


Social determinants and inequitable maternal and perinatal outcomes in Aotearoa New Zealand

Women's Health
Volume 18: 1–14
© The Author(s) 2022
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/17455065221075913
journals.sagepub.com/home/whe


Pauline Dawson¹ , Benoit Auvray², Crystal Jaye¹,
Robin Gauld¹ and Jean Hay-Smith¹

Abstract

Objectives: Aotearoa New Zealand has demonstrable maternal and perinatal health inequity. We examined the relationships between adverse outcomes in a total population sample of births and a range of social determinant variables representing barriers to equity.

Methods: Using the Statistics New Zealand Integrated Data Infrastructure suite of linked administrative data sets, adverse maternal and perinatal outcomes (mortality and severe morbidity) were linked to socio-economic and health variables for 97% of births in New Zealand between 2003 and 2018 (~970,000 births). Variables included housing, economic, health, crime and family circumstances. Logistic regression examined the relationships between adverse outcomes and social determinants, adjusting for demographics (socio-economic deprivation, education, parity, age, rural/urban residence and ethnicity).

Results: Māori (adjusted odds ratio=1.21, 95% confidence interval=1.18–1.23) and Asian women (adjusted odds ratio 1.39, 95% confidence interval=1.36–1.43) had poorer maternal or perinatal outcomes compared to New Zealand European/European women. High use of emergency department (adjusted odds ratio=2.68, 95% confidence interval=2.53–2.84), disability (adjusted odds ratio=1.98, 95% confidence interval=1.83–2.14) and lack of engagement with maternity care (adjusted odds ratio=1.89, 95% confidence interval=1.84–1.95) had the strongest relationship with poor outcomes.

Conclusion: Maternal health inequity was strongly associated with a range of socio-economic and health determinants. While some of these factors can be targeted for interventions, the study highlights larger structural and systemic issues that affect maternal and perinatal health.

Keywords

health equity, health services, maternal health, population health, social determinants of health

Date received: 8 September 2021; revised: 16 December 2021; accepted: 5 January 2022

Introduction

Health inequity is a disparity in the health of different groups or individuals that has a social justice implication. The World Health Organization (WHO) currently describes inequity using Whitehead's landmark definition of 'differences in health which are not only unnecessary and avoidable but, in addition, are considered unfair and unjust'.¹

Inequity is both a global and localized problem. Even within high-income countries, stark health inequities are present, and frequently associated with broader social disparities.^{2,3} Much of the current research on disparities in

health outcomes tends to investigate the source of these inequities via proximal variables, such as body mass index (BMI), smoking and other lifestyle factors. However, while these studies are useful, they fail to demonstrate root causes of health inequity, the *social* determinants.

¹University of Otago, Dunedin, New Zealand

²Iris Data Science, Dunedin, New Zealand

Corresponding author:

Pauline Dawson, University of Otago, PO Box 56, Dunedin 9054, New Zealand.

Email: pauline.dawson@otago.ac.nz



Marmot calls social determinants of health the 'causes of the causes',² and these are the underlying, personal, intermediary and structural issues that produce inequities. Frameworks describing these determinants and their interactions have been created by Solar and Irwin⁴ and form a core part of the WHO's efforts to address health equity.⁵ Solar and Irwin stated that the most significant stratifiers and indicators of inequity, 'include: Income, Education, Occupation, Social Class, Gender, Race/ethnicity'.⁴

The WHO Commission on Social Determinants of Health (CSDH)⁵ is unequivocal that the underlying causes of health inequity are social; not everyone has the same capability, due to social factors, to take advantage of provided opportunities.^{6,7} Social determinants as a cause of health inequity have been researched extensively and demonstrably contribute to health inequity worldwide,^{5,8} including in Aotearoa New Zealand (hereafter called New Zealand or NZ).⁹

Background

Maternity care provides an exemplar for examining the interactions between social determinants and health inequity.^{10,11} Social determinants are suggested as causes of inequity in maternal and perinatal outcomes in national monitoring reports^{12,13} and empirical research^{10,14} frequently in regard to access or engagement with care. The impact of social factors at the start of life has long been described, with life-long and intergenerational sequelae.^{2,11,15}

Maternity outcome inequities in New Zealand have been established via national reports and studies, yet there has been little shift in these outcomes over many years.^{12,13} For instance, there is a significantly higher maternal mortality rate among Māori (23.48/100,000 maternities) and Pacific women (22.23/100,000 maternities) compared to New Zealand European women (11.33/100,000 maternities) in combined data from 2006 to 2018 in the national Perinatal and Maternal Mortality Review Committee (PMMRC) report.¹² Similar perinatal mortality inequities are evident in that report. Maternal morbidity studies in New Zealand show similar trends to maternal mortality,^{10,14,16,17} and expose the poor outcomes for the most deprived New Zealand women, with over-representation of poor maternal outcomes for Māori, Pacific and women of Indian origin.^{10,18}

New Zealand has a socialized, universal health care system.¹⁹ Maternity care, from primary to tertiary level, is provided at no cost to all New Zealand resident women, unless they opt to pay for private care. In an internationally unique system, primary care is largely (93% in 2018)²⁰ provided by autonomous lead maternity carers (LMCs) that contract to the state and who are mainly midwives.^{21,22} The LMC model provides continuity of care, which is shown to reduce inequities.^{23,24} Nevertheless, the context for this study is that there are known barriers to maternal

health equity in New Zealand.²⁵ These barriers are a complex set of circumstances (access, cultural considerations, colonialism, political context and the maternity system itself) mirroring the social determinants in the aforementioned frameworks.²⁵

Uniquely, New Zealand also has obligations under the Treaty of Waitangi /Te Tiriti o Waitangi to work in partnership with Māori (the indigenous peoples of New Zealand), to preserve self-determination and strive actively to achieve health equity. A 2019 report found that the crown breached the treaty by failing to structure and fund primary health systems to address ongoing Māori health inequities.²⁶ These Māori health inequities can be linked to the 'causes of causes', or social determinants. For example, Māori have a severe housing deprivation rate of 166.0 per 10,000 compared to 41.2 per 10,000 for NZ/European,²⁷ and 63% of Māori live in the two highest deprivation quintile areas compared to 34% of non-Māori.²⁸ Māori are also less likely to gain a post-secondary school qualification than the total population (20.7% compared to 34.6%).²⁹ These statistics suggest that the health and socio-political systems are not fit-for-purpose, attributed to the ongoing effects of colonialism and racism.^{30,31}

While governmental reports describe these inequities, links to social determinant causes are only suggested and not yet specifically explored quantitatively. For example, the PMMRC^{12,32} and Maternal Morbidity Working Group (MMWG)^{13,18} reports cite 'barriers to access and/or barriers to engagement with care were the most common type of contributory factor' to poor outcomes, but do not detail or investigate what the social determinant barriers to access are. Some small New Zealand studies have reported mental health, drug and alcohol issues, family violence, cultural and language barriers and ineligibility for free care are associated with maternal mortality and morbidity.^{14,16} Barriers to engagement with care for Māori women,³³⁻³⁵ and the ongoing effects of colonialism and entrenched poverty as contributors to structural and systemic issues in maternity inequalities have also been explored.^{25,36}

Similarly, there are limitations in the international literature. While these studies may have larger cohorts, there is a focus on a few specific determinants, such as food insecurity³⁷ and homelessness³⁸ or specific populations.³⁹ A systematic review of birth outcomes in high-income countries found common determinants of poor outcome, such as poverty, but confirmed studies were usually focussed on a few variables or general population indicators (e.g. linking mortality rates with gross domestic product (GDP) or parental leave provisions).⁴⁰

While existing research indicates that there are likely social determinants underlying maternity outcomes, the relationships between poor outcome (mortality and morbidity) and a broad series of social determinant variables has not been explored in a national birthing population within New Zealand, and there is no comparable literature

Table 1. Composition of ‘any adverse event’ outcome variable.

Mortality	Maternal Neonatal Stillbirth
Morbidity (mother)	Severe postpartum haemorrhage ^a Eclampsia ICU admission Peripartum hysterectomy
Morbidity (infant) ^b	Very preterm birth (≤ 28 weeks) Low birth weight (≤ 2500 g) Neonatal level 3 ICU admission

ICU: intensive care unit.

^aReported by available variables of blood transfusion and postpartum haemorrhage combined as a proxy. No consistent data on iron infusion available.

^bLive births only.

on this internationally. Access to government-linked datasets provided an opportunity to analyse a significant period of national birthing population data linked to a range of social determinants in New Zealand.

In this study, we examined the relationships between a composite poor perinatal outcome for mother and/or baby and social determinants of health within New Zealand for a large majority of the total birth population over a 16-year period. We hypothesized that the socio-economic determinant variables of health inequity, selected using established frameworks, would be correlated with poor outcomes.

Methods

Study design and participants

This study was a retrospective population cohort study utilizing large linked governmental datasets. The Ministry of Health maternity data contained all known pregnancies of 20+ weeks gestation in New Zealand between 2003 and 2018, which is estimated to cover 97% of all births in that period.⁴¹ As this was all the birthing population data available from national government sources and constituted almost all births for a 16-year period, it can be defined as purposive total population sampling.⁴² Based on approximate annual birthing numbers of 60,000 per annum, we estimated the data set would contain data describing over ~950,000 birth events.

These maternal records were linked to the baby(ies) from each pregnancy, and so that connected maternal and perinatal outcomes and demographic data were obtained. Each unique pregnancy was also linked to social determinant variables found in other government data sets. Our focus was on the circumstances around each individual pregnancy/birth as these circumstances might change (or not) between pregnancies/births. In a longitudinal birth population, some women would likely appear more than

once, and this could therefore be a confounder of the relationship between circumstances and outcome.

Use of these data was approved by the University of Otago Human Research Ethics Committee (HD18/024) and a New Zealand Health and Disability Ethics Committee ‘Out of Scope’ letter (19 February 2018). Te Tiriti obligations were honoured through consultation with the Ngāi Tahu Research Consultation Committee and other stakeholders through the course of the research.

Data source and collection

The data were sourced from the Statistics NZ Integrated Data Infrastructure (IDI),⁴³ a linked administrative database. The IDI contains 14,854 variables and approximately 70 million records sourced from 15 different agencies.⁴⁴ De-identified data are linked probabilistically and individuals allocated a unique key, allowing (in this instance) health data to be related to data collected from other agencies, such as taxation, social welfare, government statistical surveys and also some non-government organizations.⁴³ Strict regulations surround access to these data that protect any potential identification of individuals through a multi-layered ‘five safes’ precautionary system.⁴³ The IDI can only be accessed by approved researchers, for projects that are in the public interest and within a secure accredited data lab. Any datasets created and analysed cannot be removed unless through strict centralized output checking processes.⁴⁵ These regulations meet requirements under the Statistics Act 1975 Section 37C⁴⁶ and the Privacy Act 2020⁴⁷ negating individual consent for use of these data. The rigorous data output rules⁴⁵ means that all raw counts reported here have been randomly rounded either up or down to the nearest multiple of 3 (RR3), small numbers are suppressed and usually ranges cannot be reported.

Outcomes and variables

The primary outcome variable was any adverse perinatal outcome – defined as experience of any one or more maternal or neonatal mortality or severe morbidity variables (Table 1). Selection of maternal morbidity variables (severe postpartum haemorrhage, eclampsia, intensive care unit (ICU) admission and peripartum hysterectomy) was informed by the New Zealand Maternal Morbidity Monitoring Group¹³ and the severe acute maternal morbidity study.¹⁰ Common neonatal morbidity variables, very preterm birth (≤ 28 weeks) and low birth weight (≤ 2500 g) were selected a priori. Level 3, the highest level of neonatal intensive care unit (NICU) admission, was also chosen as a proxy for morbidity in the new-born. A composite outcome (any adverse event) was decided on to reflect the interconnectedness of the mother–infant dyad and the nature of birth (and any negative aspects) as a wider family and community event.

Table 2. Demographic variables.

Variable	Categorization (reference group in bold)
Age group	Under 16, 16–19 , 20–24, 25–29, 30–34, 35–39, 40–44, 45 and over
Parity	0 , 1, 2, 3, 4, 5, 6 +
Prioritized ethnicity	NZ/European , Māori, Pacific, Asian, Other
NZDep index decile (1–10)	Decile 1–10
Locality	Urban , semi-rural, rural, remote rural
Educational level ^a	No qualification , high school only, undergraduate, post graduate

NZDep: New Zealand deprivation; NZ: New Zealand.

^aExcludes those educated outside New Zealand or whose education pre-dated the available records (secondary school records from 2007 and 1994 for tertiary).

Reference group is indicated in **bold**.

Demographics variables of age group, parity, prioritized ethnicity, New Zealand deprivation (NZDep) index decile (1–10), locality and educational level were gathered at the time of the birth event (Table 2). Social determinant variables (Table 3) were assessed at the time of birth, if possible, but dictated by data availability. For example, it could not be ascertained if someone was registered with a primary general health service at the time of birth, only if they had ever been registered. The temporal aspects of the variables are indicated in Table 3. In line with this, although census data (collected 5-yearly) were available for the study period, they were not used because these could be up to 5 years distant from the birth event.

While demographics are themselves independent variables, in this instance, they have been categorized as covariates to adjust for in regression modelling. It could be argued that some of these demographic variables (deprivation decile, location and education) could be classed as either demographic or social determinants. However, this is the nature of social determinant research – as all social determinant variables could also be called demographic in that they describe the nature of a population.⁴⁸

Self-reported ethnicity at maternal registration is recorded in the Ministry of Health data as a single prioritized ethnicity. In the prioritized ethnicity system, a person is allocated a single ethnicity (if they declare more than one) in the following order of priority: Māori, Pacific, Asian and European/Other.⁴⁹ Where these data were not obtained at registration, they were available by linking to Ministry of Health ethnicity metadata sourced from other health encounters and therefore were largely complete.

NZDep index decile⁵⁰ was also included based on the residential address of the birthing person at the time of the birth, ten being most deprived and one being least deprived.

Table 3. Social determinant variables.

Income and employment
State beneficiary at time of birth
Crime
Ever in prison
Birth in prison
Victim of any crime (2014–2018)
Victim of IPV (2014–2018)
Victim of any violent crime (2014–2018)
Violent offender ever
Housing
Accommodation supplement benefit received at time of birth
In state-owned (public) housing at time of birth
More than three notified address changes in year of birth (6 months either side of birth)
Health
More than three visits to emergency department in year of birth
Trimester when first registered for antenatal care (first , second, third, unregistered at birth) ^a
Unregistered for care at birth
Any contact with secondary mental health, drug and alcohol services ever
Ever registered with a primary care practice/family doctor
Has a disability assessed as qualifying for government assistance at time of birth
Access
Current driver's licence at time of birth
Family
Mother ever had contact with child welfare services as a child (including being in foster care)
New Zealand resident at time of birth
Refugee (came to live New Zealand as an asylum seeker)

IPV: intimate partner violence.

^aReference category in **bold** (first trimester).

NZDep is a New Zealand standard for measuring deprivation in small geographic areas derived from the most recent census data. Dimensions used to develop the index include income, digital access, employment, home ownership, family makeup and housing conditions.⁵¹

New Zealand's population is sparsely distributed in some areas, with people having to travel over four hours by road to get to a secondary or tertiary hospital. Therefore, urban, semi-rural, rural or remote rural geographic funding designations, which are based on distance of the birthing person's residential address to the nearest hospital, were included.

Social determinants were grouped into several domains (Table 3). Variable selection was determined by existing research evidence, deprivation indexes,^{50,52} WHO reports and frameworks,^{4,5} and tempered by what data were available within the IDI data source. Several iterations of variable development were required as we explored alignment with frameworks and existing research evidence, duration for which data were available and the extent of 'missingness'. For instance, income and employment were represented by

whether a state income benefit was received at the time of birth or not. This is a likely proxy for financial deprivation as the New Zealand welfare benefit provides an income below the poverty line.⁵³ Other sources of data were problematic as indicators of low levels of economic resource. For instance, tax data can show that some people declared a financial loss for the year without this being an indicator of low income. Where data were only obtainable for a short period in relation to the birth data set (e.g. crime victimization data were only available 2014–2018), the analysis only included births from the same time period.

Health-related determinants were included as they frequently have aspects related to social issues. Also, the health system itself is identified as an intermediary social determinant in Solar and Irwin's framework.⁴ For instance, emergency department usage was included as this service is frequently utilized where there are access barriers to more appropriate primary services.⁵⁴ Another health inclusion was disability where government financial support was in place. While some argue disability is a core health issue⁵⁵ proponents of the social model of disability see this as a focus on impairment rather than the societal limitations and impacts of living with a disability.⁵⁶ As there are few disabilities that might physiologically impair a positive birth outcome, it was included as a social determinant.

Statistical analysis

Logistic regression modelling (binomial dependent variables) was used to investigate association between social determinant variables and outcome variables. A combined composite variable of 'any adverse maternal or perinatal outcome' was created and used for the overall analysis reported here. Each independent determinant variable was analysed individually as adjusted and unadjusted odds against the composite adverse outcome variables. Adjusted modelling took account of demographic covariates described in Table 2.

Data extraction, initial counts and data management were carried out directly using Microsoft SQL Server Management Studio (SSMS) 2012 software and structured query language (SQL) code. Additional analysis was completed with R version 3.4.1⁵⁷ via RStudio provided in the IDI lab environment. Specific R packages utilized for analysis are referenced within the text.

Because there was a strong association between independent variables (tested by Cramér's V – see section A of the Supplementary Material), the effect of each social determinant variable was fitted in a separate logistic model.

Imputation

For the largest robust dataset possible, multivariate single imputation was carried out using a machine learning algorithm via the R software package *missRanger* (version 2.1.0).⁵⁸ *missRanger* can handle both continuous

and categorical variables and each variable is imputed by predictions from a random chained forest model using all the other variables as covariables.^{59,60} While single imputation can underestimate variance,⁶¹ the chosen method is proven and robust.^{59,62} External validation was carried out for variables with large missing components (e.g. education). Further technical detail about this method of imputation and parameters used are reported in section B of the Supplementary Material.

Results

Population characteristics

Counts for the 2003–2018 period (randomly round by 3)⁴⁵ gave a set of 972,378 pregnancies from 548,949 individual women. These pregnancies resulted in 972,996 live babies. The demographic makeup of the population (prior and after imputation) is shown in Table 4. Over the 16 years, more than half of births were to women aged between 25 and 34 years (56%).

Forty percent of births were the first and another third were second births. Most women (68%) resided in urban areas and there were more births for women who lived in higher deprivation areas than in low deprivation regions. While over 40% of women had completed some form of tertiary education, 26% had no high school or higher educational attainment. Māori and Pacific women were more likely to live in highly deprived areas (Figure 1). These groups also had lower mean age at birth and higher parity (Table 5).

Proportions after imputation did not change significantly except for education, so that external validation was completed. Census data of all women aged 15–50 were extracted for 2006 and 2018 census²⁹ (section B of the Supplementary Material) to give an indication of highest qualification levels at that time. Having no qualifications dropped from 22% in 2006 to 17% in 2018 and there was an increase in post-graduate qualifications (6%–12%). The census also had missing data (4%–6%). While these census data are not the same as the imputed proportions in this study, the populations cover different time spans (our study contains data from 2003 to 2018) and we can also assume that some women in the 15–50 census group were childless.

Population proportions before and after imputation for the social determinant variables are reported in section B of the Supplementary Material. The missing data predominantly related to linkage issues between data sets, so that, proportions are the same for many variables, for example, 1.6% when people in the maternity data did not link to anywhere elsewhere in the IDI.

Relationships between demographics and adverse outcome

Raw unadjusted odds ratio (OR) demonstrated that, compared to NZ European (NZE) women and those

identifying as European, all other prioritized ethnic groups had increased odds of any adverse outcome; the greatest odds were observed for Asian women (OR=1.42, 95% confidence interval (CI): 1.39–1.45). Compared to 16- to 19-year-olds, those who were 45 years and over had higher odds of adverse outcomes (OR=1.51, 95% CI=1.33–1.7) with reduced odds of poor outcome in age groups of 25–29 years (OR=0.73, 95% CI=0.11–0.76) and 30–35 years (OR=0.71, 95% CI=0.69–0.74). Poor outcomes increased with parity and with higher deprivation deciles. Outcomes were slightly better for those in rural areas when compared to urban.

When adjusted for other demographic factors, the odds of adverse outcome reduced for Pacific women from adjusted odds ratio (aOR) of 1.24%–1.09 (95% CI=1.06–1.12), while Māori only had a slight reduction from 1.39 to 1.21. The aOR of the over 45 age group rose from OR=1.51 to aOR=1.94 (95% CI=1.71–2.2). While outcome still worsened with increasing decile (i.e. lower socio-economic status), this effect was reduced (Table 6).

Relationships between social determinants and adverse outcome

The results from the social determinant variable analysis were grouped by domain and, within each domain, the data ordered by the aOR are shown in Figure 2 and detailed in Table 7.

In regression modelling, greater odds and adjusted odds of any adverse outcomes were associated with one or more variables in each of the social determinant domains and most of these associations were statistically significant. The greatest adjusted odds of any adverse outcomes were health related: high use of emergency departments (aOR=2.68, 95% CI=2.53–2.84), those with a disability qualifying them for state assistance (aOR=1.98, 95% CI=1.83–2.14) and being unregistered at birth (indicating no antenatal care; aOR=1.89, 95% CI=1.84–1.95). The most protective elements were: having ever been registered with a primary health care organization (aOR=0.85, 95% CI=0.78–0.92) and registering for any antenatal care indicated by registration before birth.

In non-health-related determinants, receiving a state benefit (aOR=1.34, 95% CI=1.32–1.37), having ever been in prison (aOR=1.57, 95% CI=1.50–1.64), unstable housing (aOR=1.42, 95% CI=1.35–1.49) or state provided housing (aOR=1.28, 95% CI=1.24–1.32), or the mother's involvement with child welfare services themselves (aOR=1.34, 95% CI=1.31–1.37) were all significant in relation to any adverse outcomes. It is of note that all of the unadjusted ORs reduced when adjusted for ethnicity, age, parity location, educational level and deprivation indicating that there might be significant relationships between demographic factors and the social determinants.

Discussion

Our study found that the least poor outcomes were for Pākehā/European women aged 25–35 with a tertiary degree, having their second to fourth baby, living in areas with NZDep deciles 1–4; and those who received antenatal care (booked prior to birth), did not have a disability, had a drivers' licence and were registered with a primary health care organization. The current system appears to serve these women well. Older mothers (or the very young), with higher parity, living in higher deprivation areas, on state benefits, non-European or non-Pākehā, and those represented highly in the health, housing, crime and access domains had markedly poorer outcomes.

In comparison with international population data and social determinant studies, we demonstrated that, while stark, the identified barriers to maternal health equity in New Zealand, such as racism, poverty and difficulties in accessing care, are not unique in high-income countries.^{11,63,64} Though the context for inequity is singular in New Zealand,²⁵ the birthing population is not dissimilar to other high-income countries. While ethnic groupings differed and ethnicity data were collected and collated differently between countries, empirical research shows Black, indigenous and people of colour (BIPOC) are over-represented in measures of deprivation and poor outcomes.^{11,64} A similar pattern is seen in national reports and data repositories. In the United Kingdom,^{65,66} the United States⁶⁷ and Australia,⁶⁸ BIPOC had higher rates of adverse maternal and perinatal outcomes. These sources all indicated that people of higher deprivation, lower educational level and the youngest and oldest age groups all had poorer outcomes, as was found in this study. The maternal mortality or perinatal morbidity outcomes were usually reported individually, so that ORs are not comparable with the composite outcome reported in our study.

Many international research studies have examined social determinant data only for very specific cohorts (e.g. teen mothers on welfare) or outcomes (e.g. low birth weight). It was notable that more studies report perinatal outcomes, and fewer on the relationships between maternal morbidity and mortality and social determinants. Comparison between studies is difficult due to inconsistency in the choice and reporting of determinants or outcome definitions. For instance, perinatal mortality is defined differently across the Organisation for Economic Co-operation and Development (OECD); while stillbirth is after 20-week gestation in New Zealand, other countries use a 24-week cutoff.⁶⁹ Furthermore, while our choice of a composite 'any adverse' variable gives an overview of how social determinants impact pregnancy and birth outcomes, it makes comparisons to other studies more difficult.

Blumenshine et al.'s⁷⁰ systematic review of industrialized OECD countries looked at social determinants (grouped as income, education, occupational class and area-based socio-economic measures) and preterm birth

Table 4. Demographic composition of population before and after imputation.

Prioritized ethnicity	Before imputation	After imputation
NZE/European	476,898 (49%)	476,898 (49.1%)
Māori	247,662 (25.5%)	249,231 (25.5%)
Pacific	107,949 (11.1%)	107,949 (11.1%)
Asian	119,646 (12.3%)	119,646 (12.3%)
Other	18,660 (1.9%)	18,660 (1.9%)
Unknown	1569 (0.2%)	
Age group		
Under 16	2202 (0.2%)	
16–19	58,698 (6%)	
20–24	170,328 (17.5%)	
25–29	248,664 (25.6%)	
30–34	287,127 (29.5%)	
35–39	166,503 (17.1%)	
40–44	36,651 (3.8%)	
45 and over	2202 (0.2%)	
Parity		
Primipara (0)	361,224 (37.1%)	390,036 (40.1%)
1	295,701 (30.4%)	319,455 (32.9%)
2	134,280 (13.8%)	145,902 (15%)
3	55,344 (5.7%)	61,332 (6.3%)
4	24,711 (2.5%)	27,921 (2.9%)
5	12,036 (1.2%)	13,842 (1.4%)
6 and over	11,718 (1.2%)	13,890 (1.4%)
Unknown	77,367 (8%)	
Locality		
Urban	663,831 (68.3%)	664,131 (68.3%)
Semi-rural	92,349 (9.5%)	92,406 (9.5%)
Rural	164,871 (17%)	164,937 (17%)
Remote rural	50,886 (5.2%)	
Unknown	444 (0%)	
NZDep decile index (10 is most deprived)		
Decile 1	72,720 (7.5%)	72,753 (7.5%)
Decile 2	83,538 (8.6%)	83,601 (8.6%)
Decile 3	82,923 (8.5%)	82,923 (8.5%)
Decile 4	84,162 (8.7%)	84,270 (8.7%)
Decile 5	91,485 (9.4%)	91,521 (9.4%)
Decile 6	92,445 (9.5%)	92,544 (9.5%)
Decile 7	98,067 (10.1%)	98,067 (10.1%)
Decile 8	107,397 (11%)	107,466 (11%)
Decile 9	113,952 (11.7%)	113,988 (11.7%)
Decile 10	145,245 (14.9%)	
Unknown		
Highest formal educational level at birth		
No formal educational qualification	135,912 (14%)	250,812 (25.8%)
High school/vocational	181,227 (18.6%)	315,120 (32.4%)
Undergraduate	236,778 (24.4%)	351,366 (36.1%)
Postgraduate	44,589 (4.6%)	55,080 (5.7%)
Unknown	373,872 (38.4%)	

NZE: New Zealand European; NZDep: New Zealand deprivation.

All counts have been randomly rounded (up or down) to the nearest multiple of 3 (RR3).

and low birth weight outcomes. Consistent positive relationships between high socio-economic deprivation and poor neonatal outcomes were demonstrated; the aORs ‘for

the effect of socioeconomic disadvantage on birth outcomes ranged from 1.1 and 1.5 in 35 studies (54%); from 1.5 to 2.0 in 18 studies (28%); and 2.0 in 12 studies

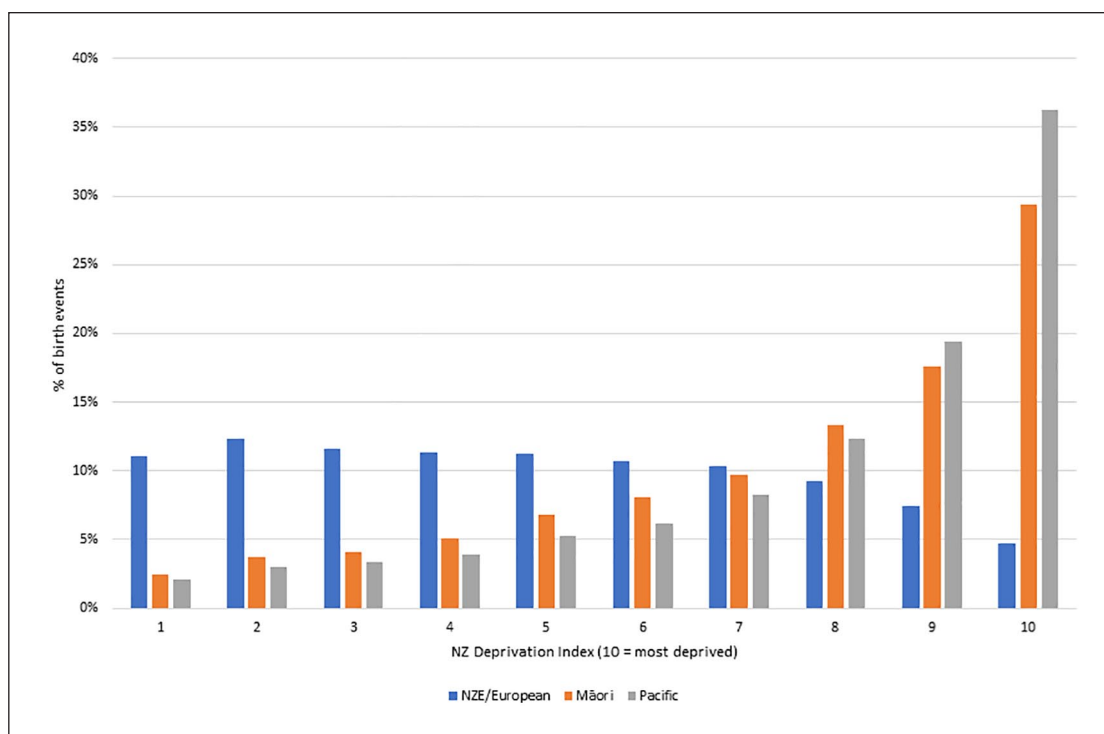


Figure 1. Ethnic makeup of deprivation scales.

Table 5. Ethnicity, mean, age and mean parity.

Ethnicity	Mean age	Mean parity
NZE/European	30.63	0.9
Māori	26.44	1.5
Pacific	28.23	1.6

NZE: New Zealand European.

(18%)⁷⁰. Any adverse outcomes for state welfare beneficiary (a proxy for poverty) in our study had an aOR = 1.34 (95% CI = 1.32–1.37) apparently consistent with the 54% of perinatal studies in Blumenshine et al.⁷⁰ that had an adjusted odds in the range of 1.1–1.5. As previously noted, comparability may be reduced through the different in outcome choice (perinatal only versus composite adverse outcome).

Strengths and limitations

The primary strength of this article is that the association of a broad range of social determinants with any poor maternal and perinatal outcomes is evidenced in a large, almost complete, longitudinal birthing population sample (97% of New Zealand births over 16 years, with 972,378 pregnancies). This has not been done for both maternal and perinatal health at a total birthing population level in New Zealand before, nor has such a

study been observed internationally over such a range of determinants. In this regard, this study traverses new territory and provides an important contribution to the field. The analysis is also distinguished by using individual factors for those giving birth as close to the time of the event as possible, not simply a geographic residential deprivation score.

What the study provides, therefore, is quantitative data that highlight the range of social factors that are frequently structural and systemic, and significantly affect maternal and perinatal health. It is anticipated that this will assist a shift in focus to addressing these factors alongside clinical measure as they are of a magnitude that cannot be ignored.

The study does have some constraints due to the source of the data.⁷¹ While de-identified, the data are administrative and not collected for research. Each data set has varying quality issues, which may encompass changes in collection methods and policies. Probabilistic linking within the IDI system can be unreliable⁷¹ and there is also presence bias, where those that frequently interact with government agencies have many data points available and others with little interaction may not.

Another limitation is that we considered each birth event individually and did not adjust for women appearing more than once in the data set. As a result of the assumption of independence between observations being violated, residual standard errors may be underestimated and the

Table 6. Demographic ORs and aORs for any adverse outcome.

	OR	95% CI	Pr (> z)	Sig.	aOR [^]	95% CI	p	Sig.
Prioritized ethnicity								
NZ/European	0.07	0.07–0.08	<2e–16	***	1			
Māori	1.35	1.32–1.37	<2e–16	***	1.21	1.18–1.23	<2e–16	***
Pacific	1.24	1.21–1.27	<2e–16	***	1.09	1.06–1.12	2.05E–09	***
Asian	1.42	1.39–1.45	<2e–16	***	1.39	1.36–1.43	<2e–16	***
Other	1.09	1.04–1.16	0.0014	**	1.05	0.99–1.11	0.0842	.
Age group								
Age under 16	1.34	1.18–1.53	5.67E–06	***	1.28	1.12–1.45	0.000169	***
Age 16–19	0.11	0.11–0.11	<2e–16	***	1.00			
Age 20–24	0.84	0.82–0.87	<2e–16	***	0.95	0.92–0.98	0.003761	**
Age 25–29	0.73	0.71–0.76	<2e–16	***	0.90	0.87–0.93	1.44E–10	***
Age 30–34	0.71	0.69–0.74	<2e–16	***	0.94	0.91–0.98	0.001096	**
Age 35–39	0.80	0.77–0.82	<2e–16	***	1.09	1.06–1.14	1.40E–06	***
Age 40–44	1.04	0.99–1.08	0.113		1.38	1.32–1.45	<2e–16	***
Age 45 and over	1.51	1.33–1.7	4.67E–11	***	1.94	1.71–2.2	<2e–16	***
Parity								
Para 0	0.10	0.10–0.1	<2e–16	***	1.00			
Para 1	0.70	0.69–0.71	<2e–16	***	0.70	0.68–0.71	<2e–16	***
Para 2	0.75	0.73–0.77	<2e–16	***	0.72	0.71–0.74	<2e–16	***
Para 3	0.90	0.88–0.93	6.29E–11	***	0.82	0.79–0.85	<2e–16	***
Para 4	1.05	1.01–1.09	0.0245	*	0.90	0.86–0.94	1.95E–06	***
Para 5	1.14	1.08–1.21	4.19E–06	***	0.94	0.88–0.99	0.025344	*
Para 6 and over	1.32	1.25–1.39	<2e–16	***	1.01	0.95–1.06	0.821551	
Locality								
Urban	0.09	0.09–0.09	<2e–16	***	1.00			
Semi-rural	0.94	0.92–0.96	1.84E–06	***	1.00	0.98–1.03	0.833994	
Rural	0.94	0.92–0.96	5.33E–09	***	0.98	0.96–1	0.041903	*
Remote rural	0.89	0.86–0.92	2.19E–11	***	0.92	0.89–0.96	8.23E–06	***
NZDep decile (10=most deprived)								
NZDep decile 1	0.07	0.07–0.08	<2e–16	***	1.00			
NZDep decile 2	1.00	0.96–1.04	0.8245		0.99	0.96–1.03	0.768929	
NZDep decile 3	1.04	1.00–1.08	0.0416	*	1.03	0.99–1.07	0.137363	
NZDep decile 4	1.05	1.01–1.09	0.0132	*	1.04	1.00–1.08	0.067873	.
NZDep decile 5	1.13	1.09–1.17	4.64E–10	***	1.10	1.06–1.14	7.87E–07	***
NZDep decile 6	1.15	1.11–1.19	3.51E–13	***	1.11	1.07–1.16	2.24E–08	***
NZDep decile 7	1.20	1.16–1.25	<2e–16	***	1.15	1.11–1.19	3.49E–13	***
NZDep decile 8	1.27	1.23–1.32	<2e–16	***	1.20	1.16–1.25	<2e–16	***
NZDep decile 9	1.35	1.30–1.4	<2e–16	***	1.26	1.22–1.31	<2e–16	***
NZDep decile 10	1.47	1.43–1.53	<2e–16	***	1.35	1.30–1.4	<2e–16	***
Formal educational qualification								
No educational qualification	0.09	0.09–0.09	<2e–16	***	1.00			
High school/vocational	1.08	1.06–1.1	5.98E–16	***	1.09	1.07–1.11	<2e–16	***
Undergraduate degree	0.90	0.88–0.92	<2e–16	***	0.95	0.93–0.97	6.05E–08	***
Postgraduate degree	0.80	0.77–0.83	<2e–16	***	0.85	0.82–0.88	<2e–16	***

OR: odds ratio; CI: confidence interval; aOR: adjusted odds ratio; NZDep: New Zealand deprivation.

Significance codes (sig): ***p < 0.001; **p < 0.01; *p < 0.05; ¹p = 0.01.

[^]Adjusted for ethnicity, age, parity, location (rural/urban), educational level and deprivation.

narrow CIs observed in this analysis may be due to this underestimation rather than to low levels of uncertainty. Imputation may also have introduced uncertainty. However, when compared to external data, results did not appear unreasonable.

There is some critique of the use of large linked administrative data set for research, and in New Zealand, issues have been raised regarding consent and also indigenous data sovereignty.^{72–74} Such an expansive set, while surrounded by privacy and ‘common good’ protections, opens

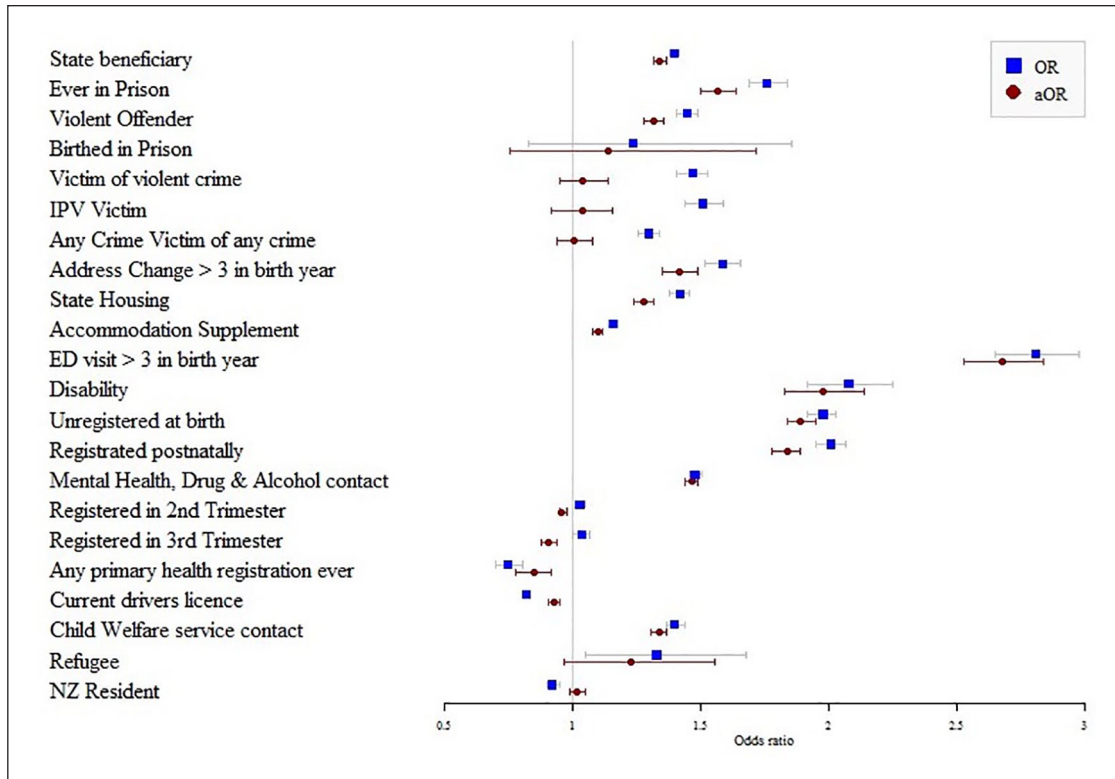


Figure 2. OR and aORs of any adverse outcome.

the possibility of misuse. The data collections are frequently deficit focussed and measures are not selected by populations but by governments and administrative agencies. Kitchin & Lauriault described such repositories as ‘expressions of knowledge/power, shaping what questions can be asked, how they are asked, how they are answered, how the answers are deployed, and who can ask them’⁷⁵ This means that any researcher using the IDI must be acutely aware not just of legal responsibilities, but also of ethical and cultural frameworks and obligations^{72,76} and work in partnership with affected communities.

In light of these considerations, there also needs to be strengths-based analysis using wellbeing variables to interrogate the common features of ‘good outcomes’. These outcomes will need to be carefully defined as it may well be that ‘good’ is not simply an absence of mortality or morbidity.

Conclusion

The implication of these results is that any improvement on maternity outcome inequity must involve addressing underlying social determinants which are shown here to have a significant impact on outcomes. This supports theories⁷⁷ that medical care and the health system only goes so far to ameliorate these inequities and, therefore, broader action is required.

In turn, this leads to questions around the mechanisms by which these inequities are allowed and enabled to continue and the structures that hold them in place. These questions and corresponding responses include systemic issues around the distribution of power and the political will (or lack thereof) to make transformative change. Some determinants identified here may provide targets for active change and intervention, for example, making care more acceptable and accessible in order to improve engagement. However, it must be acknowledged that the issues are not just at an individual or intermediary level, but structural and systemic, and so far-reaching change is required.

A shift in intervention focus – from problematizing individuals to addressing bias in systems that disadvantage those who already face the greatest social barriers to health – is vital as health disparities have been quantified and described for a significant time period. However, this has not translated into progress towards the end of inequity⁷⁸ with much of the research measuring inequity failing to advance progress on reducing it. In alignment with this, we contend that future efforts in the area of maternal and perinatal inequity must be a programme of cross-disciplinary, culturally appropriate interventional programmes and societal and political transformation to bring real progress to the elimination these inequities in New Zealand and internationally.

Table 7. Social determinant ORs and aORs for any adverse outcome..

Variable	OR	95% CI	p	Sig.	aOR [^]	95% CI	p	Sig.
Income and employment								
Beneficiary	1.40	1.38–1.42	<2e–16	***	1.34	1.32–1.37	0.000	***
Crime								
Ever in prison	1.76	1.69–1.84	<2e–16	***	1.57	1.50–1.64	0.000	***
Violent offender	1.45	1.41–1.49	<2e–16	***	1.32	1.28–1.36	0.000	***
Birth in prison	1.24	0.83–1.86	0.300		1.14	0.76–1.72	0.519	
Violent victim	1.47	1.41–1.53	<2e–16	***	1.04	0.95–1.14	0.386	
IPV victim	1.51	1.44–1.59	<2e–16	***	1.04	0.92–1.16	0.551	
Crime victim	1.30	1.26–1.34	<2e–16	***	1.01	0.94–1.08	0.770	
Housing								
Address change > 3	1.59	1.52–1.66	<2e–16	***	1.42	1.35–1.49	0.000	***
State housing	1.42	1.38–1.46	<2e–16	***	1.28	1.24–1.32	0.000	***
Accommodation supplement	1.16	1.14–1.18	<2e–16	***	1.10	1.08–1.12	0.000	***
Health								
ED > 3	2.81	2.65–2.98	<2e–16	***	2.68	2.53–2.84	0.000	***
Disability	2.08	1.92–2.25	<2e–16	***	1.98	1.83–2.14	0.000	***
Unregistered	1.98	1.92–2.03	<2e–16	***	1.89	1.84–1.95	0.000	***
Postnatal registration	2.01	1.95–2.07	<2e–16	***	1.84	1.78–1.89	0.000	***
Mental health drug and alcohol	1.48	1.46–1.51	<2e–16	***	1.47	1.44–1.49	0.000	***
Reg. in second trimester	1.03	1.02–1.05	0.000	***	0.96	0.95–0.98	0.000	***
Reg. in third trimester	1.04	1.00–1.07	0.039	*	0.91	0.88–0.94	0.000	***
PHO registration ever	0.75	0.70–0.81	0.000	***	0.85	0.78–0.92	0.000	***
Reg. in first trimester	1				1			
Access								
Driver	0.82	0.81–0.83	<2e–16	***	0.93	0.91–0.95	0.000	***
Family								
Child welfare service contact	1.40	1.37–1.44	<2e–16	***	1.34	1.31–1.37	0.000	***
Refugee	1.33	1.05–1.68	0.018	*	1.23	0.97–1.56	0.086	
NZ resident	0.92	0.90–0.95	0.000	***	1.02	0.99–1.05	0.113	

OR: odds ratio; CI: confidence interval; PHO: primary health organization; IPV: intimate partner violence.

[^]Adjusted for ethnicity, age, parity, location (rural/urban), educational level and deprivation.

Significance codes: ***p = 0; **p < 0.001; *p < 0.01; p < 0.05.

Authors contribution(s)

Pauline Dawson: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing – original draft; Writing – review & editing.

Benoit Auvray: Data curation; Formal analysis; Methodology; Software; Validation; Writing – review & editing.

Crystal Jaye: Investigation; Supervision; Writing – review & editing.

Robin Gauld: Investigation; Supervision; Writing – review & editing.

Jean Hay-Smith: Conceptualization; Investigation; Supervision; Writing – review & editing.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Disclaimer

These results are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure

(IDI) which is carefully managed by Stats NZ. For more information about the IDI, please visit <https://www.stats.govt.nz/integrated-data/>.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship and/or publication of this article: The University of Otago provided only funding and other logistical support, and had no direct role in any aspect of the design of the study, analyses, interpretation of the results or in the preparation, review or approval of the manuscript.

ORCID iD

Pauline Dawson  <https://orcid.org/0000-0002-8666-3117>

Data sharing statement

Due to the nature of the Statistics New Zealand Integrated Data Infrastructure data source, data used in this research study is unavailable to be shared.

Supplemental material

Supplemental material for this article is available online.

References

- Whitehead M. The concepts and principles of equity and health. *Int J Health Serv* 1992; 22(3): 429–445.
- Marmot M. *The health gap: the challenge of an unequal world*. London: Bloomsbury, 2015.
- Wilkinson RG and Pickett KE. *The spirit level: why equality is better for everyone*. 3rd ed. London: Penguin Press, 2010.
- Solar O and Irwin A. *A conceptual framework for action on the social determinants of health (Social determinants of health discussion paper 2 (policy and practice))*. Geneva: World Health Organization, 2010.
- CSDH. *Closing the gap in a generation: health equity through action on the social determinants of health (Final report of the Commission on Social Determinants of Health)*. Geneva: World Health Organization, 2008.
- Sen A. *Inequality reexamined*. Oxford: Oxford University Press, 1992.
- Anand P and Dolan P. Equity, capabilities and health. *Soc Sci Med* 2005; 60(2): 219–222.
- Marmot M, Allen J, Boyce T, et al. *Health equity in England: the Marmot review 10 years on 2020*. London: Institute for Health Equity, 2020.
- Gurney J, Stanley J and Sarfati D. The inequity of morbidity: disparities in the prevalence of morbidity between ethnic groups in New Zealand. *J Comorb* 2020; 10: 971168.
- Lawton B, Macdonald EJ, Brown SA, et al. Preventability of severe acute maternal morbidity. *Am J Obst Gynecol* 2014; 210: 557.e551–557.e556.
- Crear-Perry J, Correa-de-Araujo R, Lewis Johnson T, et al. Social and structural determinants of health inequities in maternal health. *Journal of Women's Health* 2020; 30: 230–235.
- Perinatal Maternal Mortality Review Committee. *Fourteenth annual report of the Perinatal and Maternal Mortality Review Committee: reporting mortality and morbidity 2018*. Report no. ISBN 978-1-98-859932-8, 2021. Wellington, New Zealand: Health Quality and Safety Commission.
- Maternal Morbidity Working Group. *Maternal Morbidity Working Group annual report: 1 September 2017 to 31 August 2018*. Report, 2019, HQSC website: Health Quality and Safety Commission, Wellington, New Zealand.
- Sadler L, Austin D, Masson V, et al. Review of contributory factors in maternity admissions to intensive care at a New Zealand tertiary hospital. *Am J Obstet Gynecol* 2013; 209(6): 549.e1–549.e7.
- Wadsworth M. Early life. In: Marmot M and Wilkinson RG (eds) *Social determinants of health*. 2nd ed. Oxford: Oxford University Press, 2006, pp. 44–63.
- Farquhar C, Sadler L, Masson V, et al. Beyond the numbers: classifying contributory factors and potentially avoidable maternal deaths in New Zealand, 2006–2009. *Am J Obstet Gynecol* 2011; 205(4): 331e1–331.e8.
- Lawton B, Wilson L, Dinsdale R, et al. Audit of severe acute maternal morbidity describing reasons for transfer and potential preventability of admissions to ICU. *Aust N Z J Obstet Gynaecol* 2010; 50(4): 346–351.
- Maternal Morbidity Working Group. *Maternal Morbidity Working Group annual report*. Wellington, New Zealand: Health Quality and Safety Commission, 2018.
- Gauld R. The New Zealand healthcare system. In: Mossialos E, Djordjevic A, Osborn R, et al. (eds) *International profiles of health care systems*. New York: The Commonwealth Fund, 2017, pp. 123–131.
- Ministry of Health. *Report on Maternity Web tool*. 15 September 2020 ed. Wellington, New Zealand: Ministry of Health, 2020.
- Grigg CP and Tracy SK. New Zealand's unique maternity system. *Women Birth* 2013; 26(1): e59–e64.
- Hendry C. The New Zealand Maternity System: a midwifery renaissance. In: Davis-Floyd R, Barclay L, Daviss B-A, et al. (eds) *Birth models that work*. Berkeley, CA: University of California Press, 2009, pp. 55–87.
- Sandall J, Soltani H, Gates S, et al. Midwife-led continuity models versus other models of care for childbearing women. *Cochr Datab Syst Rev* 2016; 4: CD004667.
- McRae DN, Muhajarine N, Stoll K, et al. Is model of care associated with infant birth outcomes among vulnerable women? A scoping review of midwifery-led versus physician-led care. *SSM: Popul Health* 2016; 2: 182–193.
- Dawson P, Jaye C, Gauld R, et al. Barriers to equitable maternal health in Aotearoa New Zealand: an integrative review. *Int J Equity Health* 2019; 18: 168.
- Waitangi Tribunal. *HAUORA: report on stage one of the health services and outcomes kaupapa inquiry*. WAI 2575. Lower Hutt, New Zealand: Legislation Direct, 2019.
- Amore K, Viggers H and Howden Chapman P. *Severe housing deprivation in Aotearoa New Zealand, 2018 (June 2021 update)*. Wellington, New Zealand: University of Otago, 2021.
- Ministry of Health. Neighbourhood deprivation, <https://www.health.govt.nz/our-work/populations/maori-health/tatau-kahukura-maori-health-statistics/nga-awe-o-te-hauora-socioeconomic-determinants-health/neighbourhood-deprivation> (2018, accessed 22 October 2021).
- Statistics New Zealand. 2018 census, <https://www.stats.govt.nz/2018-census/> (2020, accessed 12 October 2021).
- Pool I. Māori health, colonization and post-colonization: Aotearoa New Zealand, from 1769. *J Northern Stud* 2016; 10: 19–43.
- Harris R, Stanley J and Cormack D. Racism and health in New Zealand: prevalence over time and associations between recent experience of racism and health and wellbeing measures using national survey data (research article) (survey). *Plos ONE* 2018; 13: e0196476.
- Perinatal Maternal Mortality Review Committee. *Thirteenth annual report of the Perinatal and Maternal Mortality Review Committee: reporting mortality and morbidity 2017*. Report, 2019, Health Quality Safety Commission, Wellington, New Zealand.
- Filoche SK, Lawton B and Stanley J. Access to secondary mental health services in a cohort of New Zealand mothers. *Community Ment Health J* 2016; 52(8): 964–971.
- Makowharemahihi C, Lawton B, Cram F, et al. Initiation of maternity care for young Maori women under 20 years of age. *New Zealand Med J* 2014; 127: 52–61.

35. Stevenson K, Filoche S, Cram F, et al. Lived Realities: Birthing experiences of Māori women under 20 years of age. *Alt: Int J Indigenous Peoples* 2016; 12: 124–137.
36. Rumball-Smith JML. Not in my hospital? Ethnic disparities in quality of hospital care in New Zealand: a narrative review of the evidence. *New Zealand Med J* 2009; 122: 68.
37. Fitzhugh CD, Pearsall MS, Tully KP, et al. Social determinants of health in maternity care: a quality improvement project for food insecurity screening and health care provider referral. *Health Equity* 2021; 5: 606–611.
38. Cutts DB, Coleman S, Black MM, et al. Homelessness during pregnancy: a unique, time-dependent risk factor of birth outcomes. *Matern Child Health J* 2015; 19(6): 1276–1283.
39. Hickey S, Roe Y, Ireland S, et al. A call for action that cannot go to voicemail: research activism to urgently improve Indigenous perinatal health and wellbeing. *Women Birth* 2021; 34(4): 303–305.
40. Kim D and Saada A. The social determinants of infant mortality and birth outcomes in Western developed nations: a cross-country systematic review. *Int J Environ Res Publ Health* 2013; 10: 2296–2335.
41. Ministry of Health and Statistics New Zealand. *IDI data dictionary for the maternity collection – September 2018* (ed SN Zealand). Wellington, New Zealand: Statistics New Zealand, 2018.
42. Etikan I, Musa SA and Alkassim RS. Comparison of convenience sampling and purposive sampling. *Am J Theor Appl Stat* 2016; 5: 1–4.
43. Statistics New Zealand. Integrated data infrastructure, <https://www.stats.govt.nz/integrated-data/integrated-data-infrastructure/> (2020, accessed 12 December 2020).
44. Elliott T, Milne B and Li E. What's in the IDI? A web app for searching IDI variable information, <https://terourou.org/idisearch> (2021, accessed 23 March 2021).
45. Statistics New Zealand. *Microdata output guide* (ed Statistics New Zealand). 4th ed. Wellington, New Zealand: Statistics New Zealand, 2016.
46. Statistics Act 1975. Wellington, New Zealand: New Zealand Government, 1975.
47. Privacy Act 2020. Wellington, New Zealand: New Zealand Government, 2020.
48. Salkind NJ. *Encyclopedia of research design*. Los Angeles, CA: SAGE, 2010.
49. Health Information Standards Organisation. *HISO 10001:2017 ethnicity data protocols* (ed Ministry of Health). Wellington, New Zealand: Ministry of Health, 2017.
50. Atkinson J, Salmond C and Crampton P. *NZDep2013 index of deprivation*. Dunedin, New Zealand: University of Otago, 2014.
51. Atkinson J, Salmond C and Crampton P. *NZDep2018 analysis of census 2018 variables*. Dunedin, New Zealand: University of Otago, 2021.
52. Exeter DJ, Zhao J, Crengle S, et al. The New Zealand indices of multiple deprivation (IMD): a new suite of indicators for social and health research in Aotearoa, New Zealand. *PLoS ONE* 2017; 12(8): e0181260.
53. Haigh D. Poverty in New Zealand. *Whanake: Pacific J Commun Dev* 2018; 4: 102–115.
54. Jones PG and Thornton V. Does cost drive primary care patients to New Zealand's emergency departments? A systematic review. *New Zealand Med J* 2013; 126: 15–24.
55. Shakespeare T. Still a Health Issue. *Disab Health J* 2012; 5: 129–131.
56. Oliver M. The social model of disability: thirty years on. *Disab Soc* 2013; 28: 1024–1026.
57. R Core Team. *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing, 2019.
58. Mayer M. missRanger: fast imputation of missing values. 2.1.0. ed. 2019, <https://CRAN.R-project.org/package=missRanger>
59. Stekhoven DJ and Bühlmann P. MissForest: non-parametric missing value imputation for mixed-type data. *Bioinformatics* 2011; 28: 112–118.
60. van Buuren S and Groothuis-Oudshoorn K. Mice: multi-variate imputation by chained equations in R. *J Stat Softw* 2011; 45: 1–67.
61. Rubin DB and Little RJA. *Statistical analysis with missing data (Wiley series in probability and statistics)*. 3rd ed. Hoboken, NJ: John Wiley & Sons, 2020.
62. Waljee AK, Mukherjee A, Singal AG, et al. Comparison of imputation methods for missing laboratory data in medicine. *BMJ Open* 2013; 3: e002847.
63. Chin MH, King PT, Jones RG, et al. Lessons for achieving health equity comparing Aotearoa/New Zealand and the United States. *Health Policy* 2018; 122(8): 837–853.
64. Downe S, Finlayson K, Walsh D, et al. 'Weighing up and balancing out': a meta-synthesis of barriers to antenatal care for marginalised women in high-income countries. *BJOG* 2009; 116(4): 518–529.
65. Knight M, Bunch K, Tuffnell D, et al. *Saving lives, improving mothers' care: lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2015-17*. Oxford: National Perinatal Epidemiology Unit, University of Oxford, 2019.
66. Draper E, Gallimore I, Smith L, et al. *MBRRACE-UK perinatal mortality surveillance report, UK perinatal deaths for births from January to December 2017*. Leicester: The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester, 2019.
67. Centers for Disease Control and Prevention (CDC). *Natality, 2016-2018 expanded results*. Atlanta, GA: CDC Wonder, 2018.
68. Australian Institute of Health and Welfare (AIHW). *Australia's welfare 2019 in brief*. Sydney, NSW, Australia: AIHW, 2019.
69. OECD. *OECD health statistics 2019 definitions, sources and methods: perinatal mortality*. Paris: OECD, 2019.
70. Blumenshine P, Egarter S, Barclay CJ, et al. Socioeconomic disparities in adverse birth outcomes. *Am J Prev Med* 2010; 39: 263–272.
71. Milne BJ, Atkinson J, Blakely T, et al. Data resource profile: the New Zealand integrated data infrastructure (IDI). *Int J Epidemiol* 2019; 48: 677.e–677.e.
72. Kukutai T and Cormack D. Mana motuhake ā-raraunga: datafication and social science research in Aotearoa. *Kōtuitui: New Zealand J Soc Sci Online* 2019; 14: 201–208.
73. Kukutai T and Taylor J. *Indigenous data sovereignty: toward an agenda*. Canberra, ACT, Australia: ANU Press, 2016.

74. Atatoa Carr P, Paine S-J and Prickett K. *Ethical considerations of the use of child data in the IDI*. Auckland, New Zealand: Health Research Council of New Zealand, 2021.
75. Kitchin R and Lauriault T. *Towards critical data studies: charting and unpacking data assemblages and their work* (The programmable city working paper 2 2014: 1-19. pre-print version of chapter to be published in Eckert J, Shears A and Thatcher J (eds) *Geoweb and Big Data*). Lincoln, NE: University of Nebraska Press, <https://ssrn.com/abstract=2474112>
76. Ballantyne A and Style R. Health data research in New Zealand: updating the ethical governance framework. *New Zealand Med J* 2017; 130: 64.
77. Braveman P and Gottlieb L. The social determinants of health: it's time to consider the causes of the causes. *Publ Health Rep* 2014; 129(Suppl. 2): 19–31.
78. Plamondon KM, Bottorff JL, Caxaj CS, et al. The integration of evidence from the Commission on Social Determinants of Health in the field of health equity: a scoping review. *Crit Publ Health* 2020; 30: 415–428.