Smoking	468 (1.63)	1.20 (1.06, 1.35)*	1.05 (0.91, 1.21)	3655 (12.8)	0.83 (0.79, 0.87)*	0.86 (0.81, 0.90)*	7784 (27.0)	0.78 (0.75, 0.81)*	0.90 (0.86, 0.93)*
SEIFA (IRSD) quintiles									
1st (Most disadvantaged)	2047 (1.13)	1.70 (1.57, 185)*	1.77 (1.58, 2.00)*	13 365 (15.9)	1.24 (1.20, 1.28)*	1.24 (1.19, 1.29)*	47 837 (26.1)	0.78 (0.77, 0.79)*	0.87 (0.84, 0.89)*
2nd	2030 (1.10)	1.65 (1.52, 1.79)*	1.63 (1.44, 1.83)*	13 602 (15.0)	1.15 (1.12, 1.19)*	1.13 (1.09, 1.18)*	53 526 (28.4)	0.87 (0.86, 0.89)*	0.93 (0.90, 0.96)*
3rd	2478 (1.04)	1.56 (1.44, 1.69)*	1.46 (1.30, 1.63)*	18 661 (15.3)	1.18 (1.15, 1.21)*	1.17 (1.13, 1.21)*	70 389 (29.2)	0.91 (0.89, 0.92)*	0.96 (0.93, 0.98)*
4th	2236 (0.85)	1.28 (1.18, 1.38)*	1.20 (1.07, 1.34)*	18 433 (14.4)	1.09 (1.06, 1.13)*	1.07 (1.03, 1.11)*	81 609 (30.8)	0.98 (0.96, 0.99)*	1.03 (1.00, 1.06)
5th (Least Disadvantaged)	2026 (0.67)	Ref	Ref	18 235 (13.3)	Ref	Ref	95 996 (31.2)	Ref	Ref
Rurality (ARIA+)									
Major cities	6710 (0.84)	Ref	Ref	55 087 (14.5)	Ref	Ref	242 337 (30.1)	Ref	Ref
Rural/Remote	4114 (1.10)	1.31 (1.24, 1.38)*	1.22 (1.13, 1.32)*	27 217 (14.9)	1.03 (1.01, 1.05)*	1.08 (1.05, 1.11)*	107 403 (28.2)	0.91 (0.90, 0.92)*	0.92 (0.90, 0.94)*

[a]Adjustment factors: Maternal age, parity, partner status, IRSD (Index of relative Socio-economic Disadvantage), rurality, smoking, country of birth, maternal medical conditions (pre-existing diabetes mellitus, gestational diabetes mellitus, hypertension, pre-eclampsia, eclampsia), birth type (for maternal admission to ICU and PPH), BMI.

*Value of $p < 0.001$.

TABLE 3 Association between maternal disadvantage and neonatal outcomes in Victoria, 1999–2016.

Neonatal outcomes												
	Perinatal mortality[a]			Preterm birth			Admission to NICU/SCN			Low birthweight		
Maternal characteristics	*n* (%)	cOR (99% CI)	aOR (99% CI)[b]	*n* (%)	cOR (99% CI)	aOR (99% CI)[b]	*n* (%)	cOR (99% CI)	aOR (99% CI)[b]	*n* (%)	cOR (99% CI)	aOR (99% CI)[b]
Prevalence in whole population	7140 (0.60)			70 641 (6.0)			156 783 (13.4)			57 059 (4.8)		
Maternal age												
<20 years	347 (1.16)	2.05 (1.78, 2.37)*	1.65 (1.21, 2.24)*	2441 (8.2)	1.46 (1.38, 1.56)*	1.02 (0.91, 1.14)	5025 (16.9)	1.35 (1.29, 1.40)*	0.94 (0.86, 1.03)	2427 (8.1)	1.80 (1.70, 1.90)*	1.02 (0.88, 1.18)
20–35 years	5350 (0.57)	Ref	Ref	53 856 (5.7)	Ref	Ref	121 527 (13.1)	Ref	Ref	44 001 (4.7)	Ref	Ref
35+ years	1426 (0.66)	1.16 (1.08, 1.25)*	1.16 (1.00, 1.34)	14 306 (6.6)	1.18 (1.14, 1.20)*	1.26 (1.20, 1.31)*	30 139 (14.2)	1.10 (1.08, 1.12)*	1.16 (1.13, 1.20)*	10 603 (4.9)	1.05 (1.02, 1.08)*	1.12 (1.06, 1.19)*
Partner status												
Partnered	5658 (0.55)	Ref	Ref	57 302 (5.6)	Ref	Ref	129 611 (12.8)	Ref	Ref	44 374 (4.3)	Ref	Ref
Unpartnered	1401 (0.94)	1.73 (1.60, 1.86)*	1.14 (0.96, 1.35)	12 671 (8.5)	1.58 (1.54, 1.63)*	1.26 (1.20, 1.33)*	25 872 (17.5)	1.45 (1.42, 1.48)*	1.19 (1.14, 1.24)*	12 145 (8.2)	1.98 (1.93, 2.04)*	1.21 (1.13, 1.30)*
BMI (kg/m^2)												
BMI <18.5 Underweight	79 (0.51)	1.07 (0.80, 1.44)	0.84 (0.59, 1.17)	1146 (7.5)	1.36 (1.25, 1.47)*	1.33 (1.21, 1.46)*	2326 (15.5)	1.18 (1.11, 1.25)*	1.05 (0.97, 1.13)	1413 (9.2)	2.13 (1.98, 2.30)*	2.10 (1.90, 2.34)*
BMI 18.5–29.9 Non-obese	1940 (0.48)	Ref	Ref	22 644 (5.6)	Ref	Ref	52 438 (13.4)	Ref	Ref	18 308 (4.6)	Ref	Ref
BMI 30–34.9 Obese Class I	387 (0.63)	1.31 (1.13, 1.51)*	1.18 (1.00, 1.41)	3792 (6.2)	1.10 (1.05, 1.15)*	1.03 (0.98, 1.09)	9717 (16.2)	1.25 (1.22, 1.29)*	1.26 (1.21, 1.31)*	2418 (3.9)	0.86 (0.81, 0.91)*	0.73 (0.68, 0.79)*
BMI 35–39.9 Obese Class II	184 (0.73)	1.52 (1.25, 1.86)*	1.34 (1.05, 1.70)	1702 (6.8)	1.22 (1.14, 1.30)*	1.05 (0.97, 1.14)	4632 (18.9)	1.51 (1.44, 1.57)*	1.50 (1.42, 1.58)*	979 (3.9)	0.85 (0.78, 0.93)*	0.66 (0.58, 0.74)*
BMI ≥40 Obese Class III	100 (0.81)	1.69 (1.30, 2.20)*	1.43 (1.04, 1.96)	885 (7.2)	1.31 (1.19, 1.43)*	1.09 (0.98, 1.21)	2670 (22.3)	1.86 (1.75, 1.97)*	1.80 (1.67, 1.94)*	493 (4.0)	0.88 (0.78, 0.99)	0.62 (0.53, 0.73)*
Smoking after gestational age 20 weeks												
No smoking	2356 (0.53)	Ref	Ref	25 695 (5.8)	Ref	Ref	57 792 (13.1)	Ref	Ref	19 197 (4.3)	Ref	Ref
Smoking	246 (0.85)	1.62 (1.36, 1.92)*	0.94 (0.75, 1.16)	2983 (10.4)	1.88 (1.79, 1.98)*	1.74 (1.64, 1.85)*	6045 (21.2)	1.79 (1.72, 1.86)*	1.41 (1.34, 1.48)*	3214 (11.2)	2.78 (2.64, 2.93)*	3.02 (2.79, 3.27)*
SEIFA (IRSD) quintiles												
1st (Most disadvantaged)	1504 (0.82)	1.76 (1.60, 1.93)*	1.50 (1.24, 1.83)*	12 223 (6.7)	1.28 (1.24, 1.33)*	1.13 (1.07, 1.20)*	29 452 (16.2)	1.48 (1.45, 1.51)*	1.37 (1.31, 1.43)*	11 171 (6.1)	1.61 (1.55, 1.66)*	1.40 (1.29, 1.51)*
2nd	1228 (0.65)	1.39 (1.26, 1.54)*	1.25 (1.02, 1.53)	12 035 (6.4)	1.22 (1.19, 1.26)*	1.10 (1.03, 1.16)*	25 694 (13.8)	1.22 (1.19, 1.25)*	1.04 (1.00, 1.09)	10 034 (5.3)	1.39 (1.34, 1.44)*	1.28 (1.18, 1.38)*
3rd	1515 (0.63)	1.34 (1.22, 1.47)*	1.26 (1.05, 1.52)	14 759 (6.1)	1.17 (1.14, 1.21)*	1.10 (1.04, 1.16)*	33 058 (14.0)	1.24 (1.21, 1.26)*	1.12 (1.08, 1.17)*	11 951 (5.0)	1.29 (1.25, 1.33)*	1.17 (1.09, 1.26)*
4th	1428 (0.54)	1.15 (1.04, 1.26)*	1.08 (0.90, 1.30)	15 254 (5.8)	1.10 (1.06, 1.13)*	1.04 (0.98, 1.09)	33 178 (12.7)	1.11 (1.08, 1.13)*	1.02 (0.98, 1.06)	11 823 (4.5)	1.15 (1.11, 1.19)*	1.08 (1.01, 1.16)
5th (Least Disadvantaged)	1444 (0.47)	Ref	Ref	16 222 (5.3)	Ref	Ref	35 066 (11.6)	Ref	Ref	11 960 (3.9)	Ref	Ref

TABLE 3 (Continued)

Neonatal outcomes													
Maternal characteristics	Perinatal mortality[a]			Preterm birth			Admission to NICU/SCN			Low birthweight		
	n (%)	cOR (99% CI)	aOR (99% CI)[b]	*n* (%)	cOR (99% CI)	aOR (99% CI)[b]	*n* (%)	cOR (99% CI)	aOR (99% CI)[b]	*n* (%)	cOR (99% CI)	aOR (99% CI)[b]
Rurality (ARIA+)												
Major cities	4642 (0.58)	Ref	Ref	46 427 (5.8)	Ref	Ref	99 197 (12.4)	Ref	Ref	38 035 (4.7)	Ref	Ref
Rural/Remote	2484 (0.65)	1.13 (1.06, 1.21)*	1.04 (0.91, 1.18)	24 152 (6.3)	1.10 (1.08, 1.13)*	1.00 (0.96, 1.04)	57 404 (15.5)	1.29 (1.27, 1.31)*	1.11 (1.08, 1.15)*	18 976 (5.0)	1.06 (1.03, 1.08)*	0.90 (0.85, 0.95)*

[a]Perinatal mortality defined as death occurring before or during labour and/or birth (stillbirth) or up to 28 days after birth (neonatal death) where gestational age is 20 or more completed weeks of gestation or with a birthweight of at least 400 g (Australian Institute of Health & Welfare, 2021).

[b]Adjustment factors: Maternal age, parity, partner status, IRSD (Index of relative Socio-economic Disadvantage), rurality, smoking, country of birth, maternal medical conditions (pre-existing diabetes mellitus, gestational diabetes mellitus, hypertension, pre-eclampsia, eclampsia), BMI, gestation.

*Value of $p < 0.001$.

time-trend analysis is unadjusted, the results should be interpreted with caution.

4 | DISCUSSION

4.1 | Main findings

In this large population-based study, we found that social disadvantage and related factors were associated with increased odds of adverse perinatal outcomes. When women experienced one or more elements of disadvantage, and after adjusting for covariates and maternal medical conditions, we found significantly higher odds of maternal admission to ICU and PPH, perinatal mortality, preterm birth, admission to SCN/NICU and LBW babies.

4.2 | Strengths and limitations

This was a large population-based study including over 1 188 872 births in the data set. The data are a near complete record for a large population of childbearing women ensuring that selection bias is minimised within the cohort. Data were collected over a period of 18 years adding to both reliability and validity of the study. The VPDC has been validated by researchers and found to have high levels of accuracy (90.2–100%) and may be reliably used for population health reporting and research.[55]

Limitations in the use of routinely collected data are evident, however, with respect to social factors. This study could not consider factors such as family or intimate partner violence, which is more prevalent in disadvantaged communities[56] and is associated with intrauterine growth restriction (and subsequent LBW), preterm birth and stillbirth.[57] Similarly, women and families experiencing disadvantage are at increased risk of early life abuse or traumatic experiences leading to complex trauma,[58] which can also impact on maternal and neonatal outcomes.[59] This information is not routinely or reliably collected by VPDC,[37] so the evaluation of the impact of these factors was not possible. In addition, other environmental and social factors such as stress,[60] pollution,[61,62] nutrition,[63,64] mental illness,[65] housing quality,[66] cultural needs[67] and social isolation[5,68] are critical to understanding contributors that may create the mechanism through which disadvantage impacts so markedly on perinatal outcomes. Furthermore, maternal smoking status may be impacted upon by underreporting due to the self-reporting nature of this variable[69] and the social desirability bias that may exist.[70]

A further limitation of this study is that indigenous status, which has been demonstrated to be independently associated with increased prevalence of all adverse maternal and neonatal outcomes[71,72] was not available in the data set received from the VPDC. Further to this, patient admission status (private or public) was not available within the data set used for this study and model of care data

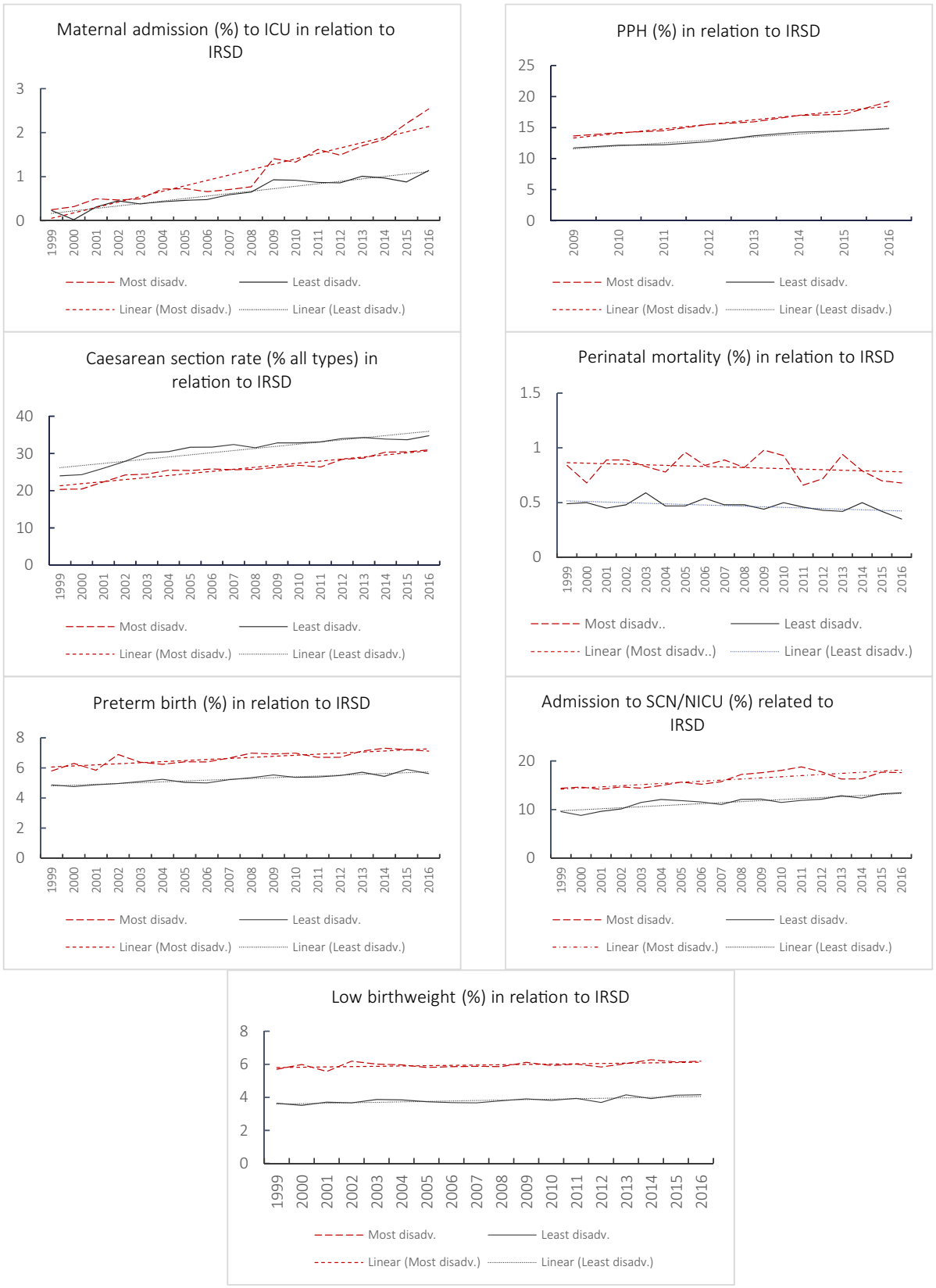

FIGURE 1 Maternal admission to intensive care unit (ICU), postpartum haemorrhage (PPH), caesarean section rate, perinatal mortality rate, preterm birth, admission to special care nursery/neonatal intensive care unit (SCN/NICU), low birth weight (LBW) by year comparing the most disadvantaged and least disadvantaged areas (Index of Relative Socio-economic Disadvantage [IRSD] quintiles).

(obstetric, midwifery-led care, etc.) were not been routinely collected by VPDC until 2022 when the Maternity Care Classification System (MaCCS) was introduced as a data item.[73]

4.3 | Interpretation (in light of other evidence)

The impact of social disadvantage on maternal and neonatal outcomes is significant and our findings are consistent with previous research.[3,5,23,26,35,74–85] Our analysis of trends over time aligns with findings from the UK that demonstrate an overall declining trend in perinatal mortality but a persistent inequality in the prevalence of this, preterm birth and fetal growth restriction rates in the most disadvantaged communities.[86,87] A United States study also noted a 65% increase in severe maternal morbidity between 2007 and 2014[88] and Victorian Severe Acute Maternal Morbidity (SAMM) data indicates that postpartum haemorrhage is the most common reason for maternal admission to ICU.[89] Although socio-economic circumstances are independently influential variables, this does not seem to account for the entire deprivation gap that exists between the most and least disadvantaged women and their families.[90] Neighbourhood-level factors seem to compound maternal social determinants and health behaviours that may also independently adversely affect perinatal outcomes[90] in addition to perpetuating intergenerational disadvantage through social exclusion and a lack of opportunity.[91]

The causal pathways by which these outcomes persist remains largely unknown and is complex. This may be related to disadvantage impacting on women's capacity to access care,[92,93] delayed engagement with care,[94,95] environmental factors such as occupational class,[5] intimate partner violence prevalence in disadvantaged households,[96] psychosocial stress[5,97] and fetal programming,[98] among other antecedents. Australia has a universal healthcare system in which maternity care is provided free of charge and these findings indicate that socio-economic disparities persist for perinatal outcomes even with a universal healthcare system in place. For women living in disadvantaged rural areas this may be the result of a lack of rural maternity services resulting in a shifting of cost, burden and risk from health services to women and their families in vulnerable circumstances.[99] The impact of this on antenatal engagement, access to care (both routine and emergency) and subsequent clinical outcomes in rural areas is largely unknown. Understanding how maternity care is delivered and experienced across all jurisdictions is critical to understanding barriers that exist, and examining elements that disempower,[100] threaten, stigmatise[101] and disengage vulnerable or marginalised women.[102]

The data presented in this study illuminate a picture of inequity and persistent disparities that have existed for disadvantaged women over a long period of time. The healthcare system and associated governing bodies and healthcare organisations can effect change through policy and resource decisions that are made through an 'equity lens', particularly with respect to access. Co-design and co-production of perinatal services with women living in vulnerable circumstances will ensure that services meet the needs of women at greatest risk of experiencing adverse outcomes.[103] Integrating trauma-informed training and practice into maternity care may facilitate earlier and sustained contact with the health system during pregnancy, labour, birth and through the early parenting period.[104] Furthermore, midwifery models of care that are based in continuity, in collaboration with the broader healthcare team, have been shown to improve perinatal outcomes for socially disadvantaged women and babies[105] as well as improving the experience of maternity care for this vulnerable group.[106] However, access to midwifery continuity of care models have not historically been available to less privileged women, who also experience health states that indicate risk (such as smoking and obesity).[107] Maternity care reform that leverages collaborative models of care and addresses equitable access to care that is safe, individualised, relational and based in their own community using digital health capability will ensure disadvantaged women consistently receive the right care, in the right place, at the right time.

Further research examining the social patterning of health behaviours such as smoking and obesity and their link to poverty, education, cultural deprivation and stressful circumstances[108] will enable initiatives to be targeted at those social elements rather than at an individual level. Furthermore, strategies targeting disadvantaged areas to improve access to services and interventions through equitable distribution will mitigate the impact of these social determinants.[109]

5 | CONCLUSION

Social disadvantage for childbearing women in Victoria between 1999 and 2016 was associated with increased rates of adverse perinatal outcomes. This aligns with national and international evidence regarding the impact of disadvantage. System-wide reform is required including models of care that enhance trust and engagement and reduce systemic barriers that exist for vulnerable women within complex maternity systems. Addressing the social determinants of health impacting on the health and well-being of disadvantaged women and their newborns is also key to mediating the impact of social disadvantage.

AUTHOR CONTRIBUTIONS

FF contributed to conceptualisation, methodology, data curation, data cleaning, data analysis, writing – original draft, investigation, formal analysis, writing – review & editing. TS contributed to supervision, methodology, evaluation design, data cleaning, data analysis,

writing – original draft, writing – review & editing. HM contributed to supervision, conceptualisation, methodology, evaluation design, writing – original draft, writing – review & editing. DF, IM and BC contributed to writing – review & editing. KE contributed to supervision, evaluation design, data curation, data analysis, writing – original draft, writing – review & editing.

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CONFLICT OF INTEREST STATEMENT

None declared. Completed disclosure of interests form available to view online as supporting information.

DATA AVAILABILITY STATEMENT

Access to data that support the findings of this study can be sought from the Consultative Council on Obstetric and Paediatric Mortality and Morbidity, Safer Care Victoria, via the VAHI Data Request Hub https://vahi.freshdesk.com/support/home (contact via perinatal.data@dhhs.vic.gov.au). Data cannot be shared publicly because the authors only have permission to use data for the research outlined in the data request, and the authors do not have permission to share data. The authors did not have any special access privileges that others would not have.

ETHICS APPROVAL

La Trobe University Faculty Human Ethics Committee on 8 May 2020 (FHECS17-150).

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