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Effects of perinatal conditions and local area socioeconomic status on early childhood mortality in New South Wales: linked data analysis

Main report

Prepared by the Australian Institute of Health and Welfare
for the Child Death Review Team, NSW Ombudsman

A report under section 34H
Community Services (Complaints, Reviews and Monitoring) Act 1993

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Abbreviations

ABS	Australian Bureau of Statistics
AEDC	Australian Early Development Census
AIHW	Australian Institute of Health and Welfare
APGAR	Appearance, Pulse, Grimace, Activity and Respiration (score for babies at birth)
BRC	Birth Registration Collection
CDRT	Child Death Review Team
HDLU	Health Data Linkage Unit (AIHW)
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th revision
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
IRSEO	Indigenous Relative Socioeconomic Outcomes
NDI	National Death Index
NICU	neonatal intensive care unit
NSW	New South Wales
OR	odds ratio (from a logistic regression)
PDC	Perinatal Data Collection
PPH	postpartum haemorrhage
RR	risk ratio
SA2	Statistical Area Level 2
SCN	special care nursery
SEIFA	Socio-Economic Indexes for Areas
SIDS	sudden infant death syndrome
SUDI	sudden unexpected death in infancy

Executive summary

This report analyses the relationship between early childhood mortality in New South Wales and maternal and baby characteristics at the time of birth (perinatal conditions) using a linked data set created for this project.

This summary focuses on the key findings from the major components of this report in chapters 5 and 6 (multivariate regression analyses).

A stand-alone Summary report is also published separately, which provides further details than in this executive summary, including on the study design and methods used, data linkage process, and other results from the preliminary descriptive analyses presented in other parts of this report.

The study population consists of all babies born in New South Wales between 2005 and 2018. Their perinatal conditions are derived from the NSW Perinatal Data Collection. These birth cohorts were linked to NSW and national death registration records to identify the children who died by the end of 2019, and their age at death. In addition, several area-level socioeconomic status indicators, based on the usual area of residence of the mother when giving birth, were added to the linked data set from the Socio-Economic Indexes for Areas (SEIFA) and the Australian Early Development Census (AEDC).

The study was commissioned by the NSW Child Death Review Team (CDRT) and builds on previous analyses by the Australian Institute of Health and Welfare (AIHW) of the CDRT Register of Child Deaths (NSW CDRT 2014, 2018). Earlier studies focused on analysing data available only for the children who had died. This study extends the scope of analyses by connecting these death records to the birth records of the full cohorts of babies born in New South Wales. This allowed risk factors for child mortality to be better identified by directly comparing the characteristics of babies who have died with those of babies who have survived to specific ages.

The analysis using linked birth and death data changes the study focus slightly – from the analysis of all NSW-registered deaths, as in most previous studies, to the analysis of deaths among all NSW-born babies.

The NSW perinatal and birth registration datasets identified 1,393,488 unique records of live-born babies in New South Wales between 2005 and 2018 (an average of around 99,500 births per year). The PDC records alone identified 1,337,341 unique live-born babies in NSW (an average of around 95,500 per year). The latter count represents the total number of births available for analysis in this study because the effects of perinatal conditions on mortality can be considered only for births with a full PDC record.

From this total number of births, the data linkage identified 3,715 child deaths under age 5, most of which were deaths under age 1 (3,067 or 83% of total under-5 deaths).

The linked data file also identified around 60,300 Aboriginal and Torres Strait Islander children born in New South Wales during this period, based on Indigenous status as recorded in either the birth or death records. Among them, 383 had died under age 5, of whom 309 (81%) had died under age 1.

The risk factors for early childhood death in New South Wales are analysed separately for:

1. death under age 1 of all children in these birth cohorts
2. death between ages 1 to 4 of all children in these birth cohorts
3. death under age 1 among Indigenous children only.

For death under age 1 of all children (where the total number of deaths is sufficiently large) separate analyses are done for 3 birth cohorts: babies born between 2005–2010, babies born between 2011–2014 and babies born between 2015–2018.

Key findings

The analyses in this study confirm the key role played by several perinatal characteristics in explaining infant mortality (death under age 1) and child mortality between ages 1 to 4. Perinatal characteristics were shown to have a larger role in explaining deaths in children under age 1 than deaths between ages 1 to 4.

Among deaths under age 1, perinatal characteristics had a larger effect in explaining total deaths – including those that occurred within the first week after birth (roughly half of all deaths under age 1) – than deaths that occurred after the first 7 days.

Preterm birth was the most significant risk factor for death under age 1, especially if the gestational age for the preterm birth was under 32 weeks. Baby's birthweight being small for gestational age and being born to a teenage mother (aged 19 or under) were other consistently identified risk factors.

Death under age 1 – all babies

The perinatal characteristics having the most consistent effect as significant risk factors that increased the odds of dying under age 1 among all children were:

- preterm birth, further categorised by gestational age
  - under 32 weeks (211 to 280 times as likely to die as full-term babies)
  - between 32 to 36 weeks (around 5 times as likely as full-term babies)
- baby's birthweight was small for gestational age (2.6 to 2.7 times as likely compared with other birthweight categories)
- born to a teenage mother (1.4 to 1.7 times as likely compared with babies born to mothers aged 26–30).

The risk of dying among preterm babies under 32 weeks gestational age was reduced if the delivery was by caesarean section rather than by other methods, including normal vaginal birth. Preterm babies in this gestational age category delivered by caesarean section were still more likely to die (40 to 58 times as likely) than full-term babies with a caesarean delivery; however, the relative risk of dying among preterm babies born under 32 weeks gestational age was lower if they had a caesarean delivery rather than a vaginal delivery.

Caesarean delivery did not significantly alter the risk of dying for preterm births between 32 and 36 weeks gestational age; however, caesarean delivery in conjunction with full-term births (37 weeks or over) was found to be a consistent risk factor for death under age 1.

Other perinatal characteristics that did not have consistently significant effects in all the time periods or for all birth cohorts examined – but had a general tendency to increase the odds of dying under age 1 – were:

- being a male baby (1.2 times as likely to die as female babies)
- being an Indigenous baby (1.5 to 1.8 times as likely as other babies)
- being born to a mother who experienced postpartum haemorrhage requiring a blood transfusion (1.6 to 2.7 times as likely compared with a mother not experiencing postpartum haemorrhage requiring a blood transfusion).

In the most recent period (2015–2018) covered in this study, there was no significant difference in the risk of dying for Indigenous babies compared with non-Indigenous babies (once other differences among Indigenous and non-Indigenous babies were adjusted for in the multivariate regression analyses).

This result is consistent with a continuous decline in Indigenous child mortality in New South Wales (and elsewhere in Australia), and at a faster pace than for non-Indigenous children. While mortality for Indigenous children remains higher even in the most recent period, the gaps have narrowed over time.

When deaths occurring within the first 7 days of life were excluded in the analyses of deaths under age 1:

- the risks associated with preterm birth under 32 weeks and between 32 and 36 weeks were both reduced, but remained as significant risk factors (32 to 40 times as likely to die among preterm babies under 32 weeks, and around 3 times as likely to die among those between 32 and 36 weeks gestational age)
- the risk of dying among preterm babies under 32 weeks gestational age continued to be lower if the delivery was by caesarean section rather than by other methods
- there were increased risks associated with birthweight being small for gestational age (to 2.2 to 3.1 times as likely to die), and being born to a teenage mother (to around 2 times as likely)
- smoking during pregnancy became a significant risk factor (in 2 of 3 periods, with babies born to mothers who smoked 1.5 to 1.7 times as likely to die)
- mother experiencing postpartum haemorrhage requiring a blood transfusion was no longer a significant risk factor.

Death between ages 1 to 4 – all children

Due to the small number of deaths in this age group, the records of all birth cohorts from 2005 to 2018 were pooled and a single model estimated for this whole period.

Several perinatal characteristics continued to be significant in explaining death between ages 1 to 4. These include:

- baby's birthweight was small for gestational age (1.7 times as likely)
- being an Indigenous baby (2.2 times as likely)
- being a male baby (1.3 times as likely)
- being born to a young mother aged 20 to 25 (1.4 times as likely compared to babies born to the reference group of mothers aged 25 to 30).

There were some differences in the significant risk factors associated with child death under age 1 and between ages 1 to 4. For instance, 2 important risk factors for deaths under age 1 that did not have a significant effect on death between ages 1 to 4 were:

- preterm birth (including among those with a gestational age under 32 weeks)
- mother experiencing postpartum haemorrhage requiring a blood transfusion.

Maternal smoking – found to be a risk factor for death of babies aged between 7 days and 1 year – was also a significant risk factor for death of babies between ages 1 to 4 (1.3 times as likely to die).

Death under age 1 – Indigenous babies

The risk factors for death under age 1 among Indigenous children were analysed separately for a single birth cohort model of 2005 to 2018. Similar risk factors were identified for death under age 1 among Indigenous children compared with those found in the overall infant population.

For example, some of the significant risk factors for Indigenous babies were:

- being born preterm (over 100 times as likely to die if born under 32 weeks gestational age, and 2.3 times as likely to die for preterm births between 32 and 36 weeks gestational age, compared with a full-term baby)
- being small for gestational age (2.0 times as likely)
- being born to a teenage mother (1.6 times as likely).

Caesarean delivery also reduced the risk of dying among preterm Indigenous babies under 32 weeks gestational age. The likelihood of dying under age 1 for an Indigenous preterm baby under 32 weeks gestational age with a caesarean delivery was lower at 23 times as likely to die as a full-term and caesarean delivery baby.

Some risk factors previously identified in the overall analyses of death under age 1 for all children were not found to be significant in the separate analysis for deaths among Indigenous infants. These included being a male baby, mother experiencing postpartum haemorrhage requiring a blood transfusion and caesarean delivery (for babies born full-term or between 32 and 36 weeks preterm).

One maternal characteristic found to be a significant risk factor for deaths under age 1 only for Indigenous babies was being born to mothers residing in *Major cities* areas at time of giving birth (compared with residing in *Inner* or *Outer regional* areas or in *Remote* or *Very remote* areas of New South Wales). This is an unexpected result requiring further investigation. The higher risk of death for Indigenous infants in *Major cities* areas of New South Wales has not to our knowledge been reported in other studies. Since access to medical and allied health services before and after birth might ordinarily be expected to be easier in *Major cities*, the result in this report may indicate some unobserved differences between Indigenous babies and their families living in *Major cities* relative to other families living in *Major cities*.

More analyses will be needed to confirm the extent of, and reasons for, the difference in identified risk factors for death under age 1 between Indigenous children and all children. Some of the differences noted in this report could be related to the very large difference between the small number of deaths of children classified as Indigenous compared with deaths classified as non-Indigenous. The relatively small total number of deaths of Indigenous babies (even when pooled for all birth cohorts from 2005 to 2018) make it difficult to reliably estimate the risks associated with factors specific to Indigenous children.

Area-level socioeconomic status variables

Compared with the effects of the perinatal characteristics, the effects of the different area level socioeconomic status indicators (such as the SEIFA rank of the area the mother lived in, or the proportion of children assessed as being developmentally vulnerable on the AEDC) were not shown to be important factors with consistently significant effects when the regression models were estimated jointly with the perinatal characteristics. This is an unexpected finding. Socioeconomic status, even when measured as an area-level average, is expected to affect health and mortality outcomes, including overall life expectancy (AIHW 2017).

There also were minimal differences in the effects of the perinatal variables when only the perinatal variables were included in the estimated models, compared with models with perinatal variables in combination with area-level variables. The latter result indicates that the effects of the perinatal characteristics operate mainly as direct effects on the risk of dying and not through being a proxy for socioeconomic status effects.

There were only 3 instances of the area-level variables having a small significant effect in the expected direction, showing that living in a lower socioeconomic status area increased the risk of child death.

Living in the lowest ranked bottom 3 SEIFA deciles (compared with the highest 3) was found to be a significant risk factor in only one model:

- the 2005–2010 birth cohort for deaths under age 1.

Living in the middle ranked 4 SEIFA deciles (compared with the highest 3) was found to be a significant risk factor in two model results:

- the 2005–2010 birth cohort for deaths under age 1, and
- the 2005–2010 birth cohort for deaths under age 1 that exclude deaths in the first week after birth

In the second instance the result is not logically consistent, showing a higher risk of child death for those living in the middle deciles, but without any greater risk for those living in the bottom 3 decile areas (when compared with the top 3 deciles).

The AEDC-derived child developmental vulnerability indicator of low socioeconomic status was estimated to be a significant risk factor for:

- deaths among all children under age 1, excluding deaths within the first 7 days of birth (in the period 3 model for the 2015–2018 birth cohort)

(The AEDC data on developmental vulnerability is available only for all children in an area; hence, it was not included in the separate subgroup model of Indigenous infant deaths.)

These instances where the area-level socioeconomic indicators were found to be statistically significant are also noted in Table S.1 in the next section of this summary.

Interpretation of results on the Indigenous status variable in regression models on the risks of dying among all children

Several of the multivariate regression models estimated over the full population of all NSW born children show a result that Indigenous children have an associated higher risk of dying than non-Indigenous children. These results should not be interpreted to mean that being an Indigenous baby is, in itself, a separate risk factor. The Indigenous status variable is typically a proxy for differences between Indigenous children and non-Indigenous children in other important factors related to child mortality.

Differences in some of these other important factors affecting the risk of dying are already accounted for in the estimated models in this report, such as smoking during pregnancy (41% among Indigenous mothers versus 8.3% among non-Indigenous mothers, on average, over the 2005–2018 period), preterm births (11% versus 6.9%), and teenage motherhood (16% versus 2.4%), all of which are higher among Indigenous mothers. But not all factors associated with the risk of dying that vary systematically between Indigenous children and non-Indigenous children are captured in the variables available in the perinatal data collection, and hence they could not be included in the regression models estimated in this study.

The estimated model results on the Indigenous status variable presented in this report should therefore be treated with caution because it is likely to reflect the effect on the risk of dying of other unobserved factors not included in the model that may vary between Indigenous and non-Indigenous children.

‘Top 8’ list of significant perinatal characteristics

Table S.1 summarises the results obtained from the several different regression models presented in this report for:

- the 8 perinatal characteristics that had the most consistent effect across all the estimated models
- the 2 area-level socioeconomic status indicators examined.

Being born small for gestational age was the most consistent risk factor significantly increasing the risk of dying in the results for each of the 8 different models analysed (from the different combinations of birth cohort period, age at death and Indigenous subgroup).

This was followed by preterm birth (both under 32 weeks gestational age and for 32 to 36 weeks gestational age) and being born to a teenage mother, both of which are identified as significant risk factors in 7 of these 8 instances (the exception was death between ages 1 to 4, where preterm birth in any sub-category and being born to a teenage mother were not found to be significant risk factors).

Caesarean delivery among full-term births was an identified risk factor in 5 of the 8 models; but caesarean delivery in combination with preterm births under 32 weeks gestational age was generally a protective factor. Preterm babies under 32 weeks who had a caesarean delivery were less likely to die than preterm babies under 32 weeks born through other delivery methods, including vaginal delivery.

The effects captured by Indigenous status were significant in 5 of the 8 models, followed by the higher risk of dying for male children in 4 of the 8 models.

Table S.1: Effects of the most consistently identified perinatal risk factors for child death, by age at death, birth cohorts and Indigenous status, and effects of the 2 area-level socioeconomic status variables

Maternal/birth characteristic	All children							Indigenous children
	Under age 1			Under age 1, excluding first 7 days			Ages 1–4	Under age 1
	2005–2010	2011–2014	2015–2018	2005–2010	2011–2014	2015–2018	2005–2018	2005–2018
Preterm birth:								
- under 32 weeks gestational age	✓	✓	✓	✓	✓	✓	×	✓
- 32 to 36 weeks gestational age	✓	✓	✓	✓	✓	✓	×	✓
Baby born small for gestational age	✓	✓	✓	✓	✓	✓	✓	✓
Teenage mother under age 20 when giving birth (compared to a mother aged 26 to 30)	✓	✓	✓	✓	✓	✓	×	✓
Caesarean delivery (for full-term births)	✓	✓	✓	✓	✓	×	×	×
Indigenous baby	✓	✓	×	✓	✓	×	✓	n.a.
Male baby	✓	✓	×	✓	×	×	✓	×
Mother smoked during pregnancy	×	×	×	✓	×	✓	✓	×
Postpartum haemorrhage requiring a blood transfusion	×	✓	✓	×	×	×	×	×
Proportion of children in SA2 of mother's usual residence assessed as developmentally vulnerable on 1+ AEDC domains	×	×	×	×	×	✓	×	n.a.
Mother's usual residence was in (using 2011 SA2 rankings):								
- lowest 3 SEIFA deciles (versus highest 3 deciles)	✓	×	×	×	×	×	×	×
- middle 4 SEIFA deciles (versus highest 3 deciles)	✓	×	×	✓	×	×	×	×

✓ Indicates a statistically significant risk factor (at the 5% test level).

× Indicates a characteristic that was not statistically significant at the 5% test level for a given model and birth period.

n.a. = not applicable; AEDC= Australian Early Development Census; SA2 = Statistical area, Level 2

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1 Introduction

The aim of this study is to better understand and quantify the role of specific risk factors for child mortality under age 5 in New South Wales. The specific focus is on the effects of selected characteristics of the mother or baby at the time of birth (perinatal conditions) on infant mortality (deaths under age 1) and on deaths between ages 1 to 4 (among those who survived to age 1).

The NSW Child Death Review Team (CDRT) commissioned this study, which builds on previous analyses by the Australian Institute of Health and Welfare (AIHW) of the CDRT Register of Child Deaths (NSW CDRT 2014, 2018). Earlier studies focused on analyses of data available only for the children who had died. This study extends the scope of analysis by connecting these death records to the full cohorts of babies born in New South Wales. This enables risk factors for child mortality to be better identified by directly comparing the characteristics of babies who died with the characteristics of those who survived to specific ages.

To analyse child deaths within their full birth cohorts requires data in the birth and death records to be linked. The analysis of that linked data leads to a more complete understanding of the fundamental risks of child death within the full birth cohorts, through detailed statistical modelling of the risks of an individual baby's dying before a specified age.

This study is based on the cohorts of all liveborn babies in New South Wales between 2005 and 2018. Their perinatal characteristics are sourced from the NSW Perinatal Data Collection (PDC). The births data set was then linked to death records from 2005 to 2019 compiled from the AIHW National Death Index (NDI) and the CDRT Register of Child Deaths to identify which child had died by 2019 and their age at death.

As well, several area-level socioeconomic status indicators, based on the usual area of residence of the mother when giving birth, were added to the linked data set from the Australian Bureau of Statistics (ABS) derived Socio-Economic Indexes for Areas (SEIFA), and the Australian Early Child Development Census (AEDC). The PDC does not report any socioeconomic status variable for the mother or the baby's family, such as household income or parental education, employment or occupation. Hence the area-level variables are introduced into this analysis as a proxy for the socioeconomic gradient that is usually seen for health and mortality outcomes for children as well as adults (Marmot 2017; WHO 2011).

The use of linked data where mortality events are connected to their full birth cohorts shifts the focus of the analysis slightly from the risk factors behind all NSW-registered deaths (as in most previous studies) to risk factors for deaths among all NSW-born babies (as in this study).

One sub-component of deaths missing from the latter are deaths among children who were born elsewhere in Australia or overseas but died in New South Wales. There is not, however, adequate evidence to show that the mortality rate and causes of death among these children differ much from that for NSW-born children. Nevertheless, the slight difference in the scope of the deaths covered in this report must be kept in mind, especially if comparing it with other studies that analyse the largely overlapping (but not identical) category of all deaths registered in New South Wales.

1.1 NSW Child Death Review Team

The NSW CDRT is a statutory body established to prevent or reduce the deaths of children in New South Wales. To do this, it maintains a register of all child deaths up to age 17 occurring in the state and prepares detailed reports based on those death registration records, identifying trends and patterns in the data (for example, NSW CDRT 2019, 2021). It also recommends legislation, policies, practices and services to prevent or reduce the likelihood of child death (NSW CDRT 2020).

Another key function of the CDRT is to identify topics requiring further research and to fill those gaps. The CDRT has previously commissioned the AIHW to conduct research on child mortality in New South Wales related to child protection history, and on geographic variation in child mortality (NSW CDRT 2014, 2018). The collaboration continues with this project.

1.2 Background

Child mortality has continued to decline in New South Wales in line with a general decrease across Australia (AIHW 2020a, 2020b; Australian Government 2020). The key risk factors contributing to child mortality are generally understood; what is less understood are the complex relationships between the social determinants of health and specific health-related factors (AHMAC 2017; AIHW 2018), such as:

- the conditions of birth (such as preterm birth and low birthweight)
- maternal health and risk factors during pregnancy (such as smoking during pregnancy, and pre-existing maternal chronic conditions such as diabetes and hypertension)
- access to and timely use of antenatal care
- the socioeconomic status of the mother and family, as well as of the area in which the mother (and baby) resided at the time of birth (neighbourhood effects).

There is no clear evidence available on the interplay of all relevant factors – and which specific factors play a primary role for child death in New South Wales – nor on whether the importance of specific factors has changed over time, because of data availability issues. Moreover, there is a lack of easily accessible data sets containing all variables of interest.

Previous analyses of the CDRT Register of Child Deaths have often relied on aggregate data, such as regional-level child mortality rates (NSW CDRT 2018), or analysis of variations only among children who have died – for example, comparing causes of death (NSW CDRT 2014). Other studies have focused on specific types of death, such as the sudden unexpected death in infancy (SUDI) component of child mortality in New South Wales, for which the main risk factors highlighted were being male and Indigenous, living in areas with higher levels of socioeconomic disadvantage, and living outside *Major cities* (NSW CDRT 2016). Children with a child protection history were also estimated to be 9 times as likely to die from SUDI as children without a child protection history (NSW CDRT 2014).

Reporting on child death based on data collected from many sources on the characteristics of children whose deaths are registered in New South Wales is a vital part of the role of the NSW CDRT. However, the scope of the analyses on the underlying risk factors for child death and methodological tools that can be used is limited when the analyses are based only on data on children who have died.

To overcome these drawbacks, the NSW CDRT commissioned the AIHW to use linked individual-level data to model the effect on the risk of child death of:

- individual characteristics of the child and of the mother at the time of birth
- some area-level average socioeconomic characteristics of the usual place of residence of the mother (and baby) when giving birth.

The aim is to better understand the risk factors of early childhood mortality related to both sets of the above characteristics through detailed statistical modelling of the risks of an individual child dying before a specified age in the general population. This requires a data set that has similar variables collected on the key characteristics of both children who have died and children who have survived.

The data linkage for this project was carried out at the AIHW. It required the supply of personal identifying information (full names, dates of birth and addresses) of the children and their mothers to the AIHW Health Data Linkage Unit (HDLU).

Ethics approval for the data linkage and subsequent analyses for this project was sought from the AIHW Ethics Committee and granted in October 2020. It was further amended in September 2021, with approval given to conduct a separate analysis for deaths among Indigenous children identified in the linked data as there were sufficient records of Indigenous child deaths to undertake separate analyses.

1.3 Project objectives

The main project objective was to identity and quantify the role of key risk factors contributing to child mortality in New South Wales for children aged under 1 year, and children aged between 1 and 4, based on the maternal and baby characteristics at the time of birth (perinatal conditions).

The cohorts of all children born in New South Wales between 2005 and 2018 were included in the study. Their perinatal conditions are derived from the NSW PDC, and the analysis includes several other variables reflecting the average socioeconomic status of the area in which the mother lived when giving birth.

The 14-year span of the birth cohorts used in this study also allows testing for differences in the effects of specific key perinatal characteristics over time, and for time trends in overall child mortality and among specific subgroups of children.

A separate analysis of Indigenous children within those cohorts was carried out to estimate the risks of dying under age 1. This separate analysis helps to better document and understand the factors behind the known disparities in the mortality rate and causes of death between Indigenous and non-Indigenous children.

Using the linked data file that has a common set of perinatal characteristics and area-level average socioeconomic status characteristics for the area in which the mother lived when giving birth, multivariate logit regression models are estimated to identify and quantify the contribution of these selected characteristics on the probability of a child’s dying by a specified age (under age 1 or between ages 1 to 4).

The main individual-level perinatal characteristics used in the regression models relate to:

- preterm birth (births with a gestational age under 37 weeks)
- low birthweight or birthweight small for gestational age
- mother's age when giving birth
- use of timely antenatal care services
- smoking during pregnancy
- pre-existing health conditions for the mother, such as diabetes or high blood pressure
- non-singleton births, delivery methods and so on.

Data on the average socioeconomic status of the area in which the mother lived when giving birth were sourced from the ABS-derived SEIFA, and the AEDC, on the percentage of children assessed as being developmentally vulnerable in one or more domain. Previous AIHW analyses for the CDRT (NSW CDRT 2018) found that area-level data on the proportions of children assessed as being developmentally vulnerable in the AEDC were strongly related to the estimated average regional mortality rates for all children aged 0 to 17, as derived from the CDRT Register of Deaths.

1.4 Scope of birth cohorts specified in linked data

The reference population for this study is all liveborn babies in New South Wales in the 14 years from 2005 to 2018. Stillbirths were excluded from the analyses of mortality in this report, which is consistent with normal CDRT reporting practices.

The AIHW Health Data Linkage Unit created this reference population by linking the NSW PDC data set for 2005 to 2018 with the NSW Birth Registration Collection (BRC) data set for 2005 to 2018. The overwhelming majority of births are recorded in both the PDC and the BRC, but some records appear in only one source. The combination (or union) of these 2 collections (with personal identification variables) defines the full NSW-born cohorts. The main or second part of the data linkage seeks to identify which of the children in the combined PDC/BRC collections died by 2019 in the death records used for this project.

Death records from the National Death Index and the CDRT's own administrative collection, the Register of Child Deaths, were then linked to this study cohort to identify those children who had died by the end of 2019. Children born in New South Wales but who died outside the state were identified using NDI records. When a death record was not matched to a birth cohort record, the child was assumed to have survived to at least until the end of 2019.

More details about the data linkage procedures and outcomes of the linkage (in terms of the number of deaths identified within each birth cohort) are provided in chapter 2 and in Appendix B.

The death records for specific birth cohorts are distinct from the usual reporting of child death by age in a calendar year. For instance:

- the NSW CDRT Register of Child Deaths includes deaths of children up to age 17. Between 2005 and 2019, this register identified 8,307 unique records of child death. This included children born before 2005 (so they were outside the age range for this study), or were not born in New South Wales
- the AIHW data linkage found that only around 4,850 (or almost 60% of these 8,307 deaths in the CDRT records) were applicable to the NSW-born cohorts of 2005 to 2018 who died by 2019.

Hence, results from other CDRT reports on child death in New South Wales over the same 2005 to 2019 period (NSW CDRT 2019, 2021) are not directly comparable with results for this report. These CDRT reports include deaths of older children and of children born outside New South Wales, while excluding children born in New South Wales but who died outside the state.

1.5 Report structure

Chapter 2 describes the key aspects of the methodology adopted for this study, including the data linkage design and outcomes.

Chapter 3 presents summary tabulations of the underlying mortality rates and causes of death recorded for children who have died by specific ages under age 5. Separate tabulations are also presented on Indigenous child deaths recorded in the linked data.

Chapter 4 presents a comparative analysis of how the characteristics of children who survived to a specific age differ from those of children who have died. This analysis is based on the main perinatal variables of interest and measures of socioeconomic status relating to the usual place of residence of the mother.

Chapter 5 presents results from multivariate logistic regression analyses of the factors associated with child death under age 1 and separately for deaths of children between ages 1 to 4 for the full study cohort of all children born in New South Wales in 2005–2018. The variables selected for the regression analyses are mainly drawn from the results of chapter 4.

Chapter 6 presents the results of separate multivariate analyses on the risk of dying for Indigenous children for deaths under age 1 only (due to the small number of total deaths in the older ages). This analysis identifies factors that had a special connection to Indigenous infant deaths.

Chapter 7 summarises the key findings from this study, including highlights of the differences in the key risk factors and the relative size of their effects seen in the analyses of deaths among Indigenous children and all NSW-born children. Some limitations of the analyses in this report and suggestions for further research are also noted.

2 Methodology and summary data linkage outcomes

This chapter describes the key components of the methodology adopted for this study:

- the design and process of the data linkage used to create the project data set
- the outcomes of the data linkage in the total number of births and deaths recorded in the linked files
- the statistical methods used for the analyses of the project data.

The key methodological innovation of this project was to quantify the risk factors contributing to child mortality in New South Wales by placing the deaths observed in the CDRT administrative collection inside their entire birth cohorts. The focus is on children who died under age 1, and between ages 1 to 4, among all children born in New South Wales between 2005 and 2018.

This analysis of child deaths within their full birth cohorts required data linkage of the birth and death records. Such analyses with linked data provide a greater scope for accurately identifying the relevant risk factors than analyses based only on data for children who have died.

At a glance

- The study population of babies born in New South Wales between 2005 and 2018 included in the linked data for this project with perinatal data was around 1.34 million (an average of around 95,500 births per year).
- From this total number of births with perinatal data, the linkage identified 3,715 deaths of children under age 5.
- The majority of the total deaths identified under age 5 were among children under age 1 (3,067 or 83% of total under-5 deaths).
- The linked data file also identified around 60,300 children with Indigenous status associated either with the baby or the birth mother; among them, 383 children had died under age 5 of whom 309 (81%) had died under age 1.

2.1 Data linkage design

The reference population chosen for this study was all children born in New South Wales during the 14 years from 2005 to 2018. This span of birth cohorts made it possible to analyse time trends and differences in the effects of key risk factors among different cohorts. It also allowed separate analyses for different groups of children by combining data over many years, such as for Indigenous children, who are only a small percentage of all children in these birth cohorts.

There were 2 steps in the data linkage plan for this project:

1. Identify the full cohort of babies born in New South Wales between 2005 and 2018.
2. Identify which of these babies had died by the end of 2019 by linking their birth cohort records to death records.

Step 1: identify the full cohort of babies

The following 2 data sets were provided to the AIHW with full identifying personal details on the baby and birth mother, along with other selected content variables:

- NSW PDC from 2005 to 2018
- NSW BRC from 2005 to 2018.

The NSW PDC records (as in other jurisdictions) include stillbirths, which are included in the general category of perinatal mortality. However, the PDC extracts provided to the AIHW for this project excluded stillbirths because the focus was on subsequent death at specific ages among babies classified as liveborn. Excluding stillbirth from this report's analyses is consistent with normal CDRT reporting practices. It does mean, though, that the results may not be comparable with those from other analyses of perinatal mortality – or even with broader categorisation of deaths under age 1 that could include stillbirths.

The initial linkage of the PDC and BRC identified 1,393,488 unique records of liveborn babies in New South Wales between 2005 and 2018 (an average of around 99,500 births per year). This combined data set is called the PDC–BRC and formed the initial basis (spine) for the data linkage carried out for this project. Death records were linked to this spine.

The PDC records alone identified 1,337,341 unique liveborn babies in New South Wales between 2005 and 2018 (an average of around 95,500 births per year). This is also a number to note because any subsequent analyses of the effects of perinatal characteristics on child mortality in New South Wales can be carried out only for those births with a full PDC record.

Step 2: link the birth and death records

To identify which of the NSW-born children had died, their birth records were linked to death registration data from the following sources:

- NSW CDRT Register of Child Deaths collection 2005 to 2019 – for children whose deaths were registered in New South Wales
- AIHW NDI from 2005 to 2019 – for children whose deaths were registered anywhere in Australia.

Using both data sets meant that children who were born in New South Wales but died elsewhere could be included in this study.

The death records cover the years from 2005 to 2019. This identifies children who were born in 2018 and died before the end of 2019. So even the youngest children in the full cohort of babies born between 2005 and 2018 can be followed up for at least a year to identify whether they died before reaching age 1.

This study cannot identify children who died after 2019, as this was outside the scope of the death records used in the data linkage. As a result, any analyses of children surviving to age 5 with the linked data can only include children born in 2014 or earlier. For children born in later years, deaths can be recorded if they died at younger ages, but they cannot be classified as having survived to age 5 (if they have not already died by 2019). This is referred to as a problem of 'right censoring' of the data, when the span of years over which the cohort can be tracked in the death records is less than the specific age to which they have survived. (See Section 2.2 for further discussion and illustration of this censoring issue.)

A key feature of the data linkage design is that children in the NSW birth cohorts of 2005 to 2018 whose personal records cannot be matched in the death records were, by default, classified as not having died by the end of 2019. They were classified as having survived to specific ages that represent the number of years from their date of birth to the end of the death records data (31 December 2019).

This approach of identifying children who have survived to specific ages based on their absence from the death records can introduce some errors in classification, but this is an unavoidable feature of data linkage between births and death records. Independent validation that a particular child is still alive – using other criteria from additional data sources, rather than basing it only on absence in the death records – is not usually feasible.

Errors in classifying children as survivors can occur due to inaccuracies in the personal identifier variables available in the birth and death records. The scope for this kind of mismatching was reduced by also examining other identification details when they were available, such as mother's name and mother's date of birth. However, a probabilistic approach to linkage is necessary because of the variations in the reporting of the linkage variables, including variations in the full name and the way they are spelled across the different datasets. Duplicate records for the same child or mother in the same data set, with variations in some of the names provided, also have to be carefully reviewed manually and excluded from the data linkage.

Full details on the data linkage process and indicators used to assess the quality of the linkage in this project are in Appendix B. Figure 2.1 provides an overview of the outcomes from Step 2 of the data linkage for this project in identifying the total deaths among the reference NSW-born cohorts.

Each death registration data set was first matched individually with the linked perinatal and births data (the PDC–BRC). There were 4,987 matches between the CDRT death records from 2005 to 2019 and the PDC–BRC.

Similarly, there were 5,312 matches between the AIHW NDI and the PDC–BRC over the 2005–2019 period. A higher number of matches is expected here because it will include deaths of NSW-born children who died elsewhere or whose deaths were registered in other jurisdictions. Figure 2.1 identifies 461 such deaths associated with a PDC–BRC record that appear only in the NDI and not in the CDRT death records. However, the (5,321 minus 461 = 4,851) deaths from the NDI is still not an exact match with the 4,987 deaths from the CDRT source because the balance (4,987 minus 4,851 = 136) is the other type of mismatched deaths that appear only in the CDRT Register but not in the NDI.

These small differences could be genuine cases of missing or inaccurate death registrations in these 2 collections, or they could be caused by missing or inaccurate details on the personal identifier variables available for the same death in the CDRT Register and in the NDI.

The overall match is very high though. The number of deaths common to both data sources is 4,851. Among all CDRT registered NSW deaths linked to a birth cohort record (4,987), only 136 are missing from the NDI – which is a matching rate of over 97%. The converse matching rate for all NDI deaths linked to a birth cohort record (5,312) that are matched to the CDRT records is lower (91%), but this is expected due to the national coverage of the NDI.

Another adjustment to the number of deaths in the linked data that can be used in this study relate to deaths among babies that have a link to a PDC record and a valid computation of the exact age at death. The main focus of this report is on the effects of perinatal conditions on child mortality; so only death records that are matched to a PDC record so that perinatal conditions for that death are known are relevant for this study. It also must not have any missing components or mistakes in the way in which the full date of birth and date of death are recorded so that an exact age at death in days since birth can be derived. These adjustments reduce the number of deaths in the linked data relevant to this study to 4,057 (Figure 2.1)

Finally, since the focus of this study is not all deaths among the 2005 to 2018 NSW birth cohorts, but on deaths under age 5 in these birth cohorts, the final effective count of total deaths under age 5 that can be analysed from the linked data with a valid age at death and associated perinatal variables becomes 3,715. (See Section 2.2 for more details.)

Area-level data

Selected area-level variables designed to capture the average socioeconomic status of the resident population of that area were derived from the following sources:

- the SEIFA developed by the ABS from the 2011 Census. It ranks areas according to the average level of relative socioeconomic advantage/disadvantage of all individuals living in that area (ABS 2013). The specific SEIFA index used in this report is the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD).
- the AEDC collection managed by the Australian Government Department of Education. It contains assessments of child development vulnerabilities in 5 test domains when children begin their first full-year of schooling (DET 2019, 2022).[1]

After the AIHW HDLU linked the births and deaths data (using personal identifier variables), the project study team carried out the next step: adding the socioeconomic status indicator variables from the 2 area-level data sources to the linked data. This did not require access to the personal ID variable for the individual child and mother .This ‘linkage’ was based on the common geography variable used to define the usual place of residence of the mother – the Statistical Area Level 2 (SA2) category reported in the above sources and in the PDC.

This additional step assigns the same values of the area-level socioeconomic status variables to all mothers and babies from that same SA2.

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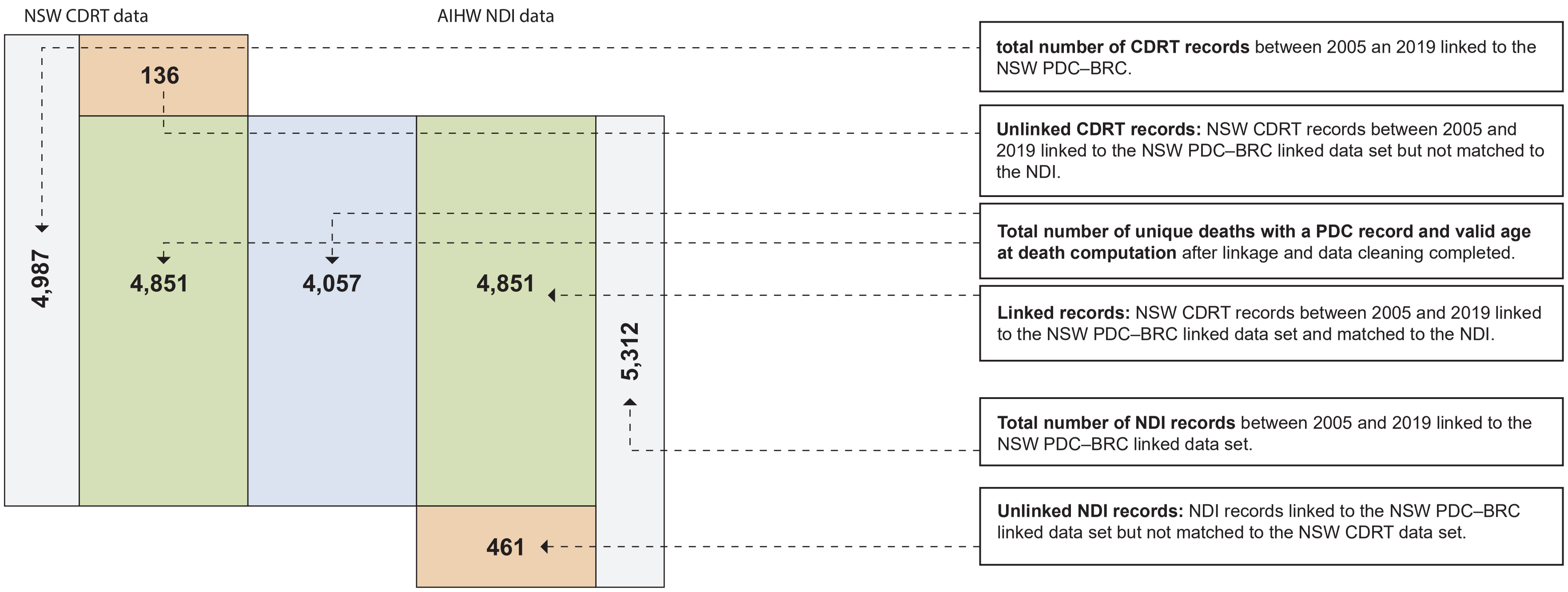
[1] The AEDC 5 test domains are physical health and wellbeing, social competence, emotional maturity, language and cognitive skills (school-based), and communication skills and general knowledge.

Figure 2.1: Linkage of NSW CDRT and NDI records to the NSW PDC–BRC based birth cohorts of 2005 to 2018



Note: Diagram not drawn to scale.

Source: Linked Perinatal, Births, CDRT and NDI data set.

2.2 Summary of mortality indicators in the linked file

Table 2.1 shows the total numbers of births and deaths in each cohort for the linked data sets. Children without a death record by the end of 2019 were classified as having survived to the end of 2019. Excluded from these results are the very few records of children who did not have an accurate date of birth and age at death in the linked data. Only children with a PDC record were included in Table 2.1 (a total of about 1.34 million records) because the main analyses in this report use data on the characteristics of the mother and baby from the PDC.

Of the 4,057 deaths identified from the NDI and CDRT records with perinatal data and a valid computation of age at death, 3,067 were deaths of children under age 1 (76%) and another 648 were deaths of children aged 1 to 4 (16%). The remaining 342 deaths were of children aged 5 and over, which is not a focus of this report. The combined total number of deaths under age 5 (also represented as deaths between ages 0 to 4) was 3,715 and the overwhelming component of that total consists of deaths under age 1 (3,067 or 83%).

Deaths of children between ages 1 to 4 (and total deaths of children aged 0 to 4) were censored from 2015 onwards because babies born in 2015 and afterwards did not have the chance to reach age 5 by the end of 2019. The number of deaths in Table 2.1 appears to drop for children born after 2015 – from 61 deaths in the cohort born in 2005 to only 3 deaths in the cohort born in 2018. This is just an artefact of the data censoring and says nothing about mortality rates over time.

There was no censoring for deaths under age 1 because the last birth cohort followed is for 2018, and deaths until the end of December 2019 were included in the linked data set.

Table 2.1: Deaths by age group and by birth year among deaths recorded between 2005 and 2019 in the NDI and CDRT records for NSW-born children with a PDC record and valid age at death derivation

Year of birth	Total births in linked file	Total deaths				Survived		
		By 2019	Under age 1	Ages 1–4	Ages 0–4	To end 2019	To age 1	To age 5
2005	90,037	387	251	61	312	89,650	89,786	89,725
2006	92,140	350	221	61	282	91,790	91,919	91,858
2007	95,351	356	247	60	307	94,995	95,104	95,044
2008	95,695	344	245	55	300	95,351	95,450	95,395
2009	95,774	331	241	54	295	95,443	95,533	95,479
2010	95,885	316	251	39	290	95,569	95,634	95,595
2011	96,613	305	222	64	286	96,308	96,391	96,327
2012	98,864	292	234	46	280	98,572	98,630	98,584
2013	96,353	303	239	52	291	96,050	96,114	96,062
2014	96,738	252	200	51	251	96,486	96,538	96,487
2015	95,737	231	185	*46	*231	95,506	95,552	95,506
2016	98,094	194	158	*36	*194	97,900	97,936	97,900
2017	95,128	199	179	*20	*199	94,929	94,949	94,929
2018	94,932	197	194	*3	*197	94,735	94,738	94,735
Total	**1,337,341**	**4,057**	**3,067**	**648**	**3,715**	**1,333,284**	**1,334,274**	**1,333,626**

Note: Cell entries from 2015 marked with asterisk (*) represent data based on censored time periods. Not all surviving babies in those specific birth cohorts would have reached age 5 and counts of deaths under age 5 will be incomplete.

Source: AIHW analyses of the linked NSW Perinatal and Deaths data.

2.3 Data analysis plan

This section outlines the 3 main categories of mortality outcomes analysed in this report and the types of statistical method used. The 3 main categories of the mortality outcomes were:

- age at death
- cohort birth period chosen for analysis
- whether the analyses were of deaths among all children in specific cohorts or focused only on deaths of Indigenous children.

The separate analysis of Indigenous child deaths is a methodological enhancement over the common alternative approach that distinguished only the Indigenous status of the child or birth mother in a combined analysis of all child deaths.

The separate analyses of Indigenous child deaths will identify if the risk factors most relevant for Indigenous child death are different from the risk factors for all child death (which will be dominated by deaths among non-Indigenous children). Even if the key risk factors are common, the separate modelling of Indigenous child deaths can show if a particular risk factor has a relatively greater or smaller role in explaining Indigenous child death than in the general model for all child death. This will help to improve our understanding of the sources of the known disparities in the mortality rate and causes of death between Indigenous and non-Indigenous children.

The age at birth and age at death in the linked data were used to create 3 main child mortality indicators that are analysed in this report:

1. child death under age 1 (a standard measure of infant mortality)
2. child death between ages 1 to 4 (that is, before reaching age 5)
3. total child deaths for ages 0 to 4 (which is the sum of the 2 age groups above, and is the standard measure of child mortality).

A high proportion of total deaths under age 1 occur in the first 7 days after birth. The causes of death in this early period can differ from the causes of death after the first week and under age 1. As a result, total deaths under age 1 (category 1) is further subdivided, in some parts of this report, into:

1a. child death under age 1 that occurs in the first 7 days after birth

1b. child death under age 1 that occurs after the first 7 days after birth.

Where there is a sufficiently large number of deaths observed in the linked data, the results were further subdivided into 3 birth cohort periods for the analyses of the risk of dying among all children:

1. birth cohorts of 2005 to 2010 (period 1, containing 6 calendar year cohorts)
2. birth cohorts of 2011 to 2014 (period 2, containing 4 calendar year cohorts)
3. birth cohorts of 2015 to 2018 (period 3, containing 4 calendar year cohorts).

This breakdown of the data analyses into 3 periods helped us to identify overall mortality trends over the 3 periods and to assess whether the risk factors associated with child death have changed over these 3 periods. The split between period 1 and period 2 at 2011 was chosen because several new PDC variables, such as smoking status at different periods during the pregnancy and the Indigenous status of the baby and not just of the mother, were collected from 2011 onwards.

These 3 birth cohort periods were also chosen to maintain some balance in the number of babies included in each period, with more babies being born in the more recent years.

The analysis of deaths among Indigenous children was not divided into these same 3 birth cohort periods due to the small number of deaths among all Indigenous children in these birth cohorts. That analysis was carried out as a combined single period with pooled data on all Indigenous children from the 2005 to 2018 birth cohorts.

Finally, the following types of statistical method were used for the data analyses in this report:

- summary mortality tabulations at aggregate level that are not related to any of the perinatal characteristics derived from the linked data (chapter 3)
- analyses of the differences in selected perinatal characteristics between children who have died and children who survived to specific ages, by birth cohort periods where possible, and by Indigenous status (chapter 4)
- multivariate analyses using logistic regression modelling to identify specific risk and protective factors related to child death among all children, by birth cohort periods where possible (chapter 5), and a separate analysis for Indigenous children (chapter 6).

The above analysis components involve increasing statistical rigour. The results from the multivariate regression modelling are the key results of interest from this study. They help in:

- identifying the significant risk and protective factors for the specific mortality outcomes analysed
- quantifying the size of their relative effects.

More details about the logistic regression approach and the interpretation of the model results are in chapter 5 and Appendix A.2.

2.4 Deriving Indigenous status

The approach adopted in this study assigns Indigenous status to a baby if there is an Indigenous identity associated with that baby in any of the data sources used in the linkage; that is, at least one of the following criteria is met:

- the mother identified as Indigenous in the PDC
- the child identified as Indigenous in the PDC (this is collected from 2011 onwards only)
- among children who have died, the child is identified as Indigenous in the CDRT data
- among children who have died, the child is identified as Indigenous in the NDI.

It should be noted that the way to record the Indigenous status of the baby in the PDC changed in the 2005 to 2018 period used for this project. Before 2011, only the Indigenous status of the mother was recorded. From 2011 onwards Indigenous status is available from either the mother or the baby being identified as Indigenous.

This change in the data collection method leads to a higher proportion of babies identified as Indigenous in the total birth cohorts from 2011 onwards. There will be cases where some babies were recorded as being Indigenous while the mother was not recorded as Indigenous. This can refer to instances where the father is Indigenous (but the mother is not), while their baby has been given an Indigenous identity at birth.

Given the low number of Indigenous child deaths expected in the linked data, this study has opted for the more general approach to increase the number of babies identified as Indigenous based on any relevant source or variable, even if all the data sources or variables were not available over the entire study period.

The expected increase in the proportion of total births in the linked data given an Indigenous status from 2011 onwards (based on mother's or baby's status) is seen in Table 2.2. In the first period birth cohorts of 2005–2010, 3.0% of babies were identified as Indigenous, based only on the mother's status. This proportion increased to 5.3% in the birth cohorts of 2011–2015 and to 5.9% in the period 3 birth cohorts of 2015–2018. Over the entire birth cohorts of 2005 to 2018 included in this study, the proportion of the total births given an Indigenous status was 4.5%.

The total number of babies given an Indigenous status by our method is 60,276 over the 2005 to 2018 period.

Table 2.2: Babies identified as Indigenous in NSW PDC and CDRT/NDI linked data, by period

Birth year cohorts/period	2005–2010 (period 1)	2011–2014 (period 2)	2015–2018 (period 3)	2005–2018 (total)
Total number of births in linked file	564,905	388,579	383,946	1,337,430(a)
Number of births given an Indigenous status	17,067	20,614	22,595	60,276
Proportion of births given an Indigenous status in total births (%)	3.0	5.3	5.9	4.5

(a) This total count of births from the PDC records of 2005 to 2018 differs slightly for the total counts of births reported in Table 2.1 (1,337,341) because the Table 2.1 count is after linkage to the death records. That count excludes some cases with inaccurate or incomplete dates of birth which makes it infeasible to compute survival status to a specific age or exact age at death.

Note: Indigenous status of a baby at birth was available only from 2011 onwards in the NSW PDC.

Source: Linked Perinatal, Births, CDRT and NDI data set.

Further details are in Appendix B, which show that the proportion of total births given an Indigenous status would have increased even if a common approach on the Indigenous status of the baby were adopted for this study, based only on the mother's Indigenous status for all birth cohorts from 2005 to 2018.

3 Summary mortality rates and time trends from linked data

This chapter presents simple tabulations of the mortality rates and causes of death that were derived from the linked data. They are all aggregate measures and are not cross-referenced with any of the specific characteristics of the baby or of the mothers as derived from the PDC. (That relationship of mortality with perinatal characteristics is analysed in the next chapter).

These summary mortality rates are derived from the same data previously presented in Table 2.1 on deaths by age group and by birth year; however, they have been converted to cohort-specific mortality rate estimates (deaths per 1,000 born in each cohort) for the 3 different birth cohort periods of 2005–2010, 2011–2014 and 2015–2018.

These cohort-specific mortality rates are also analysed by Indigenous status in Section 3.2, together with a summary of the underlying total number of Indigenous child deaths under age 5 identified in the linked data for this project. The time periods chosen for the cohort-specific mortality rates by Indigenous status are a combination of 2-calendar-year birth cohorts (for example, babies born in 2005 and 2006, and then in 2007 and 2008). This gives a clearer picture of the trends in NSW child mortality rates for Indigenous and non-Indigenous children.

Section 3.3 briefly compares the differences in the underlying cause of death for Indigenous and non-Indigenous children based on the *International Statistical Classification of Diseases and Related Health Problems, 10th revision* (ICD-10) reporting of the causes of death that are available in the linked data.

At a glance

- Cohort-specific mortality rates have decreased for both Indigenous and non-Indigenous children in the 2005 to 2018 birth cohorts.
- Under-5 mortality rates fell more substantially over time for Indigenous children.
- Although mortality rates among Indigenous children are higher than those among non-Indigenous children across all birth cohorts, the gaps have narrowed.
- For instance, for the 2005 and 2006 birth cohort, the Indigenous under-5 mortality rate was 4 times that of non-Indigenous children.
- For the last birth cohort of 2013 and 2014 that can be followed up to age 5, the rate was 2.5 times that of non-Indigenous children – a considerable narrowing of the gap.
- The underlying cause of death of children varied substantially by age at death and also by Indigenous status.
- Based on ICD-10 reporting of the causes of death, the dominant cause of death under age 1 is ‘conditions originating in the perinatal period’ for both Indigenous and non Indigenous children (accounting for 44% and 51% of total deaths under age 1, respectively).
- Conditions originating in the perinatal period account for a small proportion of total deaths of children between ages 1 to 4 – less than 3% for both Indigenous and non Indigenous children.
- The most common cause of death for children between ages 1 to 4 was ‘accidents, injuries and other external causes’. This cause accounted for 50% of all Indigenous child deaths between ages 1 to 4 (but only 26% of non-Indigenous deaths).

The results from these sections on child mortality patterns, trend and cause of death were also used to define the scope of the cohorts and time period groupings chosen for the multivariate regression modelling that follows in chapters 5 and 6. The different pattern seen for the cause of death among Indigenous children provides a key reason for carrying out a separate modelling of the risk factors specific to Indigenous child death in chapter 6.

3.1 Aggregate child mortality rates

Age-specific aggregate child mortality rates for the 3 different birth cohorts (2005–2010, 2011–2014 and 2015–2018) are shown in Table 3.1. The calculations are based on the total deaths by age group and by birth year as previously presented in Table 2.1. The data are similarly censored for children born after 2014.

Uncensored data show a clear decline in mortality under age 1: 2.6 deaths per 1,000 births in the 2005–2010 cohorts to 1.9 deaths per 1,000 in the most recent 2015–2018 cohorts.

Mortality rates are considerably lower in the 1 to 4 age group, and this rate has consistently been around 0.5 deaths per 1,000. Overall child mortality under age 5 (ages 0 to 4) has decreased from 3.2 deaths per 1,000 in the 2005–2010 cohorts to 2.9 deaths per 1,000 in the 2011–2014 cohorts.

Table 3.1: Estimated mortality rate (per 1,000 live births), by age at death and birth year periods, all NSW-born children

Age at death (years)	Mortality rate for each birth cohort period				
	2005–2010	2011–2014	2015–2018	2005–2018	2005 to 2014[a]
<1	2.6	2.3	1.9	2.3	2.5
1 to 4	0.6	0.5	(n.a. - censored)	(n.a. - censored)	0.6
0 to 4	3.2	2.9	(n.a. - censored)	(n.a. - censored)	3.0

(a) Data on deaths of children between ages 1 to 4 and 0 to 4 are right-censored from 2015 onwards; hence, aggregate mortality rate for these age groups can be computed only among those born between 2005 and 2014.

Source: AIHW analyses of the linked NSW Perinatal and Deaths data.

3.2 Cohort-specific mortality by Indigenous status

The results of the data linkage show that under age 5 mortality rate for NSW born children changed markedly over the 2005 to 2018 birth cohorts, especially for Indigenous children.

A total of around 60,300 babies were identified as Indigenous as they met at least one of the following criteria:

- the mother identified as Indigenous in the PDC
- the child identified as Indigenous in the PDC (this is collected from 2011 onwards only)
- among children who have died, the child is identified as Indigenous in the CDRT data
- among children who have died, the child is identified as Indigenous in the NDI.

Among these 60,300 babies, over the time period followed up until the end of 2019 in the CDRT and NDI records of deaths:

- 419 (0.7%) died at any age
- 309 (0.5%) died under age 1
- 74 (0.1%) died between ages 1 to 4.

Considering only deaths of children under age 5, around 80% of total deaths under 5 of Indigenous children occurred under age 1 (309 of a total of 383).

Figure 3.1 presents the cumulative cohort-specific under-5 mortality rate per 100,000 live births by year of death and Indigenous status for babies born between 2005 and 2014. Each birth year is combined into a 2-year composite or combined birth cohorts (for example, 2005 and 2006). Deaths over the 2005 to 2019 period are also grouped into 2-year periods, except for 2019. For each composite cohort, there are 4 mortality rates based on the cumulative deaths that occurred as they increase in age up to completing 5 years.[2]

Figure 3.1 clearly shows the downward shift of these cumulative mortality rates for the later birth cohorts, and that the downward shift is more prominent in the cohorts of Indigenous children. The more rapid decline in Indigenous mortality is partly due to the high baseline mortality rates observed for the earliest cohorts born in 2005 and 2006, and in the next cohort of 2007 and 2008. This rapid decline in the Indigenous under-5 mortality rate in New South Wales is also noted in previous AIHW (2021a, 2020b) reports, and at the national level (AIHW 2018).

Indigenous children born in 2005–2006 had a cumulative mortality rate under age 5 of 1,206 deaths per 100,000 births over the 2005–2011 period. In comparison, those born in

2013–2014 had a cumulative mortality rate under age 5 of 652 per 100,000 over the 2013–2019 period. This is almost half of the under-5 mortality rate in the earlier period – a fall of 46% (with an average decrease of 139 deaths per 100,000 births between each 2-year birth cohort). The exception to this pattern of declining mortality rates was the 2011–12 and 2013–14 birth cohorts, which showed a slight increase in the under-5 mortality rate (595 and 652 per 100,000 births for 2011–12 and 2013–14 cohorts, respectively).

For non-Indigenous children, the decline in under-5 cumulative mortality rates was small, dropping from 301 deaths per 100,000 births for the 2005–2006 birth cohort to 258 per 100,000 for those born in 2013–2014. This is a fall of 14%. Between each observed 2-year birth cohort, the under-5 mortality rate for non-Indigenous children fell by an average of 11 deaths per 100,000 births.

Comparing the Indigenous and non-Indigenous cohort-specific under-5 mortality rates for the 2005–2006 birth cohort, the mortality rate for Indigenous children was 4.0 times that of non Indigenous children. For the last fully observed birth cohort of 2013–2014, the under-5 mortality rate for Indigenous children had fallen to 2.5 times that of non-Indigenous children in the same birth cohort. This is a considerable narrowing of the gap.

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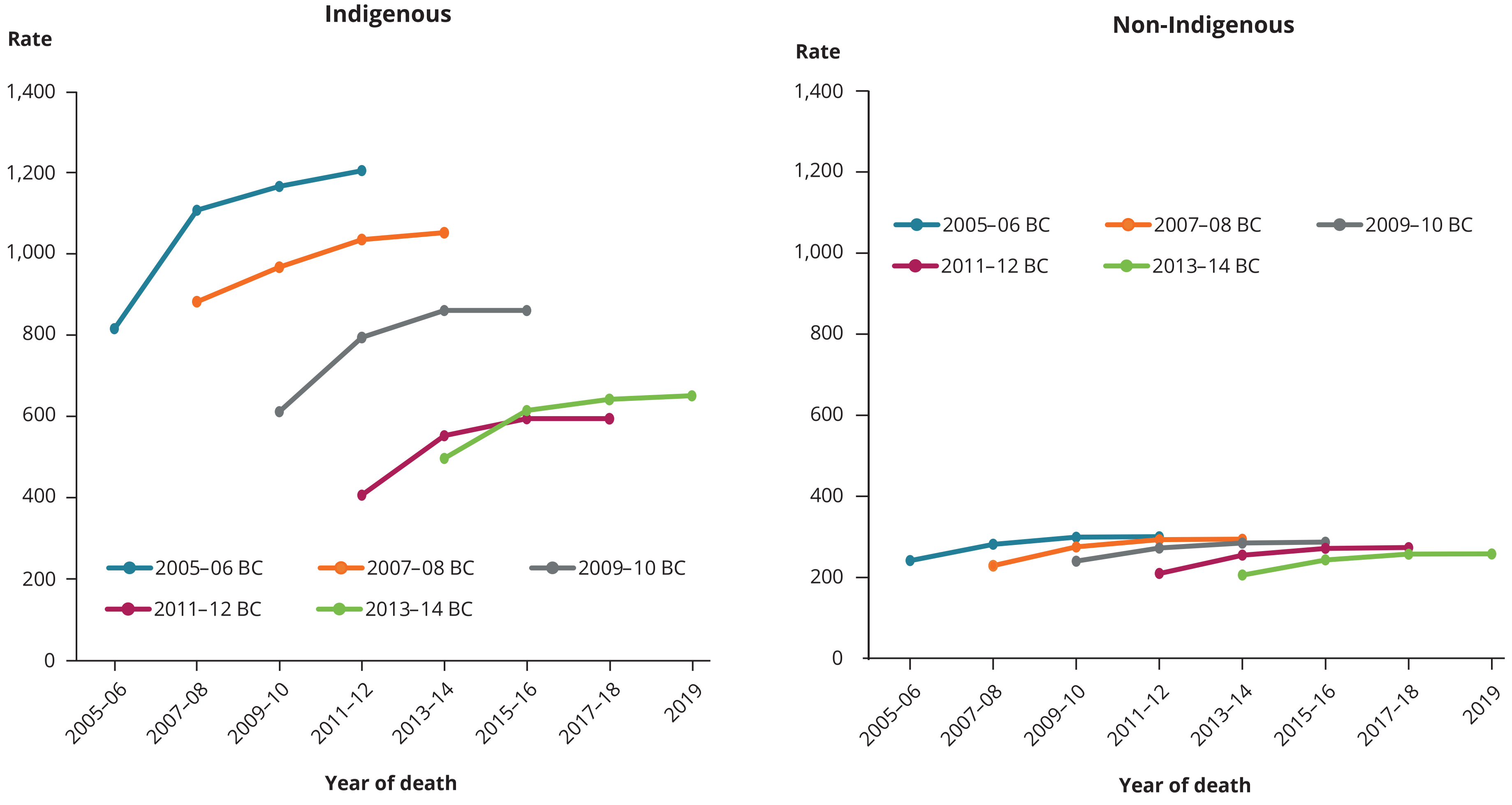
[2] *Note on how to read Figure 3.1*. Each line in the figure represents a specific 2-year birth cohort. For example, the 2005–2006 birth cohort in the Indigenous panel (line with light blue colour) represents all Indigenous children born in New South Wales in 2005 and 2006. The first dot on that line shows the proportion of these children who died in the 2005 and 2006 calendar years; this is shown as a rate of 800 out of 100,000 (equivalent to 0.8% of this cohort having died in 2005 and 2006). Most of the children who died in 2005 and 2006 were aged under 1 at death, so the rate of 800 out of 100,00 is also a proxy measure of the mortality rate under age 1. The next dot on the light blue line adds in the extra deaths for this cohort that occurred in calendar years 2007 and 2008; that shows a total death rate of around 1,100 per 100,000 (indicating that an extra 300 children from this cohort died in 2007 and 2008). The additional 2 dots on the same light blue line include the extra deaths for this cohort that occurred in 2009 and 2010, and then again in 2011 and 2012 – but always with the proviso that only deaths under age 5 for this cohort born in 2005 and 2006 are counted in each period.

Figure 3.1: Cumulative cohort-specific under-5 mortality rates per 100,000 births, by Indigenous status, birth cohort and year of death, from 2005 to 2019



BC = birth cohort (of 2-year calendar periods from 2005–2006 to 2013–2014).

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

3.3 Cause of death differences by age at death and Indigenous status

The underlying cause of death differs between Indigenous and non-Indigenous children and by the age at death. Causes of death are based on the ICD-10.

Previous analyses of Indigenous and non-Indigenous under-5 mortality at the national level showed that causes related to 'conditions originating in the perinatal period' are the main causes of death for both Indigenous and non-Indigenous children. These were followed by causes related to 'SIDS [sudden infant death syndrome] and other unknown causes' and to 'accidents, injuries and other external causes', with higher proportions among Indigenous children (AIHW 2018).

A similar pattern was found in the linked data file created for this project. The frequency distribution of specific causes of death in the linked data is reported in Table 3.2.

For total deaths under age 1, the dominant underlying cause was 'conditions originating in the perinatal period'[3] for both Indigenous and non-Indigenous children:

- for all deaths in the first year (44% for Indigenous and 51% for non-Indigenous)
- for deaths in the first week of birth[4] (74% for Indigenous and 72% for non-Indigenous).

In deaths under age 1, the largest differences in the relative share by Indigenous status was for deaths due to:

- 'SIDS and other unknown causes' (19% for Indigenous and 9% for non-Indigenous)
- 'accidents, injuries and other external causes' (6% and 3%, respectively)
- 'congenital and chromosomal conditions' (20% and 26%, respectively, with this cause being less likely for Indigenous deaths under age 1).

For deaths between ages 1 to 4, the largest differences in the relative share by Indigenous status was the higher share of Indigenous deaths due to:

- 'accidents, injuries and other external causes' (50% for Indigenous and 26% for non Indigenous)
- 'diseases of the circulatory system' (9% and 5%, respectively).

Conditions originating in the perinatal period accounted for less than 3% of total deaths between ages 1 to 4 for both Indigenous and non-Indigenous children.

Indigenous children were more likely than non-Indigenous children to die due to 'accidents, injuries and other external causes' at all ages up to age 5 – and even beyond (AIHW 2020b).

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[3] Examples of cause of death classified as 'conditions originating in the perinatal period' include being small for gestational age, extremely low birthweight, congenital viral diseases, bacterial sepsis of newborn.

[4] Note: Deaths in the first week of birth accounted for slightly more than half of total deaths under age 1.

Table 3.2: Proportion of deaths (%) by underlying cause of death, by age at death and Indigenous status, among NSW-born children 2005 to 2018

Underlying cause of death (ICD-10 classification)	Indigenous status	Age at death				
		<7 days	7 days to 1 year	1 to 4 years	Total <1 year	Total 0 to 4 years
Conditions originating in the perinatal period	Indigenous	74.1	16.9	2.9	44.4	36.7
	Non-Indigenous	72.3	23.9	1.6	50.9	43.0
	Difference (pp)	_1.9_	_–7.0_	_1.3_	_–6.4*_	_–6.3*_
SIDS and other unknown causes	Indigenous	0.0	36.4	4.4	18.9	16.2
	Non-Indigenous	0.8	20.2	3.6	9.4	8.4
	Difference (pp)	_–0.8_	_16.2*_	_0.8_	_9.5*_	_7.7*_
Accidents, injuries and other external causes	Indigenous	0.7	11.7	50.0	6.4	14.5
	Non-Indigenous	0.1	5.7	26.2	2.6	6.3
	Difference (pp)	_0.6_	_6.0*_	_23.8*_	_3.9*_	_8.2*_
Congenital and chromosomal conditions	Indigenous	23.8	16.9	5.9	20.2	17.5
	Non-Indigenous	24.3	28.2	11.8	26.0	23.7
	Difference (pp)	_–0.5_	_–11.3*_	_–5.9_	_–5.8*_	_–6.2*_
Diseases of the respiratory system	Indigenous	0.0	3.9	7.4	2.0	3.0
	Non-Indigenous	0.0	3.1	7.4	1.4	2.3
	Difference (pp)	_0.0_	_0.8_	_–0.1_	_0.7_	_0.7_
Diseases of the nervous system	Indigenous	0.0	5.2	2.9	2.7	2.7
	Non-Indigenous	0.6	6.7	9.8	3.3	4.3
	Difference (pp)	_–0.6_	_–1.5_	_–6.9_	_–0.6_	_–1.6_
Neoplasms	Indigenous	1.4	2.0	5.9	1.7	2.5
	Non-Indigenous	0.3	1.0	17.0	0.6	3.2
	Difference (pp)	_1.1*_	_1.0_	_–11.1*_	_1.1*_	_–0.7_
Endocrine, nutritional and metabolic diseases	Indigenous	0.0	0.7	2.9	0.3	0.8
	Non-Indigenous	0.9	2.7	8.2	1.7	2.7
	Difference (pp)	_-0.9_	_-2.0_	_-5.3_	_-1.3_	_-1.9*_
Diseases of the circulatory system	Indigenous	0.0	0.0	8.8	0.0	1.6
	Non-Indigenous	0.3	2.5	4.6	1.3	1.8
	Difference (pp)	_–0.3_	_–2.5*_	_4.2_	_–1.3*_	_–0.2_
All other causes	Indigenous	0.0	6.5	8.8	3.4	4.4
	Non-Indigenous	0.6	6.1	9.8	3.0	4.1
	Difference (pp)	_–0.6_	_0.4_	_–1.0_	_0.3_	_0.3_

pp = percentage point difference between the percentage value for Indigenous deaths and the percentage value for non-Indigenous deaths.

Note: pp values marked with an asterisk (*) indicate a statistically significant difference between the Indigenous and non-Indigenous percentage values at the 5% test level, corresponding to a 95% confidence interval level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

4 Differing characteristics of children who died and children who survived

This chapter presents a simple comparison of the characteristics of children who have died and who have survived to specific ages, among a wide set of the perinatal variables collected on the circumstance of their birth and on their mothers.

Some comparisons are also reported for the area-level variables that reflect the average socioeconomic status of the usual place of residence of the mother at the time of giving birth.

The reference population is the full cohort of all children born in New South Wales from 2005 to 2018 but categorised into the 3 birth cohort periods:

- birth cohorts of 2005 to 2010 (period 1, containing 6 calendar year cohorts)
- birth cohorts of 2011 to 2014 (period 2, containing 4 calendar year cohorts)
- birth cohorts of 2015 to 2018 (period 3, containing 4 calendar year cohorts)

A similar analysis for Indigenous children in the full 2005 to 2018 birth cohorts without a breakdown by period is presented in Section 4.3.

The observed differences seen in this chapter on the characteristics of the children who died and those who survived were also used to select the final set of perinatal variables and area level variables to be included in the subsequent multivariate regression analyses in chapters 5 and 6.

For instance, if the proportion of low birthweight babies among children who died under age 1 is found to be considerably higher than among those who survived to age 1, the implied mortality rate among low birthweight babies is higher than among normal or higher birthweight babies. This points to low birthweight being a critical risk factor for early child death, as is well known.

Table A4.1 (in Appendix A.1) presents full comparative results for a selected set of 32 maternal or baby characteristics (or factors) for which data are reported in the PDC, or on the area-level socioeconomic status variables derived from other sources. These comparisons highlight how the 2 groups of children (those who have died and those who have survived to age 1 and age 5) differ on these key perinatal factors.

These 32 perinatal factors are classified in 5 groups:

1. demographic
2. pregnancy period care and risk factors
3. maternal health
4. conditions of birth
5. baby’s health;

and a sixth group includes,

6. area-level socioeconomic indicators (of the SA2 the mother lived in at time of giving birth).

At a glance

Simple comparisons of the characteristics of the children who died and who survived to specific ages reveal significant differences on a range of perinatal and area-level variables.

The key risk factors for deaths under age 1 identified in these bivariate comparisons for all babies were:

- preterm birth and low birthweight (as well as birthweight small for gestational age)
- Indigenous status of the baby, but this effect has diminished over time
- mother smoked during pregnancy
- mother experienced postpartum haemorrhage requiring a blood transfusion.

For instance, in the 2015–2018 birth cohort among children who had died under age 1, around 17% of their mothers had smoked at some time during the pregnancy. For children who survived to age 1, only 8.8% of their mothers had smoked during pregnancy.

Differences among some other perinatal variables were even starker:

- This included baby being admitted to the special care nursery or neonatal intensive care for 4 hours or more, or being assigned a low APGAR score (values less than 7) at 5 minutes after birth.
- In the 2015–2018 birth cohort, among children who had died under age 1, around 55% had a low APGAR score (less than 7), while among children who had survived to age 1, less than 2% were assessed to have a low APGAR score.
- There is also a continuing effect of low birthweight and preterm status on child mortality between ages 1 to 4; however, being born to mothers who experienced postpartum haemorrhage requiring blood transfusion did not increase the risk of dying in this age group.

For Indigenous babies, there were risk factors common to those identified above.

- One difference, however, was that Indigenous babies born to mothers residing in *Major cities* were found to have significantly higher mortality rates than babies born to mothers in *Remote and Very remote* or *Inner and Outer regional* areas.

The differences highlighted in this chapter are preliminary results. The analyses did not control for the effects of other factors. This is done only in the subsequent detailed multivariate regression analyses, which are reported in chapters 5 and 6.

APGAR = Appearance, Pulse, Grimace, Activity and Respiration (score).

4.1 Key risk factor differences

This section focuses on identifying an initial set of key risk factors contributing to child death by highlighting the differences on a set of selected perinatal and area-level characteristics between children who have died and children who have not died. Examples of perinatal characteristics that differed significantly between these 2 subgroups of children (who died and survived) include low birthweight, preterm birth status and mother smoking during pregnancy. Other non-significant risk factors are also included in the tabulations presented in this section.

Table A4.1 (in Appendix A.1) presents comparative results for the full 32 maternal or baby characteristics and for the area-level socioeconomic status variables for each of the 3 different birth cohort periods.

Figure 4.1 illustrates one set of results from Table A4.1. It focuses on the most recent birth cohorts of 2015–2018, comparing the differences in the characteristics of these babies who died under age 1 and who survived to age 1. Figure 4.2 illustrates another set of results from Table A4.1, focused on the differences in the characteristics of babies born in 2011–2014 who died between ages 1 to 4 compared with babies who survived to age 5.

The fuller results in Table A4.1 show that several of the comparative differences are consistently significant across all relevant cohorts. For instance, among all children who died under age 1 (in the 3 different birth cohort periods specified), around 60% were low birthweight babies. In the comparison group of children who survived to age 1, the proportion who were low birthweight is significantly lower: around 6%.

A similar pattern also occurs with preterm birth. Among babies who died under age 1, around 60% were born preterm in each of the 3 birth cohort periods, compared with around 7% born preterm among those who survived to age 1 (Table A4.1).

There is also a continuing effect of low birthweight and preterm status on child mortality between ages 1 to 4. Among children who died between ages 1 to 4, the proportion of low birthweight babies (11% to 12% in the 2 periods with complete data) is almost double the proportion among those who survived to age 5 (6%).

Smoking during pregnancy is also associated with increased risk of the baby dying under age 1 and between ages 1 to 4. For instance, in the 2005–2010 birth cohort, 22% of the babies who died under age 1 had mothers who smoked during pregnancy, but only 13% of babies who survived to age 1 had mothers who smoked (Table A4.1). Smoking appears to have as much of an effect on child death between ages 1 to 4 as it does for death under age 1. In the 2005–2010 cohort, among children who died between ages 1 to 4, 20% of mothers smoked during pregnancy compared with 13% among babies survived to age 5.

The smoking-related proportions presented in Table A4.1 also reveal an interesting time pattern. In all 3 birth cohort periods the proportion of mothers who smoked is substantially higher among babies who died than among those who survived to specific ages. Over the 3 birth cohort periods, the proportion of mothers who smoked during pregnancy has consistently decreased. The decrease occurs irrespective of whether the mothers are in the group whose babies have died or in the group whose babies survived to the specified age.

Among babies who died under age 1, the proportion of mothers who smoked during pregnancy declined from 22% in the 2005 to 2010 birth cohort to 16% in the 2015 to 2018 cohorts. There was a similar decline among mothers in the survival group, from 13% in 2005–2010 to 9% in 2015–2018. These declines are consistent with the overall decline in the proportion of the NSW population (and general Australian population) who smoke, including potential mothers (AIHW 2020a).

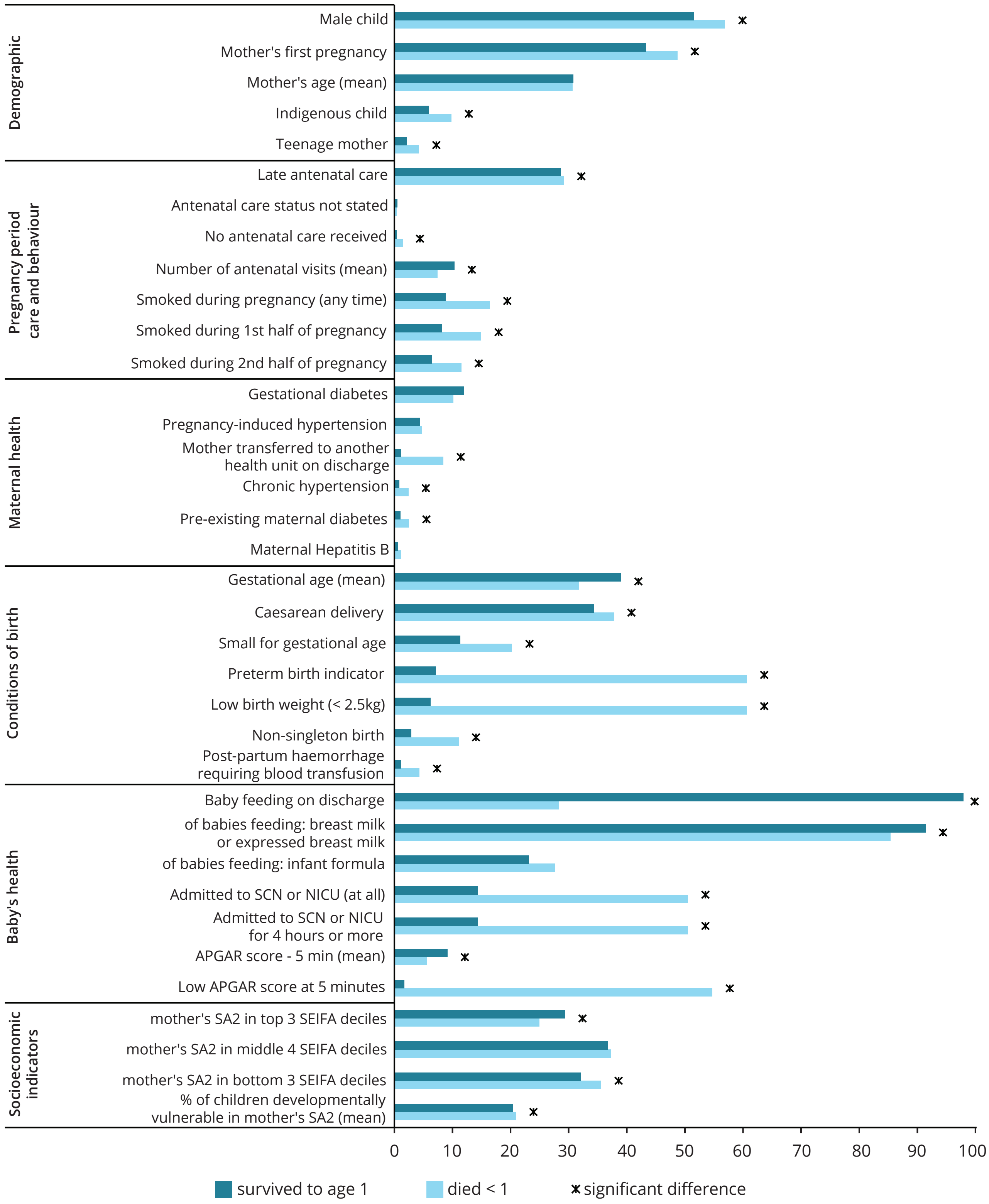
Several other perinatal characteristics had a smaller but still consistent and statistically significant effect among babies who died under age and who survived to age 1:

- child being male (risk factor)
- non-singleton births (risk factor)
- birthweight small for gestational age (risk factor)
- teenage mothers aged 19 or under (risk factor)
- total number of antenatal care visits during pregnancy (protective factor)
- postpartum haemorrhage requiring blood transfusion for the mother (risk factor)
- caesarean mode of delivery (risk factor)
- baby feeding on discharge (protective factor).

A few of the perinatal characteristics analysed in Table A4.1 did not show a consistent difference between babies who died and those who survived to specific ages. These include:

- pre-existing maternal diabetes
- chronic hypertension or pregnancy-induced hypertension.

Figure 4.1: Maternal and baby characteristics by survival status to age 1, all children, 2015–2018 birth cohort: mean values or proportion (per cent) of babies

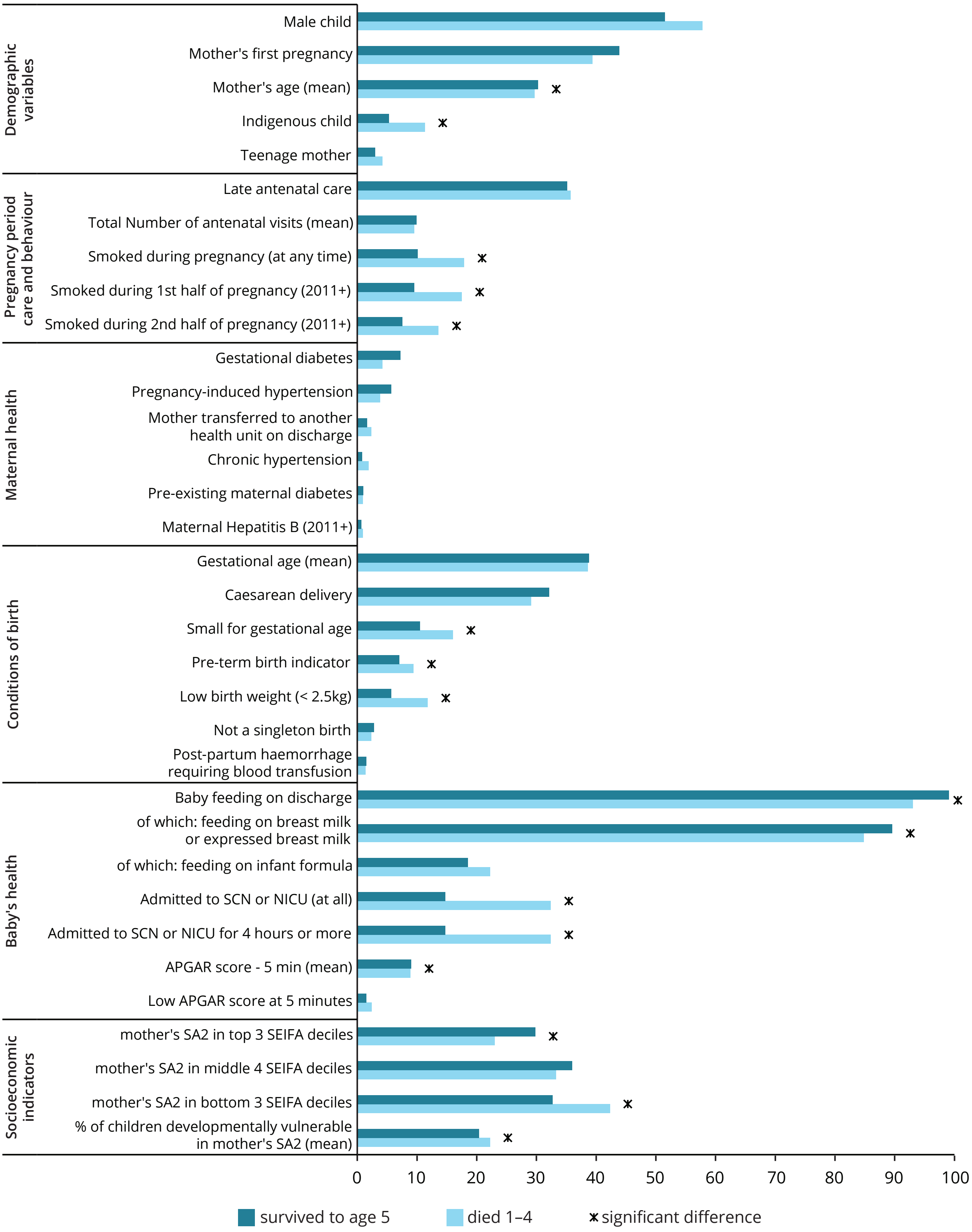


SCN = special care nursery; NICU = neonatal intensive care nursery.

Note: The units on the x-axis (related to length of the horizontal bars) are percentages for characteristics that are categorical (most items). For characteristics that are continuous variables (with the word 'mean' in the description), the units represent how that continuous variable is measured (for example, years for the age of the mother). An asterisk indicates that the value of the difference in that characteristic between children who died and those who survived to age 1 is statistically significant at the 5% test level; no asterisk indicates that the difference in that characteristic between those who died and those who survived was not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data in Appendix Table A4.1.

Figure 4.2: Maternal and baby characteristics by survival status to age 5, all children, 2011–2014 birth cohort: mean values or proportion (per cent) of babies



Note: The units on the x-axis (related to the length of the horizontal bars) are percentages for characteristics that are categorical (most items). For characteristics that are continuous variables (with the word 'mean' in the description), the units represent how that continuous variable is measured (for example, years for the age of the mother). The asterisks indicate whether the value of the difference in that characteristic between children who have died and who have survived to age 1 is statistically significant at the 5% test level. The absence of an asterisk marker indicates that the difference in that characteristic between those who died and survived was not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data in Appendix Table A4.1.

4.2 Mortality rates by perinatal characteristics

This section converts the comparative differences from figures 4.1 and 4.2 (and the fuller data in Table A4.1) into direct estimates of the proportion of children with a specific characteristic who have died. These represent cohort-specific mortality rates by specific ages, along with risk ratios for survival to a specified age between two different categories of a specific perinatal characteristic. The full set of the mortality rate comparisons for 8 selected characteristics is in Table A4.2 (Appendix A.1) for all birth cohorts and for deaths by 3 specific ages. Figure 4.3 illustrates the results for one death category (died by age 1) for the 2015–2018 birth cohort.

The 8 selected characteristics are as follows.

- sex
- Indigenous status
- low birthweight status
- preterm birth (further categorised into preterm birth under 32 weeks gestational age, and preterm birth between 32 and 36 weeks in Table A4.2, but not in Figure 4.3)
- non-singleton birth
- small for gestational age status
- smoking status of the mother during pregnancy
- remoteness area classification of the usual place of residence of the mother.

The mortality rates in this section are expressed as the number of deaths per 1,000 live births in the selected NSW birth cohorts. They are based on deaths among all children in the selected birth cohorts by the time they reach a specific age, such as age 1 or age 5, irrespective of what calendar year that death occurred in. These cohort-level mortality estimates show that the underlying risk of child death is clearly related to several demographic and other perinatal characteristics collected in the PDC.

The mortality rates in this study are not the conventional infant or child mortality estimates that are usually derived as cross-sectional estimates from calendar year data on deaths and a reference population. AIHW (2021a) has a detailed discussion of the differences between cohort-specific mortality rates and the conventional cross-sectional mortality rates, and the relative advantages of each type of estimate.

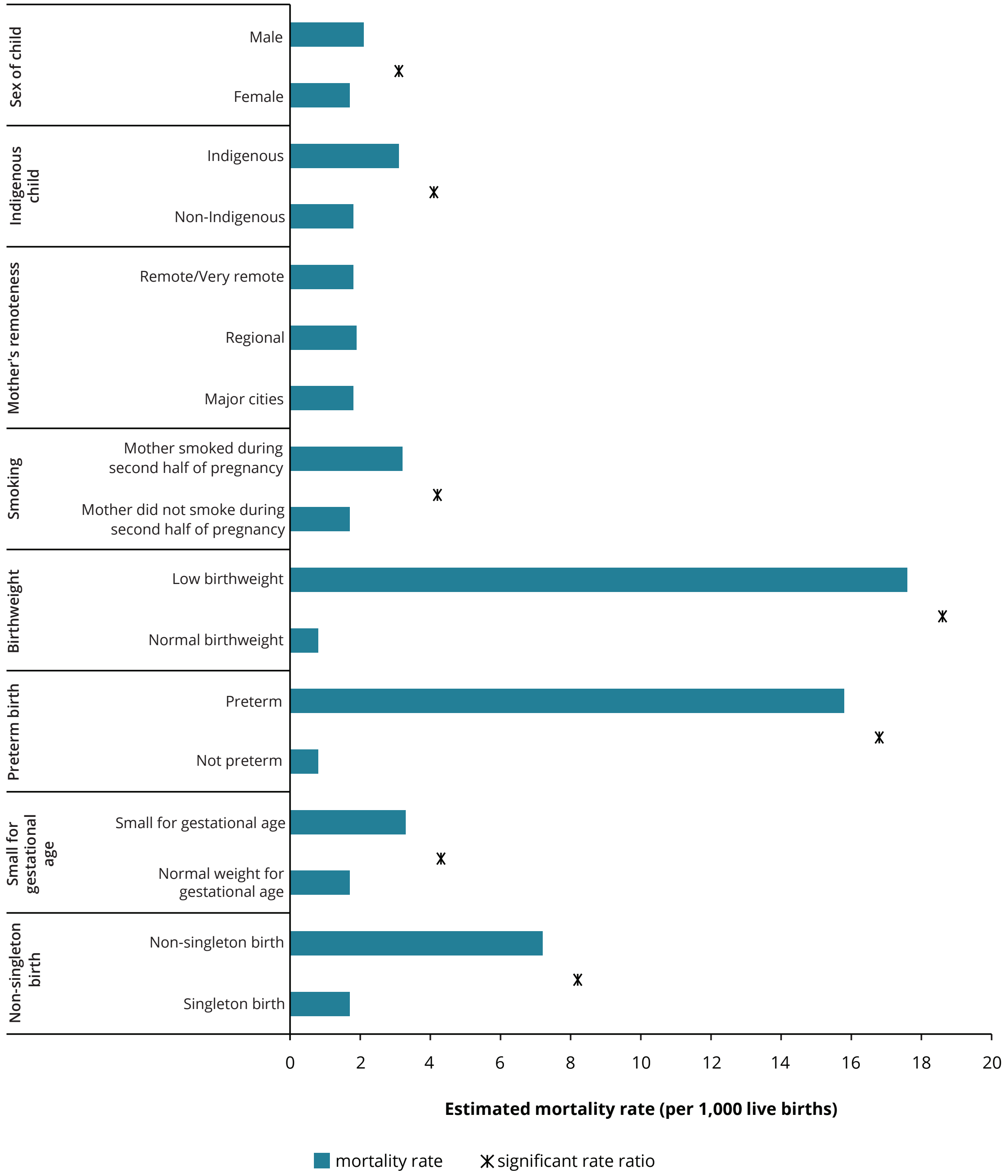
Perinatal characteristics with largest differences in mortality

The largest difference in the mortality rate among the characteristics examined (see Table A4.2) was for preterm birth under 32 weeks gestational age. For babies born in 2005–2010, 111 of 1,000 these such preterm babies had died under age 1, compared with only 1.1 deaths per 1,000 among full-term babies. Expressed as a ratio of these 2 rates, mortality under age 1 for preterm babies born under 32 weeks was roughly 101 times the mortality of full-term babies in the 2005–2010 cohorts. This was a statistically significant difference.

This large difference was also seen in the other 2 birth cohorts of 2011–2014 and 2015–2018. However, the under age 1 mortality rate among preterm babies born under 32 weeks gestational age showed a decline from 111 per 1,000 in 2005–2010 to 102 per 1,000 in 2011–2014 and 85 per 1,000 in the 2015–2018 birth cohorts.

The rate ratio between male and female mortality under age 1 was 1.2 to 1.3 in all 3 birth cohorts, which was significantly higher than 1. The rate ratio for deaths after age 1 and under age 5 was also higher than 1 (1.2 and 1.3 in the 2005–2010 and 2011–2014 cohorts, respectively), but these were not statistically significantly different from 1. This indicates that the higher risk of male babies dying persists only in the under age 1 group.

Figure 4.3: Estimated under-1 mortality rate (per 1,000 live births) by maternal and baby characteristics, all children, 2015–2018 birth cohort



Note: An asterisk denotes that the rate ratio of the mortality rates of a characteristic between children who died and children who survived to age 1 was statistically significant at the 5% test level. No asterisk indicates that the rate ratio for that characteristic between those who died and those who survived was not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data in Appendix Table A4.2.

Another characteristic showing a large difference in mortality rates was low birthweight status. For babies born between 2005–2010, 26 of 1,000 low birthweight babies had died under age 1 compared with only 1 per 1,000 among normal or higher birthweight babies – a significant rate ratio of roughly 24. This large difference was also seen in the other 2 birth cohorts of 2011–2014 and 2015–2018; however, the under age 1 mortality rate (even among low birthweight babies) declined to 18 per 1,000 in the 2015–2018 birth cohort.

Babies born small for their gestational age[5] also had significantly higher mortality rates than those born with a normal weight for their gestational age. Rate ratios for this comparison were significant at around 2 across all birth cohorts and age groups at death (Table A4.2).

The under age 1 mortality rate for babies whose mothers smoked during pregnancy was 3.2 per 1,000 in the 2015–2018 cohort compared with the lower rate of 1.7 per 1,000 among babies whose mothers did not smoke. The associated rate ratios range from 1.8 to 1.9 in the 3 different birth cohorts and are all statistically significant.

Non-singleton births showed a consistently higher mortality rate in the under age 1 category across all 3 birth cohorts. The rate ratio ranged from 3.8 to 4.2 and was significant for all 3 cohorts. There was no significant difference in the mortality rates for children aged 1 to 4 based on singleton versus non-singleton birth status.

Differences by Indigenous status and remoteness areas

These cohort-specific mortality rates are also clearly higher for Indigenous babies (classified on the basis of an Indigenous identity recorded for either the baby or the birth mother). The overall mortality rates among Indigenous children, however, has decreased over time.

The under age 1 Indigenous mortality rate, decreased over the 3 cohorts (Table A4.2):

- 7.9 deaths per 1,000 in the 2005–2010 birth cohorts (the first cohort)
- 5.1 per 1,000 in the 2011–2014 cohorts (the second cohort)
- 3.1 per 1,000 in the 2015 to 2018 births cohorts (the most recent cohort).

In each period, the under age 1 Indigenous mortality rate is considerably higher than the rate for non-Indigenous babies; but the decline in the Indigenous rate is faster than the decline in the non-Indigenous rate. The rate ratio of the Indigenous and non-Indigenous under age 1 mortality has fallen from 3.3 times higher in the first cohort to 2.4 times higher in the second cohort, to only 1.7 times higher in the most recent 2015–2018 cohort.

The rate ratio of the Indigenous to non-Indigenous mortality rate for ages 1 to 4 also fell substantially from 4.7 times higher in the first cohort to 2.3 times higher in the second cohort. (This rate cannot be computed for the most recent cohort of 2015–2018 because of data censoring for survival to age 5.) Additional comparisons of the cohort-specific mortality rates for Indigenous and non-Indigenous babies were presented in Section 3.2 of chapter 3.

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[5] Birthweight small for gestational age is birthweight at or below the 10th percentile of the full distribution of Australian birthweight for liveborn singleton babies, by sex and gestational age, as compiled across all Australian births from 2004 to 2013 – see Table 6.1 in AIHW (2022b). The 10% percentile cut-off birthweight in this distribution can differ from other international standards used for classifying babies with birthweight small for gestational age.

Mortality rates are also related to the regional classification of the mother's usual place of residence. The pattern of differences is not consistent. Across the 3-way classification of remoteness areas as *Major cities*, regional (which combines *Inner regional* and *Outer regional*), and remote (which combines *Remote* and *Very remote*), the cohort mortality rates were slightly higher in regional areas than in *Major cities* and remote areas, but the differences were minor. The rate ratios for *Major cities* compared with those for regional areas were less than 1 and were mostly significant (Table A4.2). The rate ratios for remote areas compared with regional areas had a wider range (from 0.7 to 1.6), and none were statistically significant.

Extension to multivariate analyses of difference

The simple comparisons of the cohort-specific mortality rates and rate ratios presented in this section should be treated with caution. They are based only on differences in a single characteristic – such as preterm birth, smoking during pregnancy and Indigenous status – without considering the relationships between the different characteristics. For instance, the smoking rate during pregnancy can be considerably higher for Indigenous mothers (AIHW 2020a). A simple comparison of the mortality rates for Indigenous and non-Indigenous babies would partly reflect the effect of the differences in the smoking risk factor, and hence it would not be accurate to attribute that difference being related to Indigenous status.

The multivariate logistic regression analyses reported in chapters 5 and 6 adjust for the role of other potential factors. They more clearly identify the key factors contributing directly to child death. This is a similar approach to that used in previous AIHW analyses of the risk factors for child death using national level linked data (AIHW 2021a) and analyses of neonatal deaths from the Perinatal National Minimum Data Set (AIHW 2021b).

A second reason for caution is that the cohort-specific mortality rates are sensitive to the total number of children who died with a specific characteristic that can be identified in the linked data. When the PDC records were linked to the death registration records, not all deaths could be matched to a birth record, and some inaccurate matches may have also occurred.

While the overall quality of the data linkage is high in terms of coverage and accuracy of the matching of the records (see Appendix B), there is a scope for greater inaccuracies among babies and mothers with specific characteristics that may apply only to a small component of the total birth cohorts. For instance, if a very small proportion of babies have a low APGAR score (around 1.5% of total births in this project's linked data), even a few cases of incomplete or inaccurate matching of records in the data linkage process for these babies could result in misleading cohort-specific mortality estimates for them.

4.3 Key risk factors and mortality rates by perinatal characteristics for Indigenous children

This section presents simple bivariate comparisons of the characteristics of Indigenous children who died and those who survived. The characteristics include the perinatal variables collected on the circumstance of birth and on the characteristics of the birth mother (similar to that in tables A4.1 and A4.2 for all children in the study cohorts).

Due to small number of deaths, the 3 different birth cohort periods used in the analyses for all children were combined into a single 2005–2018 birth cohort. Comparisons of the characteristics among Indigenous children who died and who survived are reported in full in Table A4.3 in Appendix A.1 for deaths in only 2 age categories: under age 1, and combined under age 5 (or between ages 0 to 4).

One difference in the characteristics compared in Table A4.3 for Indigenous children is the use of another area-level socioeconomic status indicator that is an alternative to the SEIFA index. This is the Indigenous Relative Socioeconomic Outcomes (IRSEO) index, developed in Biddle (2013). It is an Indigenous-specific index of socioeconomic indicators that reflects the average level of socioeconomic disadvantage for the Indigenous population of that area (as opposed to the socioeconomic status of the overall population, reflected in the SEIFA indices).

Figure 4.4 illustrates the results from Table A4.3 for comparing dying under age 1 and surviving to age 1. The deaths of Indigenous children under age 1 represent around 80% of total deaths under age 5. Hence, the comparison of the characteristics of children who died under age 5 or survived to age 5 is very similar to the results shown in Figure 4.4 (but those results are not presented separately). Figure 4.4 also shows whether the percentage point difference between the proportion of children who died and those who survived was statistically significant at the 5% test level for each characteristic.

The key risk factors identified for deaths under age 1 for Indigenous babies were:

- preterm birth
- low birthweight and small birthweight for gestational age
- mother smoking during pregnancy
- non-singleton birth
- fewer total antenatal care visits
- mother experienced postpartum haemorrhage requiring blood transfusion
- baby was admitted to a special care nursery or neonatal intensive care unit after birth
- baby not feeding at discharge.

These risk factors were all statistically significant for deaths under age 5, and all factors except one (smoking during pregnancy) were significant for deaths under age 1.

Unlike the results for the full cohort of all children (Table A4.1), male Indigenous babies were not found to be at increased risk of dying compared with female Indigenous babies. Similarly, babies born to Indigenous mothers aged under 20 showed no increased risk of dying than those born to Indigenous mothers aged 20 or over.

Figure 4.5 presents direct estimates of the under age 1 cohort-specific mortality rate for Indigenous babies with a specific characteristic (similar to that presented in Figure 4.3 in Section 4.2 for all children). These mortality rate comparisons for the Indigenous cohorts of 2005–2018 are made for 7 characteristics of interest: baby's sex, low birthweight status, small for gestational age status, preterm birth status, non-singleton birth status, smoking status of the mother during pregnancy, and regional classification of the usual place of residence of the mother.

Full results for the Indigenous under age 1 cohort-specific mortality rate estimates are in Appendix Table A4.4. These estimates of the Indigenous mortality rate by key perinatal characteristics in Figure 4.5 and Table A4.4 – among all NSW-born Indigenous babies over the 2005–18 period – are illustrative only due to the small number of total deaths in the linked data.

The results presented in Figure 4.5 and Table A4.4 show a generally similar pattern of risk factors for Indigenous children when compared with all children born in New South Wales. Significant differences in the mortality rate ratios for Indigenous deaths under age 1 were found for the following risk factors:

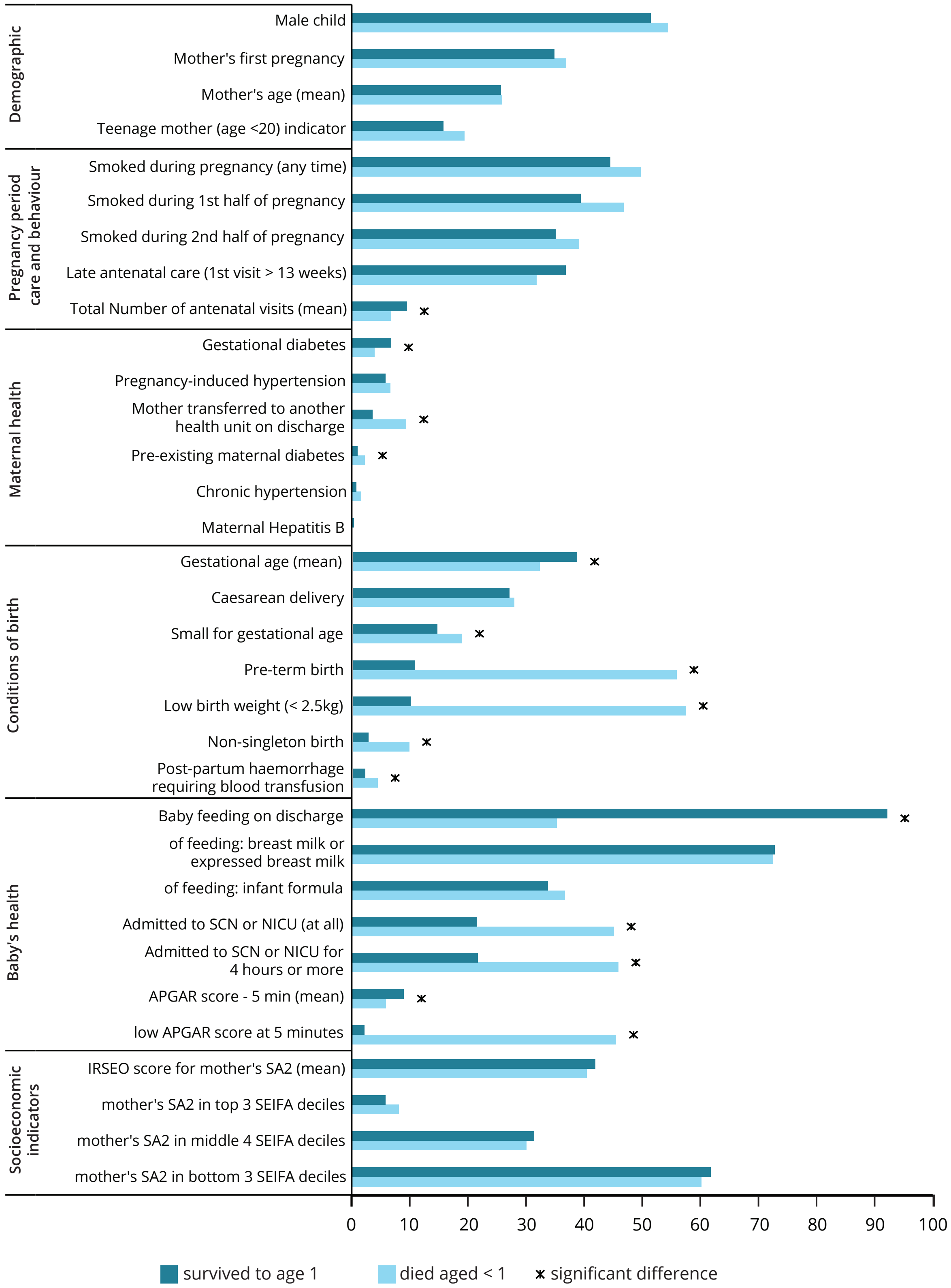
- babies born small for their gestational age
- preterm birth (less than 37 weeks)
- low birthweight (less than 2.5 kg)
- non-singleton birth.

As well, babies born to mothers residing in *Major cities* were found to have significantly higher mortality rates than those residing in remote or regional areas, with rate ratios of 2.3 and 1.4 found for deaths under age 1 when comparing *Major cities* to remote and regional areas, respectively (Table A4.4).

As deaths under age 1 are included in the number of deaths under age 5, all the above risk factor rate ratios were also significant for deaths under age 5. The rate ratio for the maternal smoking risk factor was significant only for all deaths under age 5.

Preterm birth was not further categorised into subcategories of preterm based on actual gestational age at birth for the separate analyses of mortality among Indigenous children, due to the small overall number of deaths in any preterm subcategory. A higher proportion of Indigenous babies are born preterm, and a higher proportion of Indigenous preterm babies die under age 1. However, because of the small overall number of Indigenous deaths in the linked data, more detailed mortality estimates for Indigenous preterm babies by gestational age sub-categories was not deemed appropriate.

Figure 4.4: Maternal and baby characteristics by survival status to age 1, Indigenous children, 2005–2018 combined cohort: mean values or proportion (per cent) of babies

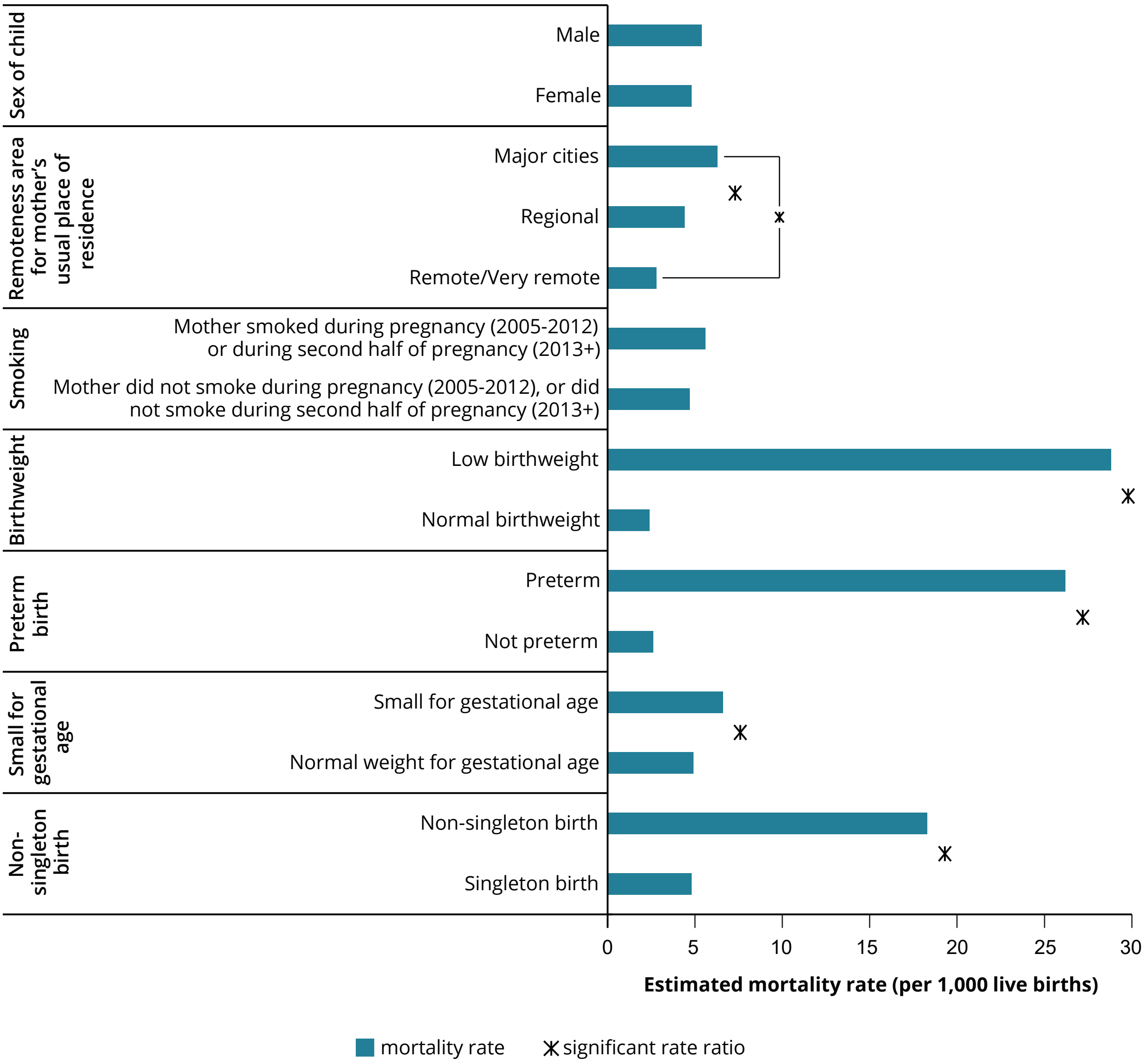


IRSEO = Indigenous relative socioeconomic outcomes index; NICU = neonatal intensive care unit; SCN = special care nursery

Note: The x-axis values show percentages for characteristics that are categories (most items). Continuous variables (with the word 'mean' in the description) show the units in which that characteristic is measured (that is, years for the age of the mother). An asterisk indicates the value of the difference in that characteristic between Indigenous children who died and those who survived to age 1 is statistically significant at the 5% test level whereas no asterisk indicates the difference was not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data in Appendix Table A4.3.

Figure 4.5: Estimated under-1 mortality rate (per 1,000 live births) by maternal and baby characteristics, Indigenous children, 2005–2018 combined cohort



Note: An asterisk indicator that the rate ratio of the mortality rates of a characteristic between Indigenous children who died and Indigenous children who survived to age 1 was statistically significant at the 5% test level, whereas no asterisk indicates that the rate ratio for that characteristic was not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data in Appendix Table A4.4.

5 Multivariate analyses of early childhood deaths – all children

This chapter presents results from multivariate logistic regression analyses of the factors associated with child death under age 1 and for between ages 1 to 4 (before turning 5) among all children in the NSW birth cohorts of 2005 to 2018.

The next chapter presents similar analyses carried out separately for Indigenous children.

Two types of logistic regression results are presented in this chapter:

1. estimated odds ratios associated with a specific characteristic of the baby and mother or of the area of usual residence of the mother when giving birth
2. estimated 'marginal effects' on the risk of dying of changes in each of these characteristics (only for selected models).

This chapter's primary aim is to identify the key risk factors and quantify their effects on the probability of a child's dying by a specific age. The 'odds' of an event is related to the probability of that event's occurring, but they are not the same statistical measure. Similarly, differences in the odds, as represented by the odds ratio estimates, are not the same as differences in the relative risk or the probability of dying (Ranganathan et al. 2015).

However, for events that occur very rarely, such as deaths in a birth cohort, differences in the odds of dying associated with a particular characteristic can be loosely interpreted as:

- How many times is the specific death outcome being modelled likely to occur among children with that specific characteristic than among children who do not have that characteristic? For instance, if the estimated odds ratio for dying under age 1 between a male and female baby is 1.2, we interpret that result loosely as the male baby being 1.2 times as likely to die under age 1 than a female baby.[6]

The 'marginal effects' in this chapter are the change in the probability of the child's dying being associated with a change in one of the characteristics of the child. For instance, the difference in the average probability of dying between boys and girls is the estimate of the 'marginal effect' of the baby's sex.

More details about the results of logistic regressions and the interpretations of the odds ratios and the marginal effects are in boxes A5.1 to A5.3 in Appendix A.2.

The list of explanatory variables used in the logistic regressions is summarised in Box 5.1. They are drawn from the variables collected in the PDC, with supplementary data for the socioeconomic characteristics of the usual place of residence of the mother when giving birth. The choice of these variables is partly determined by which of the selected characteristics of the baby or mother, as analysed in chapter 4, differed significantly between babies who had died and babies who had survived to age 1.

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[6] The odds of an event is equal to the probability of that event's occurring divided by the probability of that same event's not occurring (which is 1 minus the probability of the event's occurring). For events that occur very rarely, with low values of probability of that event – such as deaths in a birth cohort, the additional adjustment related to '1 minus the probability of the event' will itself be close to a value of 1. So, the computed odds of the event will be close to the value of the probability of the event. The ratio of 2 different odds will also be about equal to the ratio of the 2 probabilities. (See also Appendix A.2 section – Guide to key terms and concepts related to logit regression models).

At a glance

For deaths under age 1:

- babies born preterm under 32 weeks gestational age were between 211 to 280 times as likely to die as babies born full term
- babies born preterm between 32 and 36 weeks gestational age were around 5 times as likely to die as babies born full term
- for preterm births under 32 weeks gestational age (and only for that gestational age category), the risk of dying was reduced if the baby was delivered by caesarean section
- for full-term babies the risk of dying was increased if the baby had a caesarean delivery
- for babies born preterm between 32 and 36 weeks, there was no statistically significant effect of caesarean delivery: preterm babies in this gestational age had similar risks of dying whether they had a normal vaginal delivery or a caesarean delivery
- babies who were small for gestational age were between 2.6 to 2.7 times as likely to die as babies who were not
- babies born to a teenage mother were 1.4 to 1.7 times as likely to die as babies born to mothers aged 26–30
- babies born to mothers who experienced postpartum haemorrhage requiring blood transfusion were 1.6 to 2.7 times as likely to die as babies whose mothers did not experience this in the latter 2 birth cohorts (2011–2014 and 2015–2018)
- in the earlier 2 birth cohorts (2005–2010 and 2011–2014), Indigenous babies were 1.5 to 1.8 times as likely to die as non-Indigenous babies.

When deaths in the first 7 days of life are excluded in the analyses of deaths under age 1:

- the risks associated with preterm birth under 32 weeks and between 32 and 36 weeks were both reduced, but remained as significant risk factors (32 to 40 times as likely to die among preterm babies under 32 weeks, and around 3 times as likely to die among those between 32 and 36 weeks gestational age)
- there were increased risks associated with birthweight being small for gestational age (to 2.2 to 3.1 times as likely to die), and being born to a teenage mother (to around 2 times as likely)
- smoking during pregnancy became a significant risk factor (in 2 of 3 periods, with babies born to mothers who smoked 1.5 to 1.7 times as likely to die)
- mother experiencing postpartum haemorrhage requiring a blood transfusion was no longer a significant risk factor.

For deaths that occur between ages 1 to 4:

- Indigenous children were 2.2 times as likely to die as non-Indigenous children
- children who were small for gestational age at birth were 1.7 times as likely to die as children who were not
- children born to a mother aged 20–25 were 1.4 times as likely to die as children born to mothers aged 26–30; but there was no significant additional risk of being born to a teenage mother aged under 20
- male children were 1.3 times as likely to die as female children.

Box 5.1: Explanatory variables used in the logistic regression models

Demographic and geographic variables:

- birth cohort period (2005–2010, 2011–2014, 2015–2018, or a combined 2005–2018 cohort)
- age category of mother (under 20, 20–25, 26–30, 31–35, over 35)
- remoteness of mother's usual place of residence at the time of birth using a 3-way classification *Major cities*, regional area (combining *Inner regional/Outer regional*) and remote area (combining *Remote/Very remote*)
- Indigenous status of the baby (based on Indigenous status in any source in linked data)

Variables likely to be present at the ***onset of pregnancy***:

- pre-existing maternal diabetes
- chronic maternal hypertension
- the birth is the mother's first pregnancy

Variables likely to arise ***during pregnancy***:

- sex of baby
- antenatal care (no antenatal care, timely first antenatal care, or late antenatal care after 13 weeks gestational age)
- mother smoked during pregnancy
- baby was part of non-singleton births

Variables determined at the ***end of pregnancy***:

- preterm birth (in 2 subcategories by gestational age: under 32 and 32 to 36 weeks; the under 32 weeks combines 'extreme' and 'very early' preterm, and 32 to 36 weeks combines 'moderate' and 'late' preterm subcategories as conventionally defined (WHO 2012))
- small for gestational age (birthweight at the tenth percentile or below, relative to all Australian liveborn babies born between 2004–2013, by sex (AIHW 2022b)
- caesarean delivery
- postpartum haemorrhage (PPH) developed by mother that required a blood transfusion

Additional area-level socioeconomic status indicators at the SA2 level, based on the region of the usual residence of the mother at the time of giving birth:

- percentage of children in mother's usual SA2 of residence considered developmentally vulnerable on one or more domain (using the AEDC collections of 2009, 2012, 2015 and 2018)
- SEIFA index of Relative Socio-Economic Advantage and Disadvantage decile ranking for the SA2 in which the mother usually resided at the time of giving birth.

The variable selection in Box 5.1 was also based on findings of previous AIHW analyses of the risk factors for child death using national level linked data (AIHW 2021a), and analyses of neonatal deaths from the Perinatal National Minimum Data Set managed by the AIHW (AIHW 2021b). Other AIHW reports – such as AIHW (2022a) that modelled the factors that contributed to low birthweight among Indigenous babies – also guided the variable selections from the PDC to be included in the regression analyses of child deaths in New South Wales.

Some factors were excluded from this analysis because they were so dominant in the simple comparative analysis in chapter 4 that they overwhelmed other factors. For instance, a low APGAR score and the baby's not feeding at discharge were so highly correlated with subsequent death that the effects of almost all other variables become overridden and insignificant. Their exclusion allowed the analysis for other risk factors to be undertaken.

The NSW PDC has information only on general demographic characteristics of the mother, her risk factors and care received during pregnancy, and on the delivery outcomes for the mother and baby. It does not include key socioeconomic data for the mother and the family into which the baby is born – such as the education, employment, occupation and employment status of the mother and father, and earnings of the family or household. These characteristics are seen as key determinants of child health and early child development, and could also affect the risk of child death (Chen et al. 2016; Strobel et al. 2017).

To address this shortcoming of the PDC, supplementary data for the socioeconomic characteristics of the area in which the mother lived (the usual place of residence when giving birth) were added to the linked birth cohort data based on the 2011 SA2 level in the PDC. These additional area-level variables are drawn from 2 sources:

- the 2011 Census SEIFA – derived from ABS (2013)
- the 4 collections of the AEDC available at the start of this project.

The 4 AEDC collections cover the years 2009, 2012, 2015 and 2018. These collections report area-level data for the proportion of children assessed to be developmentally vulnerable when starting their first year of full-time schooling (when most children are aged 5). The proportion of children assessed to be vulnerable on at least 1 or 2 of the 5 AEDC test domains is publicly reported at the SA 2 level for each collection.

A previous AIHW report prepared for the NSW CDRT found that area-level data on the proportion of children assessed to be vulnerable on at least one AEDC test domain was well correlated with the overall child mortality rate among all children aged 0 to 17 in that area (NSW CDRT 2018).

Interpreting results on the Indigenous status variable in regression models on risks of dying among all children

Several of the multivariate regression models estimated over the full cohort of all children – where Indigenous status is one of the explanatory variables – show a result that Indigenous children have an associated higher risk of dying (or an odds ratio significantly greater than 1) compared with non Indigenous children. These results should not ipso facto be interpreted as the Indigenous status of the baby in itself being an independent risk factor.

The Indigenous status variable is usually a proxy for differences between Indigenous children and non-Indigenous children in other important factors related to child mortality that are not already accounted for in the estimated model.

Table 5.1 shows the range of comparative differences on several key perinatal characteristics between babies born to Indigenous mothers and to non-Indigenous mothers over the 3 birth cohort periods, as well as in the combined 2005 to 2018 birth cohorts used in this study.

Smoking during pregnancy and teenage motherhood are substantially more common among mother of babies identified as Indigenous in the linked data. Smoking proportions have decreased over these time periods for both subgroups of mothers; however, even in the latest 2015–2018 birth cohort, 34% of mothers of Indigenous babies smoked at some point during the pregnancy, compared with 5% for mothers of non-Indigenous babies.

Preterm birth was also higher among Indigenous babies (11% compared with 6.9% among non-Indigenous mothers); but the proportion of mothers having a caesarean delivery was lower among mothers of Indigenous babies (27% compared with 32%, respectively, over the full 2005 to 2018 cohorts).

The multivariate regression models estimated for this report include all the above characteristics as explanatory variables in the models of the risk of child death in the full sample of babies, where Indigenous status is one of the explanatory variables.

So, a result where Indigenous status is a significant risk factor – even after adjusting for the observed difference in the above factors – implies that there are also other important factors that directly or indirectly affect child mortality that differ between mothers of Indigenous and non Indigenous babies. It is likely these unobserved differences on variables not included in the model are reflected in a result of a significantly higher odds of dying for Indigenous babies/children in the results discussed later in this chapter.

Table 5.1: Proportion of births with a given maternal or baby characteristic, by Indigenous status and birth cohort period (%)

	2005–2010		2011–2014		2015–2018	
Characteristic	Indigenous	Non-Indigenous	Indigenous	Non-Indigenous	Indigenous	Non-Indigenous
Smoked during pregnancy	50.9	11.5	39.6	7.1	33.6	4.8
Preterm birth (<32 weeks gestation)	2.0	1.0	1.6	1.0	1.7	0.9
Preterm birth (32–36 weeks gestation)	9.1	5.8	9.5	6.0	8.9	6.0
Teenage mother (aged 19 or under)	19.4	3.1	16.7	2.3	12.2	1.5
Caesarean delivery	24.4	30.2	26.5	32.5	29.1	34.4

	2005 to 2018 combined	
Characteristic	Indigenous	Non-Indigenous
Smoked during pregnancy	40.5	8.3
Preterm birth (<32 weeks gestation)	1.8	1.0
Preterm birth (32–36 weeks gestation)	9.2	5.9
Teenage mother (aged 19 or under)	15.8	2.4
Male baby	51.5	51.4
Caesarean delivery	26.9	32.1

Note: Smoked during pregnancy category refers to: mother smoked at all during pregnancy (2005–2012 births) or during second half of pregnancy (2013–2018 births).

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

5.1 Factors related to deaths under age 1

This section presents the logistic regression modelling results of the factors related to child death under age 1 for the full set of all children in the selected NSW birth cohorts from 2005 to 2018. A very large proportion of deaths under age 1 occur within the first few days of birth, so a separate regression analysis was also carried out for babies who died after 7 days since birth. The aim was to robustly identify the risk factors of dying by age 1 that are not dominated by those very early deaths.

Given the large number of children in each NSW birth cohort and the possibility that the effects of the explanatory factors could change over time, the logistic regression analyses of deaths under age 1 were carried out separately over 3 birth cohort periods:

- birth cohorts of 2005 to 2010 (period 1, containing 6 calendar year cohorts)
- birth cohorts of 2011 to 2014 (period 2, containing 4 calendar year cohorts)
- birth cohorts of 2015 to 2018 (period 3, containing 4 calendar year cohorts).

These periods were chosen for 2 reasons:

- the availability and consistent measurement of the data reported in the NSW PDC
- the need to maintain some balance in the number of babies included in the time period analyses, with more babies being born in the more recent years.

The 2011 calendar year is a natural break point in the PDC series because several new variables – such as smoking status at different periods during the pregnancy, and the Indigenous status of the baby (and not just of the mother) – were collected from 2011 onwards.

For each of the 3 birth cohort periods, the regression analyses were based on a minimum of around 370,000 births and 650 deaths identified under age 1. The tables in Appendix A.2 that report on the regression results note the actual total number of observations (births) and deaths used for each regression model.

The variables used in these models include several interaction terms[7] between the key selected variables given in Box 5.1, such as between preterm birth and caesarean delivery, and between non-singleton birth indicator and caesarean delivery.

For each birth cohort period, 2 different models were estimated: one with only the variables from the NSW PDC, and another that also includes the area-level average socioeconomic status variables for the usual area of residence of the mother (as recorded when giving birth).

These area-level socioeconomic variables are of interest because of their:

- direct influences on the risk factors associated with child death
- indirect role in modifying the effects of the conventional perinatal variables associated with child death.

It is useful to compare the regression results of the models estimated with and without the area level socioeconomic variables specified in Box 5.1.

The full set of the odds ratio estimates are presented in Table A5.1 (in Appendix A.2) for each of the model's variables and for each birth cohort period for both model options (with and without the area-level variables). A summary of these full results is shown in Figure 5.1. It presents the results only for those variables that have a consistent statistically significant effect on the odds of a child's dying under age 1, based on the model that includes the area-level variables.

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[7] The interaction terms control for the possible confounding effects observed in the data between some key interrelated variables. For instance, it is of interest to model the effects of a caesarean delivery on the odds of dying under age 1 compared with a normal delivery method. This effect, however, cannot be robustly estimated because caesarean delivery can be heavily influenced by other factors specified in the model, such as multiple birth parities (non-singleton births) and preterm births. A substantially higher proportion of multiple births and preterm births are caesarean delivery in the linked data for this project. Separate interaction terms between caesarean delivery and multiple births and between caesarean delivery and preterm births are therefore added to the model to distinguish between the possibly different effects of caesarean delivery when that occurs in combination with preterm and non singleton births.

These tables identify which explanatory variables have estimated odds ratios significantly less than 1 (indicating that those variables are protective factors that reduce the risk of dying under age 1), and which other variables have estimated odds ratios significantly greater than 1 (indicating that they are risk factors that increase the risk of dying). See also Box A5.2 (in Appendix A.2) for more information on interpreting odds ratio estimates.

Several variables were consistently shown as significant risk factors that increase the odds of dying under age 1 in all 3 periods and for both model types. These were:

- preterm birth under 32 weeks gestational age
- preterm birth between 32 and 36 weeks gestational age
- baby's birthweight was small for gestational age
- born to a teenage mother (aged 19 or under)
- caesarean delivery (for babies born full term or between 32 and 36 weeks preterm).

Other risk factors that were not consistently significant in all periods but had some role in explaining deaths under age 1 were being

- a male baby
- born to a mother who experienced postpartum haemorrhage requiring a blood transfusion
- an Indigenous baby (based on Indigenous status either for the baby or the birth mother).

The significantly higher risk of dying under age 1 associated with preterm births has been noted in many other studies (for example, AIHW 2018, 2021a, 2021b). The results in this chapter add to the existing literature by showing that the higher risk of dying associated with preterm birth is strongly correlated with gestational age. There is a substantially higher risk of dying for preterm births under 32 weeks (corresponding to the even more detailed categorisation of 'extremely' or 'very' preterm birth used in the international literature, WHO 2012) than for preterm births between 32 to 36 weeks gestational age (which are usually classified as 'moderate' or 'late' preterm).

Another new dimension in the results in this chapter is that the higher risk of dying among preterm births can be moderated considerably if preterm births occur in combination with caesarean delivery, but only in the case of early preterm births under 32 weeks gestational age.[8] Caesarean delivery is not protective for older gestational age preterm births, nor for full term births at or after 37 weeks gestational age.

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[8] The odds ratio estimate for the interaction term between preterm birth and caesarean delivery in Table A5.1 is significantly less than 1, indicating that combination is a protective factor compared with preterm births not involving caesarean delivery. The combination of preterm birth and caesarean delivery still results in a higher risk of dying compared with a combination of full-term birth with any type of delivery (caesarean or non-caesarean). The significant interaction effect between preterm birth and caesarean delivery only means that, among preterm births, there is a lower risk of death if the delivery was by caesarean section than by other methods, including normal vaginal delivery. Similarly, the interaction term in Table A5.1 between non-singleton birth and caesarean delivery is also significantly less than 1, showing that combination to also be a protective factor among non-singleton births.

In Figures 5.1, 5.3 in this chapter and Figure 6.1 the effects of preterm birth among caesarean delivery babies (in rows 3 and 4) are calculated for comparison specifically with full-term births with caesarean delivery. This is derived by multiplying the odds ratio of the main effect of preterm birth in (either under 32 weeks or between 32 and 36 weeks) by the interaction term between preterm birth in these gestational ages and caesarean delivery in Appendix Tables A5.1, A5.3 and A6.1, respectively. These derived odds ratio are not directly reported in the Appendix tables.

The effect of caesarean delivery on the risk of child death can also differ by whether the caesarean delivery is medically indicated or an elective choice of the mother (Yang and Sun 2017); but this distinction was unfortunately not feasible in the NSW PDC data available for linkage in this project.

Figure 5.1: Selected regression results for child deaths under age 1: estimated odds ratios[a,b] (or how much more likely a baby with the specified characteristic or risk factor was likely to die by age 1, compared with a baby without that specified characteristic), by birth cohort periods

Maternal/baby characteristic	2005–2010	2011–2014	2015–2018	
Preterm birth under 32 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 211	🟧 280	🟧 268	times as likely
Preterm birth between 32 and 36 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 4.8	🟧 4.6	🟧 4.9	times as likely
Preterm birth under 32 weeks gestational age (caesarean delivery) (compared with a full-term birth and caesarean delivery baby)	🟧 58.2	🟧 39.5	🟧 51.1	times as likely
Preterm birth between 32 and 36 weeks gestational age (caesarean delivery) (compared with a full-term birth and caesarean delivery baby)	🟧 6.4	🟧 4.9	🟧 5.7	times as likely
Small for gestational age in birthweight (compared with a normal birthweight baby by gestational age)	🟧 2.7	🟧 2.7	🟧 2.6	times as likely
Indigenous baby (based on mother's or baby's Indigenous status) (compared with a non-Indigenous baby)	🟧 1.8	🟧 1.5	⬛ 1.1	times as likely
Mother was a teenager at time of giving birth (age 19 or under) (compared with a mother aged 26 to 30)	🟧 1.5	🟧 1.4	🟧 1.7	times as likely
Mother was aged 20 to 25 years at time of birth (compared with a mother aged 26 to 30)	🟧 1.2	⬛ 1.2	⬛ 1.2	times as likely
Caesarean delivery for a full-term baby (compared with a vaginal delivery full-term baby)	🟧 1.3	🟧 2.0	🟧 1.3	times as likely
Male baby (compared with a female baby)	🟧 1.2	🟧 1.2	⬛ 1.1	times as likely
Postpartum haemorrhage (PPH) developed by mother that required blood transfusion (compared with a baby born to a mother who did not develop PPH requiring a blood transfusion)	⬛ 1.5	🟧 1.6	🟧 2.7	times as likely
Mother smoked during pregnancy (compared with a mother who did not smoke)	⬛ 1.1	⬛ 0.9	⬛ 1.0	times as likely
Use and timing of antenatal care (compared with a mother who had first visit by 13 weeks)				
Late first antenatal care visit (after 13 weeks gestation)	⬛ 1.1	⬛ 1.0	⬛ 1.0	times as likely
No antenatal care received	⬛ 0.6	⬛ 1.1	⬛ 0.7	times as likely
Antenatal care status not stated	⬛ 1.5	⬛ 1.2	⬛ 0.6	times as likely
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (compared with a mother residing in an SA2 in the highest 3 deciles)	🟧 1.2	⬛ 1.1	⬛ 1.1	times as likely
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (compared with a mother residing in an SA2 in the highest 3 deciles)	🟧 1.5	⬛ 1.1	⬛ 1.0	times as likely
Percentage of children vulnerable on one or more AEDC domain in mother's SA2 of usual residence	⬛ 1.0	⬛ 1.0	⬛ 1.0	times as likely

🟧 Statistically significant risk factors (with odds ratios greater than 1) at least at the 5% test level.

⬛ Factors that are not statistically significant at the 5% test level.

(a) Estimates of the odds ratio are from the full model with area-level variables and specific interactions terms from Appendix Table A5.1. Some values reported in above table may differ due to rounding.

(b) Tests of significance on whether the estimated odds ratio is significantly different from 1 is done at the 5% test level.

Source: AIHW analyses of the Linked NSW PDC and Deaths data.

The summary results in Figure 5.1, with illustrative values on the range of the estimated odds ratios, show that:

- babies born preterm under 32 weeks gestational age (through vaginal delivery) were substantially more likely to die under age 1 than full term babies – between 211 to 280 times as likely in each of the 3 periods. The effect of preterm birth in this gestational age category is mediated strongly through caesarean section delivery however:
  - if the preterm baby under 32 weeks gestational age had a caesarean delivery, the likelihood of dying under age 1 was still higher, but reduced substantially to between 40 to 58 times as likely as a full-term caesarean baby
- babies born preterm between 32 and 36 weeks gestational age (through vaginal delivery) were between 4.6 to 4.9 times as likely to die under age 1 as a full-term baby
  - caesarean delivery did not significantly affect the likelihood of death for preterm babies in the 32 to 36 weeks category
- the effect of caesarean delivery by itself for full-term babies (when not interacted with preterm birth status) was a consistent risk factor, with odds ratios ranging from 1.3 in periods 1 and 3 to 2.0 in period 2
- babies small for gestational age were around 2.6 to 2.7 times as likely to have died than normal weight babies (for their gestational age)
- babies born to teenage mothers were 1.4 to 1.7 times as likely to have died than babies born to mothers aged 26 to 30
- Indigenous babies were 1.5 to 1.8 times as likely to have died than non-Indigenous babies among birth cohort periods 1 and 2.

– among babies born in the latest period (2015–2018), the Indigenous status of the baby is not a significant factor, so the risk of dying under age 1 in that period was similar among Indigenous and non-Indigenous NSW-born babies.[9]

The lower half of Figure 5.1 gives the range of estimated odds ratio values for other selected factors that were not always statistically significant in all 3 periods but worth noting:

- Male babies were 1.2 times as likely to die under age 1 as female babies in birth cohort periods 1 and 2, but the estimated odds ratio of 1.1 in period 3 was not significant.
- Babies born to the small proportion of mothers who experienced postpartum haemorrhage that required blood transfusion were also more likely to have died under age 1, but this effect was found only in birth cohort periods 2 and 3 (odds ratios range from 1.6 to 2.7).

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[9] There could be some concern that this result is affected by the change in the PDC data collection from 2011 onwards that separately records the Indigenous status of the baby, and the Indigenous identification method adopted in this study that relies on either the mother's or baby's Indigenous status. Table 2.2 in chapter 2 showed the impact of this change leading to a higher proportion of the total birth cohorts being identified as Indigenous in the period 2 and period 3 data from 2011 onwards. However, this result from the period 3 regression model that Indigenous status is no longer a significant additional risk factor for child death under age 1 in 2015–18 is not due to the changes in the PDC data collection. This result of an insignificant odds ratio associated with Indigenous status in period 3 occurs even if an alternative approach for defining Indigenous status is used, based only on the mother being Indigenous, as was the case for period 1 data. Also, the change in the PDC collection affects the Indigenous status derived for the period 2 (2011–2014) birth cohorts too. Indigenous status, however, remained a significant risk factor in the results for period 2. This shows that the changed result seen in the period 3 model is a genuine result, related more to the greater declines in Indigenous child mortality in recent periods in New South Wales, and not due to the changes in the PDC data collection for Indigenous status from 2011.

Regression results for other factors related to deaths under age 1

Table A5.1 (in Appendix A.3) gives the full set of the odds ratio estimates for each of the model's variables for each birth cohort period for both model options (with and without the area-level variables). Immediately preceding it is an explanation of how to interpret the table, which uses asterisks (*) and colour coding to identify which of the variables used – or which specific category within a variable – was statistically significant and the direction of the effect – whether it was a significant risk or protective factor.

Contrasting with the results of the significant variables highlighted in Figure 5.1, many of the other variables were found to consistently not have any effects on the odds of dying under age 1, after accounting for the role of the other variables found to be significant. The variables that were consistently insignificant were:

- the age of the mother, other than 19 or younger or 20–25 (children born to mothers in other age groups of 31–35, and over 35 had the same odds of dying as children born to mothers in the reference age group of 26–30)
- remoteness area of mother's usual place of residence (children born to mothers who lived in remote areas (combining *Remote* and *Very remote*), or *Major cities* had the same odds as those living in the regional reference area (combining *Inner and Outer regional*)
- mother had pre-existing diabetes
- mother had chronic hypertension.

Only some of the area-level socioeconomic status indicators had significant effects on the risk of dying under age 1. The SEIFA decile ranking was significant only in birth cohort period 1 (2005–2010), as a risk factor for living in areas in the bottom 3 and middle 4 deciles, compared with being in the top 3 deciles. The proportion of the children in the SA2 who were assessed to be vulnerable in at least one of the 5 domains of the AEDC child development assessments was not significant in any of the 3 periods.

In a previous AIHW report for the CDRT, the AEDC vulnerability score was found to be significantly related to child mortality in New South Wales when measured at a broad regional level for child deaths up to age 17 (NSW CDRT 2018). In analysing the risk of dying under age 1 at the level of individual children – where all children in a specific SA2 shared the same AEDC vulnerability score – that score was not significantly associated with the risk of dying under age 1, after controlling for the effects of all other variables included in this model.

Marginal effects of factors related to deaths under age 1

An alternative and more intuitive way to assess the relative role of different risk and protective factors in a logistic regression is to compute the 'marginal effect' associated with each explanatory variable. In logistic regression modelling, the 'marginal effect' estimates represent the implied change in the probability of the outcome being analysed (which is death under age 1 in this section). (See also Box A5.3 in Appendix A.2.)

The results of selected marginal effects estimates and their statistical significance are presented in Figure 5.2 (with full results in Table A5.2) for each of the 3 birth cohort periods. They were derived only for the full model, which includes area-level socioeconomic status indicators for the region in which the mother usually resided in at time of giving birth. The marginal effects results in Figure 5.2, however, are presented only for the PDC variables since, as shown by the odds ratio results in Table A5.1, the area-level variables were very rarely significant.

Figure 5.2: Selected estimated marginal effects[a,b] of the probability of a baby dying under age 1 among all NSW-born babies, 2005 to 2018 cohorts by 3 birth cohort periods (units are the change in expected number of deaths per 1,000 live births)

Maternal/baby characteristic	2005–2010	2011–2014	2015–2018	
Preterm birth under 32 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 174	🟧 177	🟧 154	change in estimated number of deaths per 1,000 live births
Preterm birth between 32 and 36 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 4.0	🟧 2.9	🟧 2.7	change in estimated number of deaths per 1,000 live births
Preterm birth under 32 weeks gestational age (caesarean delivery) (compared with a full-term birth and caesarean delivery baby)	🟧 64.2	🟧 53.2	🟧 43.4	change in estimated number of deaths per 1,000 live births
Preterm birth between 32 and 36 weeks gestational age (caesarean delivery) (compared with a full-term birth and caesarean delivery baby)	🟧 6.5	🟧 5.7	🟧 4.3	change in estimated number of deaths per 1,000 live births
Small for gestational age in birthweight (compared with a normal birthweight baby by gestational age)	🟧 3.1	🟧 3.0	🟧 2.1	change in estimated number of deaths per 1,000 live births
Indigenous baby (based on mother's or baby's Indigenous status) (compared with a non-Indigenous baby)	🟧 1.6	🟧 1.0	⬛ 0.2	change in estimated number of deaths per 1,000 live births
Mother was a teenager at time of giving birth (age 19 or under) (compared with a mother aged 26 to 30)	🟧 1.1	⬛ 0.9	🟧 1.0	change in estimated number of deaths per 1,000 live births
Mother was aged 20 to 25 years at time of giving birth (compared with a mother aged 26 to 30)	⬛ 0.4	⬛ 0.4	⬛ 0.3	change in estimated number of deaths per 1,000 live births
Caesarean delivery for a full-term baby (compared with a vaginal delivery full-term baby)	🟧 0.3	🟧 0.8	🟧 0.2	change in estimated number of deaths per 1,000 live births
Male baby (compared with a female baby)	🟧 0.4	🟧 0.4	⬛ 0.1	change in estimated number of deaths per 1,000 live births
Postpartum haemorrhage (PPH) developed by mother that required blood transfusion (compared with a baby born to a mother who did not develop PPH requiring a blood transfusion)	⬛ 1.0	🟧 1.3	🟧 2.5	change in estimated number of deaths per 1,000 live births
Mother smoked during pregnancy (compared with a mother who did not smoke)	⬛ 0.3	⬛ -0.3	⬛ 0.0	change in estimated number of deaths per 1,000 live births
Use and timing of antenatal care (compared with a mother who had first visit by 13 weeks)				
Late first antenatal care visit (after 13 weeks gestation)	⬛ 0.2	⬛ 0.0	⬛ 0.1	change in estimated number of deaths per 1,000 live births
No antenatal care received[c]	🟩 -0.9	⬛ 0.2	⬛ -0.5	change in estimated number of deaths per 1,000 live births
Antenatal care status not stated	⬛ 1.0	⬛ 0.4	⬛ -0.6	change in estimated number of deaths per 1,000 live births

Legend for indicating statistical significance of estimated marginal effects (significantly different from a value of 0):

🟩 Statistically significant protective factors (with marginal effects less than 0) at least at the 5% test level.

🟧 Statistically significant risk factors (with marginal effects greater than 0) at least at the 5% test level.

⬛ Factors that are not statistically significant at the 5% test level.

(a) Estimates of the marginal effects are from the full model with area-level variables and specific interactions terms from Appendix Table A5.2. Some values reported in above table may differ due to rounding.

(b) Tests of significance on whether the estimated marginal effect is significantly different from 0 are done at the 5% test level.

(c) This is a change in the marginal effects estimate being statistically significant while the odds ratio effect was not. The significantly protective marginal effects of 'No antenatal care received' category observed only in the 2005–10 period is not a reliable estimate and should be discounted due to the very small number of babies whose mother did not receive antenatal care.

Source: AIHW analyses of the Linked NSW PDC and Deaths data.

There is broad consistency in the model results for the marginal effects and the odds ratios in identifying the same key risk factors for child deaths under age 1.[10] Preterm birth and being small for gestational age have consistently larger marginal effects increasing the probability of dying:

- The marginal effects estimate of preterm birth under 32 weeks gestational age indicates there would be between 154 to 177 more deaths among a reference group of 1,000 such preterm vaginal delivery babies compared with a reference group of 1,000 full-term vaginal delivery babies. This is equivalent to a 15 to 18 percentage point difference in the probability of dying among 100 such babies.
- The marginal effects estimate of preterm birth between 32 and 36 weeks gestational age was 2.7 to 4.0 more deaths among 1,000 such preterm vaginal delivery babies, compared with 1,000 full-term vaginal delivery babies.
- The marginal effects estimate of the higher probability of dying for small for gestational age babies was about 3 more deaths in periods 1 and 2 among a reference group of 1,000 such babies compared with 1,000 normal weight babies (for their gestational age). In period 3, the marginal effects estimate for small for gestational age babies was slightly lower at 2 extra deaths per 1,000, but it is still statistically significant.
- The marginal effects estimate of the higher probability of dying for babies born to teenage mothers is approximately 1 extra death per 1,000 such children in periods 1 and 3 only, compared with babies born to mothers aged 26 to 30.
- The marginal effects estimate of the higher probability of dying for Indigenous babies was significant only in periods 1 and 2 (as was the case for the odds ratio results), and the marginal effects estimates ranged from 1.0 to 1.6 extra deaths per 1,000 Indigenous babies in these 2 periods, respectively, compared with non-Indigenous babies.
- The marginal effects estimate of caesarean delivery have been further classified by the other characteristics with which it was interacted in the estimated regression model (preterm by gestational age categories or full-term birth; singleton or non-singleton status).[11]

  These effects vary considerably, and are even in opposite directions (with positive and negative signs on the estimated marginal effects). Only the first result noted below for the effect of caesarean delivery among full-term births is presented in Figure 5.2; the other results are available in Appendix Table A5.2:

  - For full-term births, the estimated marginal effect of caesarean delivery makes it a risk factor in all 3 periods, though this effect is small – equivalent to around 0.2 to 0.8 additional deaths under age 1 in a reference population of 1,000 full-term babies.

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[10] Given the non-linear nature of the logistic regression model and the simulations required to compute the standard errors of the marginal effects estimates, the statistical inference on whether a given marginal effect estimate is statistically significant (different from zero) can sometimes differ from whether the estimated odds ratio for that same variable is statistically significant (different from 1), even though they are derived from the same underlying model. This can occur when either estimate is just or close to being statistically significant. Small differences in the relative size of the standard errors for either the odds ratio or the marginal effects can lead to different results on statistical significance. These small differences occur in the results between Appendix Table 5.1 (odds ratios) and Appendix Table 5.2 (marginal effects).

[11] The marginal effects are derived as the average value over the entire estimation sample of children, given the specific characteristics of each child. When the logistic regression model is estimated with interaction terms, such as between preterm births and caesarean delivery, the marginal effects can be computed for any subgroup of interest in the population. This has been done in Table A5.2 for the effects of caesarean delivery, which has very different effects for different types of preterm births compared with full-term births, and for non-singleton compared with singleton births.

- The estimated marginal effect of caesarean delivery makes it a protective factor for the early preterm births under 32 weeks gestational age in all 3 periods, where the risk of dying is reduced by caesarean delivery compared with other methods of delivery (this effect is equivalent to around 106 to 122 fewer deaths under age 1 in a reference population of 1,000 preterm babies under 32 weeks gestational age).
- For later preterm births between 32 and 36 weeks, the estimated marginal effect of caesarean delivery makes it a risk factor in periods 1 and 2, where the risk of dying is increased through caesarean delivery compared with other methods of delivery (equivalent to 2.4 to 3.2 additional deaths in a reference population of 1,000 preterm babies born between 32 and 36 weeks).
- For non-singleton births, the estimated marginal effect of caesarean delivery makes it a protective factor in all 3 periods; this effect is equivalent to around 7.4 to 12 fewer deaths under age 1 in a reference population of 1,000 non-singleton babies.
- The effect of caesarean delivery for singleton births is either not statistically significant (as in the results for periods 1 and 2) or slightly protective (equivalent to around 0.5 fewer deaths under age 1 in a reference population of 1,000 singleton babies) in period 3

Factors related to deaths under age 1, excluding deaths within 7 days of birth

This section presents the regression results for a separate group of babies who died under age 1 but survived at least 7 days from birth. In the linked data for this project, almost 54% of the total deaths by age 1 occurred within 7 days from birth. In this proportion, the overwhelming contribution is from the 32% of the total deaths by age 1 that occur on the same day as the birth. This unbalanced pattern of many deaths occurring among live births in the first few days after birth is a well-documented feature of infant mortality in Australia (AIHW 2018) and elsewhere, and the cause of death also differs.

Figures A5.1 and A5.2 (in Appendix A.2) give the frequency and cumulative distribution of age at death in days for all deaths under age 1 combined over all birth cohorts from 2005 to 2018. Table 3.2 in chapter 3 describes differences in the cause of death within the first 7 days and subsequent period to age 1.

This pattern implies the regression results on the risk and protective factors identified in the previous section will be dominated by the factors that contribute to the many deaths in those first few days after birth. Is there consistency in the factors that contribute to the early deaths and the roughly half of the total infant deaths that occur from 7 days after birth?

Even if a similar set of risk factors is related to infant deaths after day 7, it is likely that their quantitative roles could differ in their contributions to explaining all infant deaths by age 1, and deaths that specifically occur beyond that first week. Separately analysing infant deaths that occurred 7 days after birth but under age 1 attempts to answer these types of questions.

The full set of the odds ratio estimates for deaths between day 7 but under age 1 are presented in Table A5.3 (in Appendix A.2) for the same 3 birth cohort periods using the model that includes the area-level variables. The set of explanatory variables is the same as for the equivalent model with PDC and area-level variables for all deaths under age 1, as specified in the results of Table A5.1 (including the interaction terms between preterm and caesarean delivery and between non-singleton births and caesarean delivery).

A summary of the results of the significant factors related to deaths after day 7 but under age 1 is in Figure 5.3. These summary results show that:

- preterm birth under 32 weeks gestational age was still a significant risk factor for deaths by age 1 for babies who survived for 7 days. These babies were around 32 to 40 times as likely to die as full-term babies, but with the following caveats:
  - the higher odds of death associated with preterm birth in this category is considerably muted (these higher odds of 32 to 40 contrasting clearly with the higher odds ratio estimates of 211 to 280 times as likely to die for preterm babies under 32 weeks, as in Figure 5.1, when including deaths of babies who have died within 7 days after birth)
  - the higher risk of dying for preterm births under 32 weeks gestation is no longer mediated through caesarean delivery for deaths under 1 that excludes deaths in the first 7 days.
- later preterm births (between 32 weeks and 36 weeks) also remained a significant risk factor, with babies in this age group being between 3.3 to 3.6 times as likely to die as full-term babies
  - this effect of higher risks of dying for preterm births between 32 and 36 weeks was again not mediated through caesarean delivery, as was the case in the results for all deaths under age 1
- the effect of caesarean delivery by itself for full-term babies (when not interacted with preterm birth status) is a risk factor with odds ratios significantly higher than 1 in the first 2 time periods (between 1.3 and 1.8)
- babies who were small for gestational age consistently had a higher risk of dying in this specified age than normal weight babies (for their gestational age), with the odds ratio estimates between 2.2 and 3.1 as likely
- babies born to teenage mothers had a consistently higher risk of dying than babies born to mothers aged 26 to 30, with the odds ratio estimate between 1.9 to 2.3 times as likely
- the higher risk of deaths for Indigenous babies in this specified age was significant in periods 1 and 2 only (1.4 to 1.6 times as likely as a non-Indigenous baby), but not in period 3 as before (where the estimated odds ratios of 1.4 still points to a higher risk, but the effect is not statistically significant)
- babies born to mothers who smoked during pregnancy were 1.5 to 1.7 times as likely to die in periods 3 and 1, respectively
- babies born to mothers who did not have a timely first antenatal care visit (by 13 weeks of pregnancy) had an estimated higher risk of dying only in period 2 (1.2 times as likely).

The above results reflect the range of variables that were also identified as significant factors in the results for the full set of all deaths by age 1 that are reported in Figure 5.1 and Table A5.1.

The proportion of preterm babies who die is considerably higher in the first few days after birth than in the subsequent period after day 7.[12] This is seen in the risk estimates: the risk of dying for preterm babies after day 7 is considerably lower than the risk of dying from the day of birth to under age 1. This is common to several risk factors – preterm birth is but one example.

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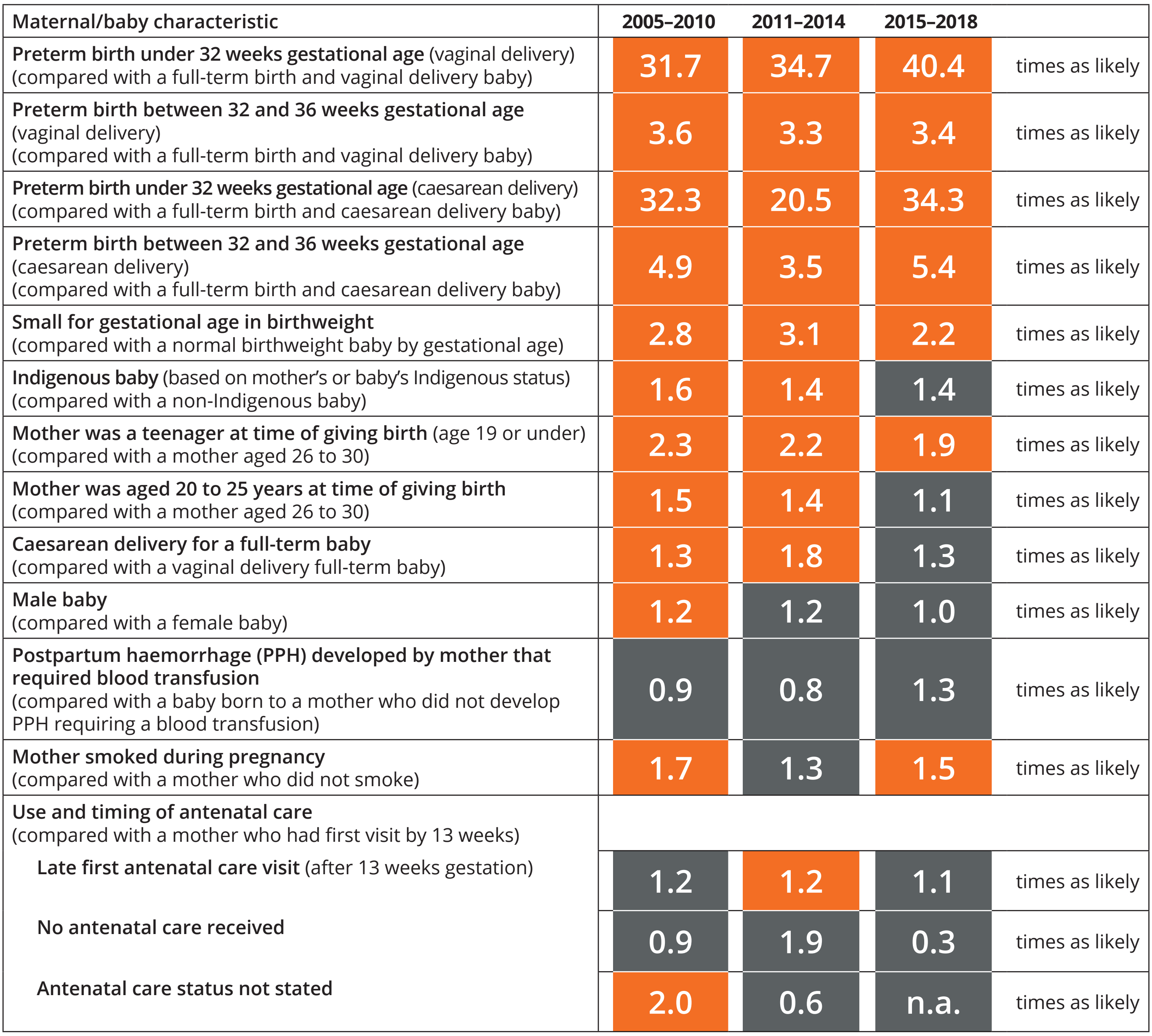
[12] In the linked data for the NSW birth cohorts of 2005 to 2018, simple tabulations of the proportion of all deaths that are preterm babies, ignoring all other contributing factors, shows it is as high as 79% among deaths within the first 7 days of birth, and around 39% among all deaths that occur from day 7 to under age 1. The combined effect is that almost 60% of all deaths by age 1 in these birth cohorts are of preterm babies.

These results differ from those in previous sections in that there is no additional risk of babies dying if their mothers experienced postpartum haemorrhage that required blood transfusion. This characteristic was a significant risk factor in the model for all child deaths under age 1 in periods 2 and 3. Therefore, the previous results should be attributed mainly to the effects of postpartum haemorrhage on deaths that occur in the very early period of up to 7 days after birth.

A minor difference in the regression results for deaths after day 7 but under age 1, compared to the results for all deaths under age 1, is that the mother usually residing in *Major cities* area is shown as a risk factor in one period (2005–2010) for deaths after day 7 but under age 1. The reasons are not clear for this one-off result of a higher risk of dying in this age category if the mother resided in a *Major cities* area at time of giving birth. It does not persist in the other two time periods; but a stronger effect is seen for the *Major cities* location among Indigenous babies in the analyses in chapter 6.

Figure 5.3: Selected regression results for child deaths under age 1 (but excluding deaths within 7 days after birth): estimated odds ratios(a,b), by birth cohort period



Maternal/baby characteristic	2005–2010	2011–2014	2015–2018	
Preterm birth under 32 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 31.7	🟧 34.7	🟧 40.4	times as likely
Preterm birth between 32 and 36 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 3.6	🟧 3.3	🟧 3.4	times as likely
Preterm birth under 32 weeks gestational age (caesarean delivery) (compared with a full-term birth and caesarean delivery baby)	🟧 32.3	🟧 20.5	🟧 34.3	times as likely
Preterm birth between 32 and 36 weeks gestational age (caesarean delivery) (compared with a full-term birth and caesarean delivery baby)	🟧 4.9	🟧 3.5	🟧 5.4	times as likely
Small for gestational age in birthweight (compared with a normal birthweight baby by gestational age)	🟧 2.8	🟧 3.1	🟧 2.2	times as likely
Indigenous baby (based on mother's or baby's Indigenous status) (compared with a non-Indigenous baby)	🟧 1.6	🟧 1.4	⬛ 1.4	times as likely
Mother was a teenager at time of giving birth (age 19 or under) (compared with a mother aged 26 to 30)	🟧 2.3	🟧 2.2	🟧 1.9	times as likely
Mother was aged 20 to 25 years at time of giving birth (compared with a mother aged 26 to 30)	🟧 1.5	🟧 1.4	⬛ 1.1	times as likely
Caesarean delivery for a full-term baby (compared with a vaginal delivery full-term baby)	🟧 1.3	🟧 1.8	⬛ 1.3	times as likely
Male baby (compared with a female baby)	🟧 1.2	⬛ 1.2	⬛ 1.0	times as likely
Postpartum haemorrhage (PPH) developed by mother that required blood transfusion (compared with a baby born to a mother who did not develop PPH requiring a blood transfusion)	⬛ 0.9	⬛ 0.8	⬛ 1.3	times as likely
Mother smoked during pregnancy (compared with a mother who did not smoke)	🟧 1.7	⬛ 1.3	🟧 1.5	times as likely
Use and timing of antenatal care (compared with a mother who had first visit by 13 weeks)				
Late first antenatal care visit (after 13 weeks gestation)	⬛ 1.2	🟧 1.2	⬛ 1.1	times as likely
No antenatal care received	⬛ 0.9	⬛ 1.9	⬛ 0.3	times as likely
Antenatal care status not stated	🟧 2.0	⬛ 0.6	⬛ n.a.	times as likely

Legend for indicating statistical significance of estimated odds ratios (significantly different from a value of 1):

🟧 Statistically significant risk factors (with odds ratios greater than 1) at least at the 5% test level.

⬛ Factors that are not statistically significant at the 5% test level.

(a) Estimates of the odds ratio are from the full model with area-level variables and specific interactions terms from Appendix Table A5.3 in Main report.

(b) Tests of significance on whether the estimated odds ratio is significantly different from 1 is done at the 5% test level.

Source: AIHW analyses of the Linked NSW PDC and Deaths data.

Another difference in the results for death after day 7 is that the area-level socioeconomic status indicators for the region in which the mother lives has an inconsistent role. This variable has a significant effect in only one instance – in period 1 for mothers who live in the middle 4 SEIFA deciles. That is shown to be a risk factor compared to living in the top 3 deciles (more advantaged) SEIFA areas; however, there isn't an equivalent higher risk estimated for those living in the bottom 3 deciles compared to the top 3 deciles. In the period 1 results for all deaths under age 1, living in areas with a lower SEIFA rank were shown to be risk factors in period 1 for both the lowest and middle SEIFA decile groupings compared with being in the top 3 deciles.

A new result is that a higher proportion of children assessed as developmentally vulnerable in at least one AEDC domain significantly increases the risk of dying after day 7, at least in period 3. In the previous results for all deaths under age 1, this variable was not a significant risk factor.

The proportion of children assessed as developmentally vulnerable is known to increase with lower average socioeconomic status of the population of that area in the AEDC data (DET 2022). It seems reasonable that the underlying socioeconomic status dimension of the AEDC child vulnerability data is a bit more apparent in the analysis of infant deaths that exclude deaths in the very first few days after birth where other risk factors may be more dominant.

Comparison of selected results on risks of dying by age 1, including and excluding early deaths within 7 days after birth

Figure 5.4 presents a summary of the differences in the odds ratio results in terms of their value and statistical significance for 4 key characteristics of the baby or mother, including Indigenous status. It draws from:

- the regression analysis with all deaths under age 1
- the analysis that excludes death within 7 days from birth.

The odds ratio differences are compared for each of the 3 birth cohort periods.

The comparisons of the data points in the Indigenous status panel of Figure 5.4 shows that, while all estimated odds ratios for this variable are higher than 1 (signifying a greater risk of dying for Indigenous babies than for non-Indigenous babies), the value of these estimated odds ratios tend to decrease over time and to not be statistically significant, especially in period 3.

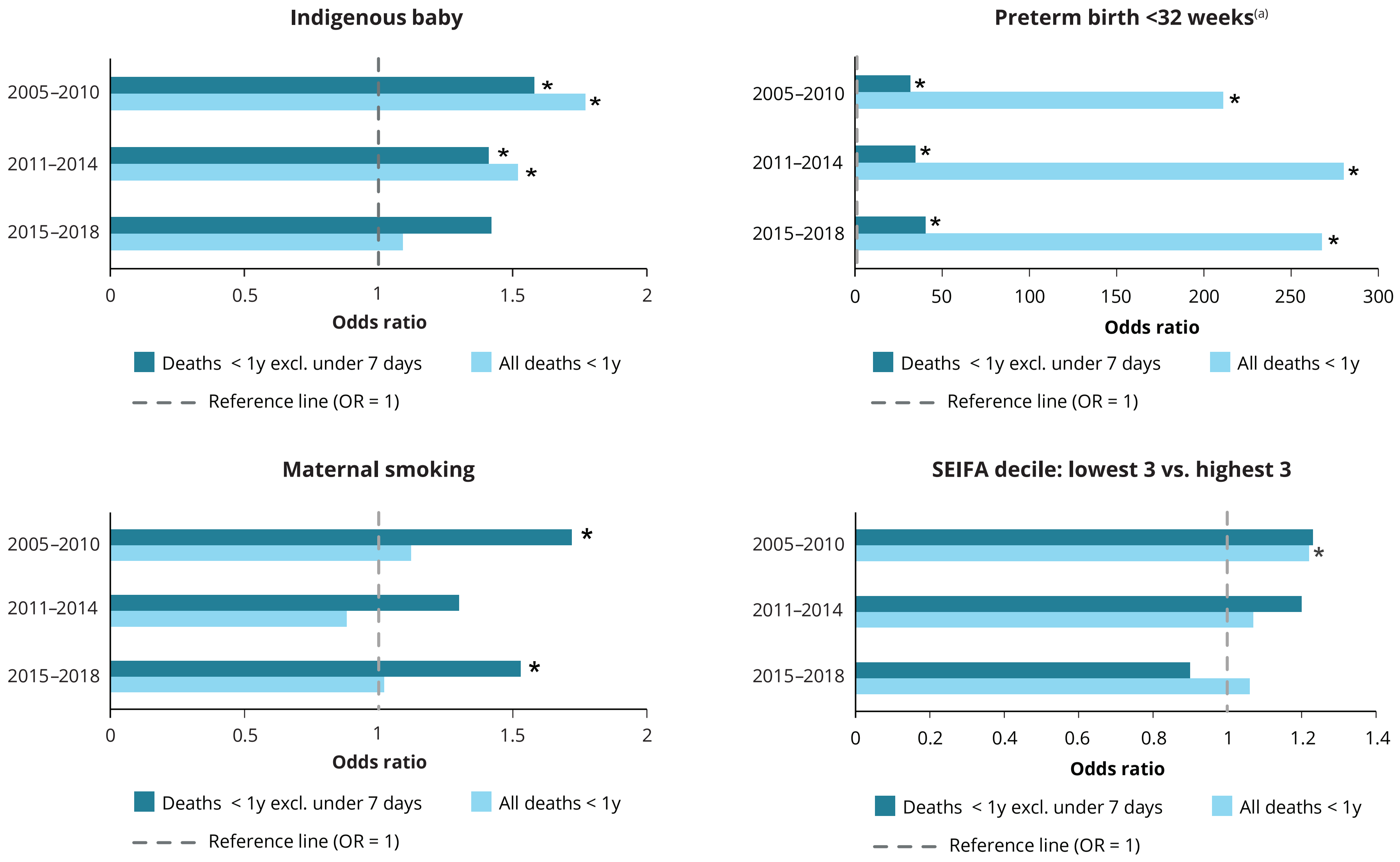
Indigenous status in itself is not an additional factor contributing to higher deaths of Indigenous babies in the most recent 2015–2018 birth cohorts. There is a higher overall rate of dying under age 1 for Indigenous babies than for non-Indigenous babies in all 3 periods (see Table 3.2). In period 3, however, the higher Indigenous mortality is not related directly to Indigenous status but is probably due to differences in the other risk factors analysed in these regression models, such as higher rates of preterm births for Indigenous babies and higher rates of smoking during pregnancy by Indigenous mothers. This result occurs in period 3 for both categories of deaths under age 1 and for the category of deaths that excludes very early deaths up to day 7.

Figure 5.4 compares the estimated odds ratios for preterm births under 32 weeks. It clearly shows the much higher risk of dying by age 1 for preterm babies under 32 weeks (compared with full-term babies) relative to deaths of preterm babies in the restricted period from day 7 to age 1.

The comparative differences in the results for the 2 other characteristics in Figure 5.4 – smoking during pregnancy and area-level SEIFA ranking – are not as large. The effect of smoking is a significant risk factor only in periods 1 and 3, and only for deaths between 7 days and 1 year.

The final panel of Figure 5.4 compares the odds ratio estimates related to the lowest 3 SEIFA decile group, relative to the highest 3 deciles. This variable is statistically significant only in period 1 and only for the model that includes all deaths under age 1. This indicates that living in more socioeconomically disadvantaged areas increased the risk of infant deaths under age 1 (even after controlling for the effect of the other perinatal variables included in the regression analyses).

Figure 5.4: Selected odds ratio estimates of risk of dying under age 1 in models including and excluding deaths under 7 days, all children, by birth cohorts 2005 to 2018



OR = odds ratio; * indicates that an estimated odds ratio for a given characteristic for that specific death category and birth period was statistically significant at the 5% test level.

(a) Compares preterm under 32 weeks gestational age vaginal delivery babies with full-term vaginal delivery babies.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

5.2 Factors related to deaths between ages 1 to 4

Deaths between ages 1 to 4 – all children

For the regression analyses of the risk factors for deaths of children between ages 1 to 4, the data for all birth cohorts from 2005 to 2018 were pooled. A single logistic regression model was estimated with a common set of explanatory variables because of the small number of child deaths reported in this age group.

The children included in this model were classified as either having:

- died after reaching age 1 but under age 5 (deaths from after 12 to before 60 months)
- survived to age 5 (completed 60 months).

The data linkage carried out for this project recorded deaths to the end of December 2019. To be classified as having survived to age 5, only children born in 2014 or earlier cohorts were included because babies born in later years would not have reached age 5 by the end of 2019.

There were two possibilities to identify the children who died in ages 1 to 4 to include in the regression analysis:

- children who died in these ages only among children born in 2014 or before,
- children who died in these ages among children born in any year of the selected cohorts from 2005 to 2018.

The second approach will include more deaths in this category – children born in 2015 to 2018 but who died under age 5 in the period up to end 2019. However, this approach introduces some irregularity in the time periods covered in the analyses – survival status would be based only on children born in 2014 or earlier, but some of the deaths could come from cohorts born after 2014.

The multivariate regression analyses to identify the risk factors for death between age 1 and 4 was carried out under both approaches. There were 543 deaths in total in this age category under the first approach, and 648 deaths under the second approach.

The regression results and the key risk factors they identify are very similar under both approaches. The results presented in this section focus only on the first approach, where both death and survival status are defined only among all babies born in 2014 or earlier. This involves a purer comparison of the risk of dying, or the alternative of surviving to age 5, among all children who can be followed up to full age 5 in the linked data.

The full set of the estimated odds ratio results for deaths in this age group is presented in Table A5.5 (in Appendix A.2). The set of explanatory variables is similar to that used for deaths under age 1, but with two minor differences:

- the antenatal care variable is recoded into 3 categories (timely first visit, late first visit/no care received, and not stated)[13]
- the interaction terms between preterm birth and caesarean delivery, and between non-singleton birth and caesarean delivery are not included in the model.[14]

The key regression results for death between age 1 and 4 are summarised in Figure 5.5. These results show that the main factors associated with a significantly increased odds of child death between ages 1 to 4 were:

- Indigenous status: Indigenous babies were 2.2 times as likely to die in this age range as non-Indigenous babies
- Birthweight small for gestational age: babies in this category were approximately 1.7 times as likely to die as babies born in the normal weight range for their gestational age
- Sex: male babies were approximately 1.3 times as likely to die in this age range as female babies
- Age of mother: babies born to younger mothers (aged 20–25) were approximately 1.4 times as likely to die as babies born to mothers aged 26–30, but there was no additional risk seen among babies born to teenage mothers aged under 20 that was statistically significant.

Several of the variables that are significant risk factors in the analysis of deaths under age 1 presented in other sections of this report (and in Table A5.1) do not have significant effects on the risk of death in the older ages from 1 to 4. These are:

- preterm birth
- caesarean delivery
- mother experiencing postpartum haemorrhage requiring a blood transfusion.

There is a difference also in the results for the role of the area-level socioeconomic status variables in the risk of dying between ages 1 to 4. None of the estimated odds ratios for the 2 lower SEIFA ranking categories (compared with living in the most advantaged area) are statistically significant. The effect of the other area-level socioeconomic status variable (the proportion of children in that SA2 assessed to be vulnerable in any one of the 5 AEDC child development domains) was also not shown to be a significant risk factor.

This section does not present any additional derivation of the 'marginal effects' of the variables used in the model to analyse the risk factors for deaths between ages 1 to 4 because there were few significant estimates of the marginal effects for death in this age group. The marginal effects are computed as an average over all data points used in the regression model, but the total number of deaths in this age group (543 spread over 10 birth cohorts) is too small to produce compact standard errors from which the statistical significance of the marginal effects can be reliably estimated.

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[13] 'No care received' was a separate category in the analyses for death under age 1; but it is combined with 'late antenatal care' here because the effects of that sub-category could not be reliably estimated due to the small number of such cases. It was considered more appropriate to combine "no care received' with 'late care' than with 'not stated due the likelihood that 'not stated' could include 'timely antenatal care'.

[14] In the regression results on deaths between ages 1 to 4 the main effects of preterm birth, caesarean delivery and non-singleton births are never significant. If their overall effects are not significant in explaining deaths in this age group, it was not necessary to introduce additional interaction terms to assess how these effects varied across their different combinations. The results presented in Figure 5.5 and Appendix Table A5.5 exclude these interaction terms; but such interaction terms are also insignificant if included in the model.

Figure 5.5: Selected regression results for child deaths between ages 1 to 4, estimated odds ratios[(a,b)], all birth cohorts combined, 2005–2018

Maternal/baby characteristic	2005–2018	
Preterm birth under 32 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	⬛ 1.2	times as likely
Preterm birth between 32 and 36 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	⬛ 1.3	times as likely
Small for gestational age in birthweight (compared with a normal birthweight baby by gestational age)	🟧 1.7	times as likely
Indigenous baby (based on mother's or baby's Indigenous status) (compared with a non-Indigenous baby)	🟧 2.2	times as likely
Mother was a teenager at time of giving birth (age 19 or under) (compared with a mother aged 26 to 30)	⬛ 1.3	times as likely
Mother was aged 20 to 25 years at time of giving birth (compared with a mother aged 26 to 30)	🟧 1.4	times as likely
Caesarean delivery for a full-term baby (compared with a vaginal delivery full-term baby)	⬛ 1.0	times as likely
Male baby (compared with a female baby)	🟧 1.3	times as likely
Postpartum haemorrhage (PPH) developed by mother that required blood transfusion (compared with a baby born to a mother who did not develop PPH requiring a blood transfusion)	⬛ 0.8	times as likely
Mother smoked during pregnancy (compared with a mother who did not smoke)	🟧 1.3	times as likely
Use and timing of antenatal care (compared with a mother who had first visit by 13 weeks)		
Late first antenatal care visit (after 13 weeks gestation) **or no antenatal care received**	⬛ 1.0	times as likely
Antenatal care status not stated	⬛ 1.5	times as likely
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (compared with a mother residing in an SA2 in the highest 3 deciles)	⬛ 1.1	times as likely
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (compared with a mother residing in an SA2 in the highest 3 deciles)	⬛ 1.0	times as likely
Percentage of children vulnerable on one or more AEDC domain in mother's SA2 of usual residence	⬛ 1.0	times as likely

🟧 Statistically significant risk factors (with odds ratios greater than 1) at least at the 5% test level.

⬛ Factors that are not statistically significant at the 5% test level.

(a) Estimates of the odds ratio are from the full model with area-level variables and specific interactions terms from Appendix Table A5.4. Some values reported in above table may differ due to rounding.

(b) Tests of significance on whether the estimated odds ratio is significantly different from 1 is done at the 5% test level.

Source: AIHW analyses of the Linked NSW PDC and Deaths data.

6 Multivariate analyses of deaths under age 1 – Indigenous infants

This chapter presents results for separate analyses of deaths under age 1 among Indigenous babies identified in the linked data set within the NSW birth cohorts of 2005 to 2018. There is a special interest in documenting and understanding the factors behind the known disparities in the mortality rate and causes of death between Indigenous and non-Indigenous children.

Differences in results are noted in comparison with the overall group of all children analysed in chapter 5. The regression results reported in this chapter identify several significant differences in the risk and protective factors associated with Indigenous infant deaths compared with those associated with all deaths under age 1 as analysed in chapter 5.

The focus in this chapter is on detailed multivariate regression analyses on the specific risk factors associated with all Indigenous infant deaths under age 1, including deaths in the first 7 days after birth. A separate regression model was not estimated for Indigenous infant deaths excluding deaths in the first 7 days (as was done in chapter 5) due the small overall number of Indigenous deaths under age 1.

At a glance

- The analysis in this chapter is based on around 60,300 babies who can be identified as Indigenous in the linked data, reflecting the Indigenous status associated with either the baby or birth mother.
- Of these, 309 (0.5%) had died under age 1, and another 74 (0.1%) died between ages 1 to 4.

Results of the regression analyses on the risk of dying under age 1 for Indigenous babies showed the following:

- Babies born preterm under 32 weeks gestational age were slightly more than 100 times as likely to die as babies born at full term, but this risk was reduced if such preterm babies were delivered by caesarean section.
- Babies born preterm between 32 and 36 weeks gestational age were 2.3 times as likely to die as full-term babies, and the risk of dying for preterm births in this subcategory was not affected by caesarean section delivery.
- Babies small for gestational age were twice as likely to die as babies who were not.
- Babies born to mothers living in *Major cities* were 1.4 times as likely to die as babies born to mothers living in regional areas.
- Babies born in 2012–2018 were 0.6 times as likely to have died by age 1 than babies born the earlier 2005–2011 period, indicating the significant decline in cohort-specific Indigenous mortality rates for death under age 1 between 2005–2011 and 2012–2018.
- The area-level socioeconomic status variables used in this chapter did not show any significant effects on the risk of Indigenous children's dying under age 1.

The multivariate regression analysis for Indigenous children follows the same approach as the models used for the full cohort of all children. The set of explanatory variables is listed in Box 5.1, with the following differences for the Indigenous-specific regression model for deaths under age 1:

- a single-period model is estimated with pooled data for all Indigenous children in the 2005–2018 birth cohorts instead of 3 different birth cohort period models.
- an additional binary time period variable is added that distinguishes the early 2005–2011 birth cohorts from the later 2012–2018 cohorts to test whether there is a time period effect on the risk of dying for Indigenous babies, even if data are pooled for the full 2005–2018 birth cohorts.[15]
- the antenatal care variable is recoded into 3 categories (timely first visit, late first visit/no care received, and not stated) as in the model for death between age 1 to 4, again due to small number of deaths that does not support a 4-way grouping of antenatal care.
- an interaction term was introduced between the above binary time period indicator and maternal smoking during pregnancy because of a change in the way the smoking status during pregnancy was collected in the NSW PDC. This interaction term allows for the smoking during pregnancy variable to have different effects on the risk of dying for the 2005–2012 birth cohorts compared with the 2013–2018 cohorts.[16]
- another area-level socioeconomic status indicator was introduced as an alternative to the SEIFA index, or in combination with the SEIFA index. This was the Indigenous Relative Socioeconomic Outcomes (IRSEO) index, developed by Biddle (2013). It is an Indigenous-specific index of socioeconomic indicators that reflects the average level of socioeconomic disadvantage for the Indigenous population of that area (as opposed to socioeconomic disadvantage of the overall population reflected in the SEIFA indices).
- the AEDC derived variable on the proportion of children assessed as being developmentally vulnerable on one or more domains was not used in this subgroup analyses of Indigenous infant deaths. SA2 level data on AEDC derived developmental vulnerability among Indigenous children are not published. Associating risks for Indigenous child death with the published vulnerability percentage for all children in an area was experimented with initially, but subsequently dropped because no relationship was seen.
- the additional logit regression results in relation to the ‘marginal effects’ of the variables are not computed due again to the lessened reliability of these estimates because of the small number of total deaths of Indigenous babies under age 1.

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[15] Another practical reason for choosing a 2-period indicator variable to break up the full 2005 to 2018 birth cohorts is due to differences in the way some PDC variables were collected in the early time periods compared with the more recent period, including the availability of data on the Indigenous status of the baby from 2011. The 2-period cut-off was not imposed exactly in 2010, however, in order to have a better balance of the number of Indigenous babies born in these 2 periods. The results of the regression analyses in this section are not affected by the choice of the calendar year cut-off to define the earlier and later birth cohorts.

[16] Since 2013, smoking during pregnancy is further categorised into smoking in the first half and smoking in the second half of pregnancy. The smoked during pregnancy variable used in the regression models in chapters 4 and 5 is based on a composite that reflects smoking at any time in the pregnancy in the 2005 to 2012 cohorts, and on the more specific smoked during the 2nd half of pregnancy from 2013. Again, the 2-period time cut-off was not imposed exactly from 2013, but from 2012. The interaction term between smoked during pregnancy and the 2005–2011 and 2012–2018 time period indicator variable will, however, help to control for the effect of this change in variable definition.

6.1 Factors related to Indigenous child death under age 1

The full results of the estimated odds ratios for risk of death under age 1 for Indigenous babies are presented in Table A6.1 (in Appendix A.3) for the 2 types of models estimated – one using only PDC variables and the other (preferred version) using both PDC and area level socioeconomic status variables. Table A6.1 also uses asterisks (*) and colour coding to identify which of the variables used (or which specific category within a variable) was statistically significant and the direction of the effect (that is, whether it was a significant risk or a protective factor).

A summary of the key results of the estimated odds ratio values is presented in Figure 6.1.

The following factors were consistently associated with significantly increased odds of death under age 1 for Indigenous babies in both model types:

- early preterm birth under 32 weeks gestational age
- later preterm birth (between 32 and 36 weeks gestational age)
- birthweight small for gestational age
- being born to a teenage mother.

These above risk factors are common with the set of consistent risk factors identified in chapter 5 analyses of deaths of all children under age 1 (Figure 5.1 and Table A5.1).

The regression results in this chapter also identified 2 key differences in the significant risk factors for Indigenous babies compared with all babies dying under age 1:

- Male sex was no longer a significant risk factor in the analyses for this chapter.

  (This could be because of the overall higher level of mortality for all Indigenous babies as seen in Figure 3.1, so that being male is not a separate additional risk; or that the overall small number of Indigenous infant deaths available for regression analyses means the sex-wise differential risk cannot be clearly identified in a statistically significant manner.)
- If the usual place of residence of the mother when giving birth was *Major cities*, this was a significant risk factor (compared with mothers living in regional and remote areas).

  (The latter is an unexpected result requiring further investigation. To our knowledge similar results have not been reported in other studies of a higher risk of infant or child death in the *Major cities* remoteness area of New South Wales. This regional classification consists essentially of the Sydney/Wollongong and Newcastle metropolitan areas (ABS 2018)).

The full regression results presented in Table A6.1 also identify 2 clear protective factors for Indigenous infant deaths under age 1. These were:

- caesarean delivery for the subcategory of early preterm births before 32 weeks (as was the case in the chapter 5 analyses)
- being born in the later birth cohort period of 2012–2018 (compared with 2005–2011).
  (The comparison was not feasible in chapter 5, but consistent with declining role of the Indigenous status variable in the chapter 5 analyses.)

The odds ratio associated with the 2012–2018 period is 0.6, indicating an almost halving of the odds of dying under age 1 for Indigenous children born in 2012–2018 compared with those born in 2005–2011. This result is consistent with the decrease in cohort-specific under 5 child mortality rates for Indigenous children from Figure 3.1.

Figure 6.1: Selected regression results for child deaths under age 1 among NSW-born Indigenous babies, estimated odds ratios[(a,b)], all birth cohorts combined, 2005–2018

Maternal/baby characteristic	2005–2018	
Preterm birth under 32 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 103	times as likely
Preterm birth between 32 and 36 weeks gestational age (vaginal delivery) (compared with a full-term birth and vaginal delivery baby)	🟧 2.3	times as likely
Preterm birth under 32 weeks gestational age (caesarean delivery) (compared with a full-term and caesarean delivery baby)	🟧 23.3	times as likely
Preterm birth between 32 and 36 weeks gestational age (caesarean delivery) (compared with a full-term and caesarean delivery baby)	🟧 4.3	times as likely
Small for gestational age in birthweight (compared with a normal birthweight baby by gestational age)	🟧 2.0	times as likely
Mother was a teenager at time of giving birth (age 19 or under) (compared with a mother aged 26 to 30)	🟧 1.6	times as likely
Mother was aged 20 to 25 years at time of birth (compared with a mother aged 26 to 30)	⬛ 1.3	times as likely
Mother lived in a Major city at time of delivery (compared with a mother living in a regional area)	🟧 1.4	times as likely
Postpartum haemorrhage (PPH) developed by mother that required blood transfusion (compared with a baby born to a mother who did not develop PPH requiring a blood transfusion)	⬛ 1.5	times as likely
Caesarean delivery for a full-term baby (compared with a vaginal delivery full-term baby)	⬛ 1.0	times as likely
Male baby (compared with a female baby)	⬛ 1.0	times as likely
Mother smoked during pregnancy (compared with a mother who did not smoke)	⬛ 0.7	times as likely
Use and timing of antenatal care (compared with a mother who had first visit by 13 weeks)		
Late first antenatal care visit (after 13 weeks gestation) **or no antenatal care received**	⬛ 0.8	times as likely
Antenatal care status not stated	⬛ 1.5	times as likely
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (compared with a mother residing in an SA2 in the highest 3 deciles)	⬛ 0.7	times as likely
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (compared with a mother residing in an SA2 in the highest 3 deciles)	⬛ 0.7	times as likely

🟧 Statistically significant risk factors (with odds ratios greater than 1) at least at the 5% test level.

⬛ Factors that are not statistically significant at the 5% test level.

(a) Estimates of the odds ratio are from the full model with area-level variables and specific interactions terms from Appendix Table A6.1. Some values reported in above table may differ due to rounding.

(b) Tests of significance on whether the estimated odds ratio is significantly different from 1 is done at the 5% test level.

Source: AIHW analyses of the Linked NSW PDC and Deaths data.

Some selected results on the range of the odds ratio results from Figure 6.1 on the key statistically significant risk factors for Indigenous infant deaths under age 1 are as follows:

- Indigenous preterm babies under 32 weeks gestational age were substantially more likely to have died under age 1 than full-term Indigenous babies – by a factor of more than 100 times as likely. This effect, however, was mediated again by caesarean delivery:
  - for an Indigenous preterm baby under 32 weeks gestational age with a caesarean delivery, the likelihood of dying under age 1 was reduced to 23 times as likely as a full-term and caesarean delivery baby.
- Indigenous preterm babies between 32 and 36 weeks gestational age were 2.3 times as likely to have died under age 1 than full-term babies (if they both had normal vaginal deliveries).
  - this effect for preterm babies between 32 and 36 weeks was not mediated by caesarean delivery, as in the case with Indigenous preterm babies under 32 weeks gestational age.
  - caesarean delivery among preterm babies between 32 and 36 weeks tends to be risk factor (with estimated odds ratio greater than 1 for their interaction term in Appendix Table A6.1, but those estimates are not statistically significant).
- The effect of caesarean delivery by itself for full-term babies (when not interacted with preterm birth status) was also not a significant risk factor for Indigenous child death.
- Indigenous babies who were small for gestational age were twice as likely to have died as normal weight babies (for their gestational age).
- Indigenous babies born to teenage mothers were around 1.6 times as likely to have died under age 1 as babies born to mothers aged 26 to 30.
- Indigenous babies born to mothers residing in *Major cities* areas were around 1.4 times as likely to have died under age 1 as babies born to mothers residing in regional areas.

It should be reiterated that the greater risk associated with *Major cities* areas is based on the usual address at which the mother resided when giving birth, and not on the location of the hospital where the birth occurred. That discounts the possibility that the greater risk associated with *Major cities* areas could be a transferred risk, whereby mothers with a complicated pregnancy or expected difficulties in delivery and postnatal care may have been transferred from other areas to a *Major cities* hospital. In such instances, these complicated pregnancy or delivery cases could likely be associated with a higher risk of dying among the babies born. However, that is not how the PDC data are coded.

Other potential channels or mechanisms that could give rise to this adverse *Major cities* effect for Indigenous babies will need to be investigated further. This result is unexpected, but it is not created only by the complicated interrelationships between all the variables used in the estimated regression model. It occurs clearly in the raw data when death of Indigenous babies under age 1 are tabulated by remoteness areas only. (See chapter 4 discussions related to Appendix Table A4.4.)

Of the roughly 60,300 Indigenous babies identified in the linked data, less than 5% are from remote areas and so there are few deaths registered in that remoteness subcategory. But around half of the total Indigenous infant deaths are placed in regional areas and around 46% in *Major cities* areas. These two regions have quite different underlying under age 1 implicit mortality rates (6.3 deaths per 1,000 live births in *Major cities* areas and 4.4 deaths per 1,000 in regional areas, from Table A4.4). The raw unadjusted odds ratio based on these proportional rates is around 1.48 times more likely to die in a *Major cities* area. This difference is maintained in the regression results of this chapter even after the confounding effects of all other variables in the model are accounted for.

This result, however, was not found in the analyses in chapter 5 on the risk factors for deaths under age 1 among all children in any of the three separate time period models (Appendix Table A5.1). Among all deaths under age 1, *Major cities* location did not have any higher or lower risk of dying than for the reference remoteness category of Inner and Outer regional areas. The higher risk of dying in *Major cities* location among all children occurred only once in the 10 different model results in chapter 5 (over Appendix Tables A5.1, A5.3 and A5.4); with the exception being the results for period 1 for the age at death category of 7 days after birth to under age 1, in Appendix Table A5.3). If this one-off exceptional result is discounted, the higher risk of dying under age 1 for babies whose mother's usual area of residence was *Major cities* can be interpreted as applying specifically to Indigenous babies.

Other studies have not, however, reported such a finding for New South Wakes or even at a national level, so some caution is still required. Previous AIHW analyses of perinatal outcomes with linked data at the national level for Indigenous babies did not find this relationship for the risk of neonatal death (under 28 days), or even for stillbirth. Indeed, some of the associated risk factors – such as low birthweight and preterm birth – were more likely to occur in other remoteness areas than in *Major cities* (AIHW 2021b).

Since access to medical and allied health services before and after birth might ordinarily be expected to be easier in *Major cities*, the result in this chapter may indicate some unobserved differences between Indigenous babies and their families living in *Major cities* relative to other families living in *Major cities*.

More analyses also needed to confirm the extent of, and reasons for, the other differences seen in the identified risk factors for death under age 1 between Indigenous babies and all babies.

Role of area-level socioeconomic status variables

The area-level socioeconomic status variables used in the regression analysis of this chapter did not show any significant effects on the risk of Indigenous babies dying under age 1.

The 2 options tried were the standard SEIFA area-level decile categories and categories of the Indigenous specific IRSEO index (Biddle 2013).

Based on the SEIFA categories, Indigenous babies born to mothers who, when giving birth, resided in the either the lowest 3 or the middle 4 SEIFA deciles did not have any significant differences in the risk of dying compared with the reference category of mothers residing in the top 3 SEIFA deciles.

Very few Indigenous families live in the top 3 SEIFA deciles, which are based on the average socioeconomic status of the total population living in each SA2. In the linked data for this project, around 6% of the Indigenous babies born in New South Wales between 2005 and 2018 had mothers living in the top 3 SEIFA deciles. However, in order to maintain consistency with the variables used in the chapter 5 analyses, the SEIFA decile coding were left unchanged for the separate analysis of Indigenous infant deaths in this chapter.

It was assumed that the alternative Indigenous-specific area-level socioeconomic status rankings based on the IRSEO index could have a better connection to the risk of dying for Indigenous infants. Those results, too, showed that the IRSEO area-level rankings for 2011 and 2016 were not related in any way to the risk of Indigenous babies dying under age 1, whether the IRSEO ranking was used as an additional variable or as a replacement to the SEIFA ranking of areas.

7 Overview, contributions and some limitations and extensions

This report analyses the relationship between early childhood mortality, maternal and baby characteristics at the time of birth (perinatal conditions) and several average socioeconomic status indicators for the mother's area of usual residence for babies born in New South Wales between 2005 and 2018.

This report is a follow-up to previous AIHW reports commissioned by the NSW CDRT that analysed deaths in New South Wales using only the administrative records of the CDRT on children who have died and the characteristics of their death (NSW CDRT 2014, 2016). The 2016 report recommended that additional analyses be carried out by linking the CDRT's data on deaths with perinatal and births data.

The analyses in the current report were based on a new project data set created by the AIHW that linked the NSW Perinatal Data Collection and Births registration records for all babies born in New South Wales during 2005–2018 to administrative data on death registration. This linkage identifies children who died by the end of 2019 and their age at death. The linked file allows more detailed analyses of the risk factors of child death than would be possible from data collected only for children who have died.

The PDC has detailed information on a wide range of topics: demographic characteristics, pregnancy period care and maternal risk factors during pregnancy, maternal health, conditions of birth and initial assessments of the baby's health. The birth cohort file was also linked to summary area-level socioeconomic status indicators from the Australian Census and the AEDC at the SA2 level of the mother's usual place of residence when giving birth.

The main statistical analyses in this report are results from multivariate logistic regressions in chapters 5 and 6 that identify and quantify the role of key factors associated with child death for specific groups of children, by specific ages at the time of death. The regression results are presented in terms of the estimated odds ratios as well as the 'marginal effects' on the risk of dying associated with each variable included in the estimated model.

The regression analyses were carried out separately for the:

- full cohorts of all babies born in New South Wales between 2005 and 2018 (and Indigenous status is one of the explanatory variables used in the analyses, chapter 5)
- cohort only of Indigenous babies born in New South Wales in this period (chapter 6).

The Indigenous status of the baby is based on the Indigenous status recorded either for the baby or the birth mother in the PDC, or for the deceased in the death records. The separate analysis of deaths among Indigenous children was carried out in order to investigate if the key risk factors associated with the deaths of Indigenous children differed from the factors related to deaths among non-Indigenous children, or among all children.

Given the large number of deaths under age 5 among all NSW-born children, the analysis in chapter 5 is repeated for different groups of babies, based on age at death (under 1, both including and excluding the very early deaths in the first 7 days after birth, and between ages 1 to 4), and by 3 time periods for the birth cohorts born between 2005 to 2018.

Given the small number of deaths recorded of Indigenous babies, the chapter 6 analysis was carried out only for all deaths under age 1 for the whole birth cohort period of 2005 to 2018. The total number of Indigenous infant deaths under age 1 is still relatively small even when pooled over 2005 to 2018. Hence the regression modelling results for Indigenous infant deaths (and also for deaths among all children between ages 1 to 4) tend to be less reliably estimated, and should be interpreted with greater caution.

Contribution to the literature

The findings of this study are broadly consistent with other Australian and international literature (AHMAC 2017; Chen et al. 2016). It is well established that the risk of dying during childhood is not randomly distributed throughout society – it varies by the child's individual and family characteristics. It is also well known that the specific conditions of birth, as reflected in the perinatal characteristics of the baby and mother, and other socioeconomic factors are important components of the health and risk of dying of the child.

Child mortality rates are known to be higher for babies who were born preterm, were small for gestational age, had congenital and chromosomal conditions, and were born to mothers with chronic health conditions (AIHW 2018; NSW CDRT 2016). There are also additional factors related to higher mortality among Indigenous children in New South Wales and elsewhere in Australia (AIHW 2020a, 2021a, 2021b).

The results from this study also point to the primary role of preterm birth and low birthweight (small for gestational age) in explaining which child has died by age 1 among all NSW-born babies. Preterm babies under 32 weeks gestational age (extremely or very preterm births) had a substantially higher risk of dying under age 1 (up to 280 times as likely to die as full-term babies), whereas preterm babies between 32 and 36 weeks gestational age (moderate to late preterm) were around 5 times as likely to die as full-term babies (37 weeks or more gestational age).

Babies small for gestational age were around 2.6 to 2.7 times as likely to have died as normal weight babies (for their gestational age). Being born to a teenage mother (age 19 or under) was also clearly identified as a consistent risk factor for babies dying under age 1 (1.4 to 1.7 times as likely to die as babies born to a reference group of mothers aged 26-30).

The effect of being small for gestational age persisted as a significant risk factor for death in ages 1 to 4, but preterm birth status was not associated with a higher risk of dying in ages 1 to 4, even for preterm babies under 32 weeks gestational age. It is reasonable to conclude that perinatal conditions linked directly to baby's health at birth are more critical in explaining death under age 1, but the effects of some conditions continue to death in ages 1 to 4.

Some other perinatal characteristics that did not have consistently significant effects in all the time periods or for all birth cohorts examined, but had a general tendency to increase the odds of dying under age 1, were:

- being male (about 1.2 times as likely to die as female babies)
- being an Indigenous baby (1.5 to 1.8 times as likely compared with other babies)
- being born to a mother who experienced postpartum haemorrhage requiring a blood transfusion (1.6 to 2.7 times as likely compared with being born to a mother who did not experience postpartum haemorrhage requiring a blood transfusion).

These results in chapter 5 associated with the higher risks of dying among Indigenous babies in some time periods should be interpreted with caution. Indigenous status by itself is unlikely to be an independent risk factor for child death. It is usually a proxy for differences between Indigenous children and non-Indigenous children in other important factors related to child mortality that are not already accounted for in the estimated model. In some cases, these other differences are not sufficiently captured by the other variables included in the regression model, and these unobservable differences can be attributed to Indigenous status.

In the results of this study, the risk associated with Indigenous status in the analyses of death under age 1 is significant and highest in the earliest birth cohorts of 2005 to 2010, significant with a smaller level of additional risk in the middle birth cohorts of 2011 to 2014, but not significant in the results for the most recent birth cohorts of 2015 to 2018. This is consistent both with the narrowing of difference between Indigenous and non-Indigenous child mortality rates in recent years (AIHW 2020a), as well as decreases in the rates of some of the other risk factors that applied to Indigenous mothers and their babies, such as smoking during pregnancy.

It should also be noted that the above results on the role of Indigenous status are not affected by the changes to the PDC, where from 2011 onwards data on the Indigenous status of the baby is collected separately to the Indigenous status of the mother. This change leads to an increase in the proportion of Indigenous babies in the birth cohorts from 2011 onwards because the approach taken in this study was to use Indigenous status of either the baby or of the mother to identify Indigenous children in the linked data.

If an alternative approach for defining Indigenous status is used, based only on the mother's Indigenous status (as was the case in the linked data up to 2010), the results associated with the role of Indigenous status in the chapter 5 analyses on the risk of dying under age 1 are not affected. The Indigenous status variable still shows a higher risk of dying in periods 1 and 2 (2005 to 2010, and 2011 to 2014) but not in period 3 (2015 to 2018).

Indigenous status remained as a significant risk factor in the analyses of child death between ages 1 to 4. Differences by birth cohort period could not be analysed for death in this age group due to the small overall number of deaths, and a single period model was estimated with combined data for all birth cohorts from 2005 to 2018.

This study did not find any significant risk of child death associated with specific maternal health and chronic conditions, such as hypertension and pre-existing diabetes. Caesarean mode of delivery was generally identified as a risk factor in the results of this study for full term births. However, when caesarean delivery is combined with preterm birth under 32 weeks gestational age, caesarean delivery becomes a significant protective factor: the risk of dying for preterm babies in this category delivered by caesarean section is significantly lower than the risk of dying for preterm babies with a normal vaginal delivery.

This result aligns with a few studies that have found similar protective effects of caesarean delivery for very low birthweight infants (Al Qurashi 2020).

This differential effect of caesarean delivery is not commonly noted in the Australia literature on child death. The international research also generally finds mixed effects of caesarean delivery on mortality in general for all babies, and specifically for preterm and low birthweight babies. Some studies find that caesarean delivery had no effect on infant deaths when compared with vaginal delivery (Kim et al. 2021); others find both higher and lower risks of death to age 5 with caesarean delivery compared with vaginal delivery (Paixao et al. 2021).

The effect of caesarean delivery has also been found to differ if the caesarean delivery is medically indicated or an elective choice of the mother (Yang and Sun 2017); but this distinction was unfortunately not feasible in the NSW PDC data extract provided for linkage in this project.

The separate subgroup analyses of the risk factors for Indigenous babies dying under age 1 in New South Wales also provided some new insights. There were several risk factors that were common for Indigenous infant deaths and deaths under age 1 in the overall population. These included preterm birth of all types (again, with very high extra risks seen for preterm births under 32 weeks gestational age), birthweight small for gestational age, and being born to a teenage mother. But there was one unusual difference: a significantly higher risk of Indigenous infant death occurring in *Major cities* compared with regional areas and remote areas. This result was not found in the analyses of risk factors for deaths among all children (apart from one exception in the results for period 1 for the age at death category of 7 days after birth to under age 1, in Appendix Table A5.3). The latter is an odd one-off result out of 10 different model results on the risk of dying among all children in different age at death categories presented in Appendix tables A5.1 to A5.4; and so should be discounted.

Access to health and allied services before and after birth are usually easier in *Major cities*, even for the Indigenous population. This result may therefore indicate some unobserved differences between Indigenous babies and their families living in *Major cities* and other remoteness areas that are not reflected in the differences on the perinatal and area-level socioeconomic status indicators of the region used in the regression analyses of this study. Further analyses should explore the underlying reasons behind this unexpected regional pattern in Indigenous child death, where living in *Major cities* is shown as a risk factor.

Apart from the results from the multivariate regression models in chapters 5 and 6, another contribution of this report is the estimation of the cohort-specific under-5 mortality rates for NSW-born children by Indigenous status (presented in chapter 3). It provides a more meaningful estimate of infant and child death rates than period rates that are based on cross sectional data. Cohort-specific mortality rates based on the mortality experience of actual birth cohorts are more informative when used to describe mortality trends (AIHW 2021a). This study found a clear pattern of declining under-5 mortality for Indigenous children born in different periods from 2005 to 2018, and a considerable narrowing of the gap with non-Indigenous cohort-specific under-5 mortality rates.

This study has also demonstrated that perinatal records can be reliably linked to death records to enable plausible and conceptually more robust estimates of child mortality rates and risk factors from unit-record regression analyses based on perinatal variables.

Some limitations and suggestions for further research

The ability to analyse child deaths within their full birth cohorts via data linkage expands considerably the scope of the analyses and applicable methodological tools. Data linkage should be done more regularly with care, but several caveats apply.

A key one is that the findings from the analyses of linked data depend critically on the quality of the linkage. The quality of the linkage, in turn, is affected most by the accuracy and completeness of the common personal identifying variables found in the data sources being linked. The data linkage for this project was based on full names and full dates of birth for babies and their mothers from the perinatal collection, and the full name and date of birth available in the death records.

Nevertheless, the matching of names and dates of birth and other personal identifier variables is still done using a probabilistic approach to finding the best match for any individual record. This is because of the variation in the reporting of the linkage variables, including variations in the full name and the way it is spelled across the different data sets. Duplicate records can also exist for the same child or mother in the same data set, with variations in some of the names provided; these have to be carefully reviewed manually and excluded from the linkage process.

Full details on the data linkage process and outcomes are in Appendix B. The overall assessment made, however, was that the quality of the personal identifier linkage variables provided to the AIHW was good, and an overall good linkage outcome was achieved.

There are also ongoing issues with quality of Indigenous identification in all administrative collections, including NSW perinatal and birth and death registrations. Given that the quality of this identification can change over time in these collections, estimates of the trends in Indigenous child mortality can be affected by these changes. This was one reason to break up the analyses of all child deaths under age 1, where Indigenous status is an explanatory variable, into 3 periods.

A limitation of the scope of analyses of risk and protective factors with linked data on full birth cohorts is that the variables of interest have to be available for both children who have died and survived. This often requires linkage with multiple administrative data sources. For instance, the role of child protection history in the risk of dying could not be analysed in this report because the child protection history is known only for children who have died (as recorded in the CDRT Register of Child Deaths), but not for the children who survived in these birth cohorts. Hence, even though previous AIHW analyses for CDRT (NSW CDRT 2014) had shown that contact with the child protection system in the previous 2 years was a significant risk factor for all-cause child mortality in New South Wales, it could not be examined in this study.

Another limitation to note is that, in linking data between birth and death records, the necessary inference when there is no match between these 2 sources is that the individual is classified as someone who has not died. This inference can sometimes be incorrect due to potential mismatches in the data linkage. These potential mismatches lead to errors in identifying who has survived to specific ages. Relatively bigger errors in the classification of children who have survived and died are possible if the data subgroups are smaller – for example, deaths among Indigenous children aged 1 to 4 (which was not analysed in this report). Nevertheless, any results of the analyses based on small numbers of deaths should be treated with more caution.

This study, however, demonstrated that linkage to a set of perinatal variables alone provides a clearer understanding of the fundamental risk factors associated with child death. Linkages to additional data sources with important variables not included in this study – such as socioeconomic status variables at the level of the individual families, including maternal and parental education, employment and household income – could be useful extensions of the birth-cohort based data linkage approach, as adopted in this study, to analyse child mortality.

The SA2 level of socioeconomic status variables used in this study, in the absence of individual or family socioeconomic status variables, did not reflect much of the social gradient in health and mortality outcomes that invariably exists in almost all populations, young and old (Marmot 2017; WHO 2013). Family level socioeconomic variables – say, from tax records or Centrelink payments history – could uncover more of the hidden inequities in the overall health and risk of dying among diverse subgroups of NSW-born babies.

Another useful source for additional linkage is to NSW-level child protection system data for the full birth cohorts – which, in itself, can be expected to strongly reflect differences in parental socioeconomic status. These and other feasible additional linkages – or use of already existing linked data projects, as in the NSW Human Services Dataset – would help to provide a fuller perspective on additional key risk factors and preventive strategies that can be adopted to reduce child deaths in New South Wales.

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Appendices

Appendix A.1 – Appendix to Chapter 4

This appendix presents the full set of tabulated data on the comparative differences in the characteristics of children who died and who survived to age 1 and age 5. These data are presented for both the overall New South Wales birth cohorts born in 2005 to 2018 as well as separately for Indigenous births only. These comparisons are discussed in chapter 4.

Data are presented in Table A4.1 for the overall cohort for a selected set of 32 maternal or baby characteristics from the variables reported in the PDC, and for several area-level socioeconomic status indicators compiled from other sources, for these 3 birth cohort periods:

- birth cohorts of 2005 to 2010 (period 1, containing 6 calendar year cohorts)
- birth cohorts of 2011 to 2014 (period 2, containing 4 calendar year cohorts)
- birth cohorts of 2015 to 2018 (period 3, containing 4 calendar year cohorts).

The data presented in Figure 4.1 in chapter 4 are based on the 2015–2018 birth cohort period of Table A4.1 for the age at death category of under 1. Similarly, the data in Figure 4.2 in chapter 4 are based on the 2011–2014 birth cohort period of Table A4.1 for the age at death category of between 0 to 4 years.

Significant differences in characteristics among those who have died and those who have survived can be inferred as factors contributing to the risk of dying. Hence, the comparative differences from Table A4.1 can also be converted into direct estimates of mortality (that is, the proportion of children with a specific characteristic who have died by a specific age). These represent cohort-specific mortality rates by age group, or conversely, survival ratios to a specified age. These rates are presented in Table A4.2 for deaths in specified ages for the same 3 birth cohort periods.

The comparisons in Table A4.1 of the 32 selected items are presented in 6 groups:

1. demographic
2. pregnancy period care and risk factors
3. maternal health
4. conditions of birth
5. baby’s health
6. area-level socioeconomic status indicators.

For characteristics that are ‘categorical’ variables, such as baby was a male child or mother was a teenager, the values in Table A4.1 under the ‘died’ and ‘survived’ column are column percentages. They show the percentage of the total babies who died (or survived) and who had the specified characteristic (or factor). For continuous variables, such as mother’s age, the values in Table A4.1 represent the average age of the mother when giving birth among babies who died, and the average maternal age among babies who survived.

The difference in the relative risk of dying as a result of these factors is shown by the whether the difference between the column percentages, or the average values of the continuous variables, in the ‘died’ and ‘survived’ columns is statistically significant.

For example, the first factor in Table A4.1 is labelled ‘Male child’, which is a categorical variable. The reported values in the respective columns for that factor show the percentage of total babies who died and who survived who were males. For instance, in the 2005–2010 birth cohort, for the mortality measure of deaths under age 1, 58% of children who died under age 1 were males – and 51% of those who survived to age 1 were males. The difference in these 2 proportions – 6.3 percentage points – is large enough to be statistically significant. This indicates that being male was a potential risk factor for infant deaths (not taking into account any other related differences that may exist between male and female babies).

The actual mortality rate for male babies compared with female babies is not shown in Table A4.1. It can, however, be derived from the same relative frequencies in the underlying data. This version of the underlying data is presented separately in Table A4.2 of this appendix.

The mortality rate comparisons reported in Table A4.2 are for a smaller subset of 8 of the 32 factors compared in Table A4.1. These 8 factors are more closely related to the variables selected for the multivariate regression analysis in chapter 5, and include the following key characteristics of interest:

- sex
- Indigenous status
- low birthweight status
- small for gestational age status
- preterm birth
- non-singleton birth
- smoking status of mother during pregnancy.

The values in Table A4.2 are implied cohort-specific mortality rates by specified ages expressed as the number of deaths per 1,000 liveborn babies in each of those birth cohort periods. For the baby’s sex, in the 2005–2010 birth cohorts, among all male babies born, 2.9 per 1,000 died under age 1, compared with 2.2 deaths per 1,000 among baby girls.

Tables A4.3 and A4.4 repeat Tables A4.1 and A4.2 for Indigenous children only. The 3 birth cohort periods are combined into a single birth cohort for all Indigenous children for reasons described in Section 4.3.

Table A4.1: Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[a]

	Perinatal characteristics	Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Demographic:											
1	Male child	<7 days	57.8	51.3	6.4*	59.6	51.5	8.0*	58.8	51.4	7.5*
		7 days <1 yr	57.4	51.3	6.1*	57.3	51.5	5.8*	54.5	51.4	3.1
		<1 yr (total)	57.6	51.3	6.3*	58.6	51.5	7.0*	56.8	51.4	5.4*
		1–4 yrs	55.2	51.3	3.8	57.8	51.5	6.2	(n.a – censored)		
		0–4 yrs (total)	57.1	51.3	5.8*	58.4	51.5	6.9*	(n.a.– censored)		
2	Indigenous child (based on mother or baby's Indigenous status)	<7 days	8.7	3.0	5.7*	11.0	5.3	5.7*	6.1	5.9	0.2
		7 days <1 yr	9.8	3.0	6.8*	12.7	5.3	7.4*	14.0	5.9	8.1*
		<1 yr (total)	9.2	3.0	6.2*	11.7	5.3	6.4*	9.8	5.9	3.9*
		1–4 yrs	12.7	3.0	9.7*	11.3	5.3	6.0*	(n.a. – censored)		
		0–4 yrs (total)	9.9	3.0	6.9*	11.6	5.3	6.4*	(n.a. – censored)		
3	Mother's age (mean)	<7 days	30.1	30.1	0.0	30.5	30.3	0.2	31.1	30.7	0.4
		7 days <1 yr	28.8	30.1	–1.3*	29.2	30.3	–1.1*	30.0	30.7	–0.7*
		<1 yr (total)	29.5	30.1	–0.6*	29.9	30.3	–0.4*	30.6	30.7	–0.1
		1–4 yrs	28.7	30.1	–1.4*	29.7	30.3	–0.7*	(n.a. – censored)		
		0–4 yrs (total)	29.3	30.1	–0.8*	29.9	30.3	–0.5*	(n.a. – censored)		

(continued)

n.a. = data not available for this period.

(a) The values in this table are column percentages for the categorical variable (such as a child being male or female) and mean value for continuous characteristics, such as mother's age.

Notes

1. The values in the difference column for categories are percentage point differences in the values in the preceding 'died' and 'survived' columns. For continuous characteristics, they represent differences in the same units as the characteristics of interest, such as years for age.

2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal Characteristics		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Demographic (continued):											
4	Teenage mother (age <20) indicator	<7 days	5.2	3.6	1.6*	4.7	3.0	1.7*	3.2	2.1	1.1
		7 days <1 yr	8.5	3.6	4.9*	7.7	3.0	4.7*	5.4	2.1	3.3*
		<1 yr (total)	6.7	3.6	3.1*	6.0	3.0	3.0*	4.2	2.1	2.1*
		1–4 yrs	6.1	3.6	2.5*	4.2	3.0	1.2			(n.a – censored)
		0–4 yrs (total)	6.6	3.6	3.0*	5.7	3.0	2.7*			(n.a.– censored)
5	First pregnancy >20 weeks gestation	<7 days	52.2	41.9	10.3*	47.3	43.9	3.3	44.3	43.2	1.1
		7 days <1 yr	38.3	41.9	–3.7	42.7	43.9	–1.3	52.4	43.2	9.2*
		<1 yr (total)	45.9	41.9	3.9*	45.2	43.9	1.3	48.6	43.2	5.4*
		1–4 yrs	38.6	41.9	–3.3	39.4	43.9	–4.5			(n.a. – censored)
			44.5	41.9	2.6*	44.1	43.9	0.1			(n.a. – censored)
Pregnancy period care and risk factors:											
6	Late antenatal care (1st visit >13 weeks)	<7 days	27.0	23.0	4.0*	30.9	35.1	–4.2*	25.3	28.6	–3.3*
		7 days <1 yr	28.9	23.0	5.9*	42.4	35.1	7.3*	33.3	28.6	4.7*
		<1 yr (total)	27.9	23.0	4.9*	36.1	35.1	1.0*	29.1	28.6	0.4*
		1–4 yrs	27.9	23.0	4.9*	35.7	35.1	0.6			(n.a. – censored)
		0–4 yrs (total)	27.9	23.0	4.9*	36.0	35.1	0.9*			(n.a. – censored)

(continued)

n.a. = data not available for this period.

(a) The values in this table are column percentages for the categorical variable (such as a child's being male or female) and mean value for continuous characteristics, such as mother's age.

Notes

1. The values in the difference column for categories are percentage point differences in the values in the preceding 'died' and 'survived' columns. For continuous characteristics, they represent differences in the same units as the characteristics of interest, such as years for age.

2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal characteristics		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Pregnancy period care and risk factors (continued):											
7	Total number of antenatal visits (mean)	<7 days	n.a.	n.a.	n.a.	6.3	9.9	–3.6*	6.2	10.3	–4.1*
		7 days <1 yr	n.a.	n.a.	n.a.	8.7	9.9	–1.1*	8.7	10.2	–1.5*
		<1 yr (total)	n.a.	n.a.	n.a.	7.4	9.9	–2.5*	7.4	10.3	–3.2*
		1–4 yrs	n.a.	n.a.	n.a.	9.5	9.9	–0.4		(n.a – censored)	
		0–4 yrs (total)	n.a.	n.a.	n.a.	7.8	9.9	–2.1*		(n.a.– censored)	
8	Smoked during pregnancy (at any time)	<7 days	16.3	12.7	3.6*	13.2	10.1	3.1*	11.8	8.8	3.0*
		7 days <1 yr	28.9	12.7	16.1*	23.1	10.1	13.0*	21.4	8.8	12.6*
		<1 yr (total)	22.0	12.7	9.3*	17.7	10.1	7.6*	16.4	8.8	7.6*
		1–4 yrs	20.2	12.7	7.5*	17.9	10.1	7.8*		(n.a. – censored)	
		0–4 yrs (total)	21.7	12.7	9.0*	17.7	10.1	7.6*		(n.a. – censored)	
9	Smoked during 1st half of pregnancy (2011+)	<7 days	n.a.	n.a.	n.a.	12.4	9.5	2.9*	11.1	8.3	2.9*
		7 days <1 yr	n.a.	n.a.	n.a.	22.1	9.5	12.5*	19.2	8.2	10.9*
		<1 yr (total)	n.a.	n.a.	n.a.	16.8	9.5	7.2*	14.9	8.2	6.7*
		1–4 yrs	n.a.	n.a.	n.a.	17.5	9.5	7.9*		(n.a. – censored)	
			n.a.	n.a.	n.a.	16.9	9.5	7.4*		(n.a. – censored)	

(continued)

n.a. = data not available for this period.

(a) The values in this table are column percentages for the categorical variable (such as a child’s being male or female) and mean value for continuous characteristics, such as mother’s age.

Notes

1. The values in the difference column for categories are percentage point differences in the values in the preceding ‘died’ and ‘survived’ columns. For continuous characteristics, they represent differences in the same units as the characteristics of interest, such as years for age.

2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

	Perinatal characteristics	Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Pregnancy period care and risk factors (continued):											
10	Smoked during 2nd half of pregnancy (2011+)	<7 days	n.a.	n.a.	n.a.	9.6	7.5	2.1	7.3	6.6	0.8
		7 days <1 yr	n.a.	n.a.	n.a.	16.6	7.5	9.1*	16.3	6.5	9.8*
		<1 yr (total)	n.a.	n.a.	n.a.	12.8	7.5	5.3*	11.5	6.5	5.0*
		1–4 yrs	n.a.	n.a.	n.a.	13.6	7.5	6.1*	(n.a – censored)		
		0–4 yrs (total)	n.a.	n.a.	n.a.	12.9	7.5	5.4*	(n.a.– censored)		
Maternal health:											
11	Gestational diabetes	<7 days	2.9	5.0	–2.1*	4.9	7.2	–2.3*	9.0	12.0	–3.1
		7 days <1 yr	5.6	5.0	0.6	7.2	7.2	0.0	11.3	12.0	–0.7
		<1 yr (total)	4.1	5.0	–0.9	5.9	7.2	–1.2	10.1	12.0	–2.0
		1–4 yrs	4.8	5.0	–0.1	4.2	7.2	–2.9	(n.a. – censored)		
		0–4 yrs (total)	4.3	5.0	–0.7	5.6	7.2	–1.6*	(n.a. – censored)		
12	Pre-existing maternal diabetes	<7 days	0.9	0.6	0.3	0.5	1.0	–0.5	2.6	1.0	1.6*
		7 days <1 yr	0.9	0.6	0.3	1.2	1.0	0.2	2.4	1.0	1.3*
		<1 yr (total)	0.9	0.6	0.3	0.9	1.0	–0.1	2.5	1.0	1.5*
		1–4 yrs	1.8	0.6	1.2*	0.9	1.0	0.0	(n.a. – censored)		
			1.1	0.6	0.5*	0.9	1.0	–0.1	(n.a. – censored)		

(continued)

n.a. = data not available for this period.

(a) The values in this table are column percentages for the categorical variable (such as a child's being male or female) and mean value for continuous characteristics, such as mother's age.

Notes

1. The values in the difference column for categories are percentage point differences in the values in the preceding 'died' and 'survived' columns. For continuous characteristics, they represent differences in the same units as the characteristics of interest, such as years for age.

2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

	Perinatal outcome indicators	Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Maternal health (continued):											
13	Chronic hypertension	<7 days	1.1	0.9	0.3	1.6	0.8	0.8*	2.4	0.8	1.6*
		7 days <1 yr	1.4	0.9	0.5	2.7	0.8	1.9*	2.4	0.8	1.6*
		<1 yr (total)	1.2	0.8	0.4	2.1	0.8	1.3*	2.4	0.8	1.6*
		1–4 yrs	0.9	0.8	0.1	1.9	0.8	1.1			(n.a – censored)
		0–4 yrs (total)	1.2	0.8	0.3	2.1	0.8	1.3*			(n.a.– censored)
14	Pregnancy-induced hypertension	<7 days	6.1	6.2	–0.1	6.3	5.7	0.6	3.4	4.4	–0.9
		7 days <1 yr	7.2	6.2	1.0	8.4	5.7	2.8*	6.3	4.4	1.9
		<1 yr (total)	6.6	6.2	0.4	7.3	5.7	1.6*	4.7	4.4	0.4
		1–4 yrs	6.2	6.2	0	3.8	5.7	–1.9			(n.a. – censored)
		0–4 yrs (total)	6.5	6.2	0.4	6.6	5.7	0.9			(n.a. – censored)
15	Maternal hepatitis B (2011+)	<7 days	n.a.	n.a.	n.a.	0.8	0.7	0.1	0.8	0.6	0.2
		7 days <1 yr	n.a.	n.a.	n.a.	0.3	0.7	–0.4	0.5	0.6	0.9*
		<1 yr (total)	n.a.	n.a.	n.a.	0.6	0.7	–0.1	1.1	0.6	0.5
		1–4 yrs	n.a.	n.a.	n.a.	0.9	0.7	0.3			(n.a. – censored)
			n.a.	n.a.	n.a.	0.6	0.7	0.0			(n.a. – censored)

(continued)

n.a. = data not available for this period.

(a) The values in this table are column percentages for the categorical variable (such as a child's being male or female) and mean value for continuous characteristics, such as mother's age.

Notes

1. The values in the difference column for categories are percentage point differences in the values in the preceding 'died' and 'survived' columns. For continuous characteristics, they represent differences in the same units as the characteristics of interest, such as years for age.

2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Maternal health (continued):											
16	Mother transferred to another health unit on discharge	<7 days	9.3	2.6	6.7*	8.6	1.6	6.9*	8.2	1.2	7.0*
		7 days <1 yr	10.7	2.6	8.1*	10.4	1.6	8.8*	8.7	1.2	7.5*
		<1 yr (total)	9.9	2.6	7.3*	9.4	1.6	7.8*	8.4	1.1	7.3*
		1–4 yrs	7.6	2.6	5.0*	2.3	1.6	0.7			(n.a – censored)
		0–4 yrs (total)	9.6	2.9	6.7*	8.0	1.6	6.4*			(n.a.– censored)
Conditions of birth:											
17	Not a singleton birth	<7 days	15.9	3.0	12.9*	14.4	2.8	11.6*	12.9	2.8	10.1*
		7 days <1 yr	5.0	3.0	2.0*	3.7	2.8	0.9	8.6	2.8	5.8*
		<1 yr (total)	10.9	3.0	7.9*	9.6	2.8	6.8*	10.9	2.8	8.1*
		1–4 yrs	3.9	3.0	1.0	2.3	2.8	–0.4			(n.a. – censored)
		0–4 yrs (total)	10.3	3.0	7.3*	8.2	2.8	5.4*			(n.a. – censored)
18	Gestational age (mean)	<7 days	28.8	39.0	–10.1*	28.3	38.8	–10.5*	28.3	38.8	–10.5*
		7 days <1 yr	35.8	39.0	–3.2*	35.9	38.8	–2.9*	35.1	38.8	–3.7*
		<1 yr (total)	32.0	39.0	–7.8*	31.7	38.8	–7.1*	31.5	38.8	–7.3*
		1–4 yrs	38.8	39.0	–0.2	38.6	38.8	–0.2			(n.a. – censored)
			33.2	39.0	–5.7*	33.1	38.8	–5.8*			(n.a. – censored)

(continued)

n.a. = data not available for this period.

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Notes

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2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Conditions of birth (continued):											
19	Birthweight (mean in grams)	<7 days	1506	3384	–1878*	1416	3366	–1950*	1427	3336	–1909*
		7 days <1 yr	2594	3382	–789*	2599	3364	–765*	2467	3335	–868*
		<1 yr (total)	2007	3385	–1378*	1953	3367	–1414*	1933	3337	–1404*
		1–4 yrs	3245	3385	–140*	3239	3367	–128*			(n.a – censored)
		0–4 yrs (total)	2237	3385	–1148*	2201	3367	–1166*			(n.a.– censored)
20	Low birthweight (<2.5 kg)	<7 days	75.8	5.7	70.2*	76.9	5.7	71.2*	76.6	6.1	70.5*
		7 days <1 yr	38.2	5.7	32.5*	38.2	5.8	32.4*	43.3	6.1	37.1*
		<1 yr (total)	58.5	5.6	52.9*	59.3	5.7	53.6*	60.4	6.1	54.3*
		1–4 yrs	10.9	5.6	5.3*	11.8	5.7	6.1*			(n.a. – censored)
		0–4 yrs (total)	49.6	5.6	44.0*	50.2	5.7	44.5*			(n.a. – censored)
21	Preterm birth indicator	<7 days	76.6	6.8	69.9*	79.4	7.1	72.4*	76.9	7.0	69.9*
		7 days <1 yr	37.8	6.8	31.0*	33.8	7.1	26.6*	41.8	7.0	34.8*
		<1 yr (total)	58.9	6.7	52.2*	58.8	7.0	51.8*	60.4	7.0	53.4*
		1–4 yrs	10.9	6.7	4.2*	9.4	7.0	2.4*			(n.a. – censored)
			50.1	6.7	43.3*	49.3	7.0	42.3*			(n.a. – censored)

(continued)

n.a. = data not available for this period.

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Notes

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2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Conditions of birth (continued):											
22	Small for gestational age indicator	<7 days	15.7	11.0	4.7*	13.6	10.5	3.1*	16.9	11.2	5.7*
		7 days <1 yr	25.2	11.0	14.2*	26.1	10.5	15.6*	23.8	11.2	12.6*
		<1 yr (total)	20.0	10.9	9.1*	19.2	10.5	8.8*	20.1	11.2	8.9*
		1–4 yrs	19.1	10.9	8.1*	16.0	10.5	5.5*	(n.a – censored)		
		0–4 yrs (total)	19.8	10.9	8.9*	18.6	10.5	8.1*	(n.a.– censored)		
23	Postpartum haemorrhage requiring blood transfusion	<7 days	3.6	1.5	2.1*	5.7	1.5	4.2*	6.1	1.0	5.0*
		7 days <1 yr	1.5	1.5	0.0	1.7	1.5	0.3	2.1	1.0	1.0
		<1 yr (total)	2.6	1.5	1.1*	3.9	1.5	2.4*	4.2	1.0	3.2*
		1–4 yrs	0.9	1.5	–0.6	1.4	1.5	–0.1	(n.a. – censored)		
		0–4 yrs (total)	2.3	1.5	0.8*	3.4	1.5	2.0*	(n.a. – censored)		
24	Type of delivery: caesarean	<7 days	29.8	30.1	–0.3	35.2	32.2	3.0	29.7	34.1	–4.3
		7 days <1 yr	39.9	30.1	9.8*	46.7	32.2	14.5*	46.4	34.1	12.4*
		<1 yr (total)	34.4	30.1	4.3*	40.3	32.1	8.2*	37.6	34.1	3.5*
		1–4 yrs	32.2	30.1	2.1	29.1	32.1	–3.0	(n.a. – censored)		
			34.0	30.1	3.9*	38.2	32.1	6.0*	(n.a. – censored)		

(continued)

n.a. = data not available for this period.

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Notes

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2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Baby's health:											
25	APGAR score – 5 min (mean)	<7 days	3.5	9.0	–5.5*	3.2	9.0	–5.8*	3.3	9.0	–5.7*
		7 days <1 yr	7.9	9.1	–1.1*	7.9	9.0	–1.1*	7.7	9.0	–1.3*
		<1 yr (total)	5.5	9.0	–3.5*	5.4	9.0	–3.6*	5.4	9.0	–3.6*
		1–4 yrs	8.7	9.0	–0.3*	8.9	9.0	–0.1*	(n.a – censored)		
		0–4 yrs (total)	6.1	9.0	–2.9*	6.0	9.0	–2.9*	(n.a.– censored)		
26	Indicator for low APGAR score (<7) at 5 minutes	<7 days	77.7	1.3	76.4*	80.7	1.6	79.2*	83.9	1.6	82.3*
		7 days <1 yr	18.9	1.4	17.5*	17.7	1.6	16.0*	21.9	1.6	20.2*
		<1 yr (total)	50.7	1.3	49.4*	51.9	1.5	50.3*	54.5	1.6	53.0*
		1–4 yrs	4.5	1.3	3.3*	2.4	1.5	0.8	(n.a. – censored)		
		0–4 yrs (total)	42	1.3	40.7*	42.3	1.5	40.8*	(n.a. – censored)		
27	Admitted to special care nursery or neonatal intensive care for 4 hours or more	<7 days	47.9	15.7	32.2*	43.7	14.7	29.0*	40.2	14.2	26.0*
		7 days <1 yr	59.6	15.7	44.0*	57.1	14.7	42.4*	59.2	14.2	45.0*
		<1 yr (total)	53.2	15.6	37.6*	49.7	14.7	35.0*	50.3	14.2	36.1*
		1–4 yrs	32.4	15.6	16.8*	32.4	14.7	17.7*	(n.a. – censored)		
			49.4	15.6	33.8*	46.4	14.7	31.7*	(n.a. – censored)		

(continued)

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Notes

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2. An asterisk (*) indicates a statistically significant ($p<0.05$) difference for that characteristic between babies who died and babies who survived to the specified ages.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Baby's health (continued)											
28	Admitted to special care nursery or neonatal intensive care (for any length of time)	<7 days	46.4	14.6	31.8*	43.8	14.7	29.1*	40.2	14.2	26.0*
		7 days <1 yr	57.6	14.6	43.0*	57.2	14.7	42.5*	59.2	14.2	45.0*
		<1 yr (total)	51.6	14.6	37.0*	49.8	14.7	35.1*	50.3	14.2	36.1*
		1–4 yrs	28.7	14.5	14.1*	32.4	14.7	17.7*	(n.a – censored)		
		0–4 yrs (total)	47.4	14.5	32.9*	46.5	14.7	31.8*	(n.a.– censored)		
29	Baby feeding on discharge	<7 days	3.3	73.0	–69.7*	4.1	99.1	–95.0*	97.6	3.7	–93.9*
		7 days <1 yr	46.2	72.9	–26.7*	63.0	99.0	–36.0*	55.7	97.5	–41.8*
		<1 yr (total)	22.9	73	–50.2*	30.6	99.1	–68.5*	28.1	97.6	–69.5*
		1–4 yrs	63.3	73	–9.7*	93	99.1	–6.1*	(n.a. – censored)		
		0–4 yrs (total)	30.3	73	–42.7*	42.6	99.1	–56.5*	(n.a. – censored)		
30	Of babies feeding on discharge: feeding on breast milk or expressed breast milk	<7 days	80.8	87.5	–6.8	95.0	89.6	5.4	71.4	91.1	–19.6*
		7 days <1 yr	77.5	87.5	–10.0*	81.9	89.6	–7.7*	86.1	91.1	–5.0*
		<1 yr (total)	77.8	87.5	–9.8*	82.8	89.6	–6.8*	85.1	91.1	–6.0*
		1–4 yrs	79.9	87.5	–7.6*	84.8	89.6	–4.8*	(n.a. – censored)		
			78.6	87.5	–8.9*	83.7	89.6	–5.9*	(n.a. – censored)		

(continued)

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Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)(a)

Perinatal outcome indicators		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Baby's health (continued)											
30	Of babies feeding on discharge: feeding on infant formula	<7 days	23.1	19.0	4.1	15.0	18.5	–3.5	35.7	23.0	12.7
		7 days <1 yr	29.3	19.0	10.3*	26.4	18.5	7.9*	26.7	23.0	3.8
		<1 yr (total)	28.8	19.0	9.8*	25.5	18.5	7.0*	27.4	23	4.4
		1–4 yrs	26.8	19.0	7.8*	22.2	18.5	3.7	(n.a – censored)		
		0–4 yrs (total)	28	19	9.0*	24.2	18.5	5.7*	(n.a.– censored)		
Area–level socioeconomic indicators											
31a	2011 SEIFA index decile for SA2 of mother's usual residence in top 3 deciles	<7 days	25.6	30.1	–4.5*	23.8	29.8	–6.0*	29.3	27.9	–1.4
		7 days <1 yr	18.7	30.1	–11.5*	22.3	29.8	–7.5*	21.4	29.3	–7.8*
		<1 yr (total)	22.5	30.1	–7.7*	23.1	29.8	–6.7*	24.9	29.3	–4.4*
		1–4 yrs	22.4	30.1	–7.7*	23.0	29.8	–6.8*	(n.a. – censored)		
		0–4 yrs (total)	22.5	30.1	–7.7*	23.1	29.8	–6.7*	(n.a. – censored)		

(continued)

n.a. = data not available for this period.

(a) The values in this table are column percentages for the categorical variable (such as a child's being male or female) and mean value for continuous characteristics, such as mother's age.

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Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.1 (continued): Maternal and baby characteristics by survival status, age at death and birth year period, all children: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators		Age at death	2005–2010			2011–2014			2015–2018		
			Died	Survived	Difference	Died	Survived	Difference	Died	Survived	Difference
Area–level socioeconomic indicators (continued)											
31b	2011 SEIFA index decile for SA2 of mother's usual residence in middle 4 deciles	<7 days	37.0	35.6	1.4	40.0	36.0	4.0	39.2	36.7	2.5
		7 days <1 yr	34.8	35.6	–0.8	32.0	36.0	–4.0	34.8	36.7	–1.9
		<1 yr (total)	36.0	35.6	0.4	36.4	36.0	0.4	37.2	36.7	0.4
		1–4 yrs	32.4	35.6	–3.2	33.3	36.0	–2.7		(n.a – censored)	
		0–4 yrs (total)	35.3	35.6	–0.3	35.8	36.0	–0.2		(n.a.– censored)	
31c	2011 SEIFA index decile for SA2 of mother's usual residence in bottom 3 deciles	<7 days	34.6	33.1	1.5	35.0	32.7	2.3	30.5	32.0	–1.5
		7 days <1 yr	45.3	33.1	12.3*	43.9	32.7	11.3*	41.1	32.0	9.1*
		<1 yr (total)	39.5	33.1	6.4*	39.0	32.7	6.3*	35.5	32.0	3.5*
		1–4 yrs	44.6	33.1	11.5*	42.3	32.7	9.6*		(n.a. – censored)	
		0–4 yrs (total)	40.4	33.1	7.4*	39.6	32.7	7.0*		(n.a. – censored)	
32	% of children in SA2 of mother's usual residence vulnerable on one or more AEDC domain (mean)	<7 days	21.2	21.0	0.3	21.1	20.4	0.7*	20.0	20.4	0.3
		7 days <1 yr	22.3	21.0	1.3*	21.7	20.4	1.3*	22.0	20.4	1.6*
		<1 yr (total)	21.7	21.0	0.7*	21.4	20.4	0.9*	20.9	20.4	0.6*
		1–4 yrs	22.4	21.0	1.4*	22.2	20.4	1.8*		(n.a. – censored)	
			21.8	21.0	0.9*	21.5	20.4	1.1*		(n.a. – censored)	

n.a. = data not available for this period.

(a) The values in this table are column percentages for the categorical variable (such as a child's being male or female) and mean value for continuous characteristics, such as mother's age.

Notes

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Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.2: Estimated mortality rate (per 1,000 live births) by maternal and baby characteristics, age at death and birth year period, all children

Perinatal outcome indicators:	Birth cohort	Age at death				
		<7 days	7 days <1 yr	<1 yr (total)	1–4 yrs	0–4 yrs (total)
1. Sex of child						
Male	2005–2010	1.6	1.3	2.9	0.6	3.5
	2011–2014	1.5	1.2	2.6	0.6	3.2
	2015–2018	1.1	0.9	2.1	(n.a. – censored)	(n.a. – censored)
Female	2005–2010	1.2	1.0	2.2	0.5	2.8
	2011–2014	1.1	0.9	2.0	0.5	2.4
	2015–2018	0.8	0.8	1.7	(n.a. – censored)	(n.a. – censored)
Rate ratio#	2005–2010	1.3*	1.3*	1.3*	1.2	1.3*
	2011–2014	1.4*	1.3*	1.3*	1.3	1.3*
	2015–2018	1.4*	1.1	1.2*	(n.a. – censored)	(n.a. – censored)
2. Indigenous child (based on mother's or baby's Indigenous status)						
Indigenous	2005–2010	4.0	3.8	7.9	2.5	10.3
	2011–2014	2.6	2.5	5.1	1.2	6.3
	2015–2018	1.0	2.1	3.1	(n.a. – censored)	(n.a. – censored)
Non–Indigenous	2005–2010	1.3	1.1	2.4	0.5	2.9
	2011–2014	1.2	1.0	2.1	0.5	2.7
	2015–2018	1.0	0.8	1.8	(n.a. – censored)	(n.a. – censored)
Rate ratio#	2005–2010	3.1*	3.5*	3.3*	4.7*	3.5*
	2011–2014	2.2*	2.5*	2.4*	2.3*	2.4*
	2015–2018	1.0	2.6*	1.7*	(n.a. – censored)	(n.a. – censored)
3. Remoteness area for mother's usual place of residence						
Major cities	2005–2010	1.3	1.1	2.5	0.6	3.0
	2011–2014	1.2	1.0	2.2	0.5	2.7
	2015–2018	1.0	0.8	1.8	(n.a. – censored)	(n.a. – censored)
Regional	2005–2010	1.6	1.3	2.9	0.7	3.6
	2011–2014	1.4	1.3	2.7	0.6	3.4
	2015–2018	0.8	1.1	1.9	(n.a. – censored)	(n.a. – censored)
Remote/Very remote	2005–2010	1.3	1.3	2.5	0.6	3.2
	2011–2014	1.0	1.0	2.0	1.0	3.0
	2015–2018	0.6	1.2	1.8	(n.a. – censored)	(n.a. – censored)

(continued)

n.a. = data not available for this period.* indicates a statistically significant ($p<0.05$) difference in the mortality rate within the categories of a perinatal outcome indicator for a given age at death and study period.

Note: Rate ratio (denoted by #) represents the ratio between the computed mortality rates per 1,000 children between the 2 specified categories. For instance, the rate ratio under sex of child is the male child mortality rate divided by the female child mortality rate.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.2 (continued): Estimated mortality rate (per 1,000 live births) by maternal and baby characteristics, age at death and birth year period, all children

		Age at death				
Perinatal outcome indicators:	**Birth cohort**	**<7 days**	**7 days <1 yr**	**<1 yr (total)**	**1–4 yrs**	**0–4 yrs (total)**
3. Remoteness area for mother's usual place of residence (continued)						
Rate ratio# (Major city vs Inner/Outer regional)	2005–2010	0.8	0.8	0.9*	0.8*	0.8*
	2011–2014	0.9	0.8*	0.8*	0.8	0.8*
	2015–2018	1.3	0.7*	1.0	(n.a. – censored)	(n.a. – censored)
Rate ratio# (Remote/ Very remote vs Inner/ Outer regional)	2005–2010	0.8	1.0	0.9	0.9	0.9
	2011–2014	0.7	0.8	0.7	1.6	0.9
	2015–2018	0.8	1.1	1.0	(n.a. – censored)	(n.a. – censored)
Rate ratio# (Remote/ Very remote vs Major city)	2005–2010	1.0	1.2	1.0	1.0	1.1
	2011–2014	0.8	1.0	0.9	2.0	1.1
	2015–2018	0.6	1.5	1.0	(n.a. – censored)	(n.a. – censored)
4. Smoking						
Mother smoked during pregnancy (2005–2012 births) or during second half of pregnancy (2013+ births)	2005–2010	1.8	2.7	4.5	0.9	5.4
	2011–2014	1.6	2.3	3.9	1.0	4.9
	2015–2018	1.3	2.1	3.2	(n.a. – censored)	(n.a. – censored)
Mother did not smoke during pregnancy (2005–2012 births), or did not smoke during second half of pregnancy (2013+ births)	2005–2010	1.3	1.0	2.3	0.5	2.8
	2011–2014	1.2	0.9	2.1	0.5	2.6
	2015–2018	0.9	0.7	1.7	(n.a. – censored)	(n.a. – censored)
Rate ratio#	2005–2010	1.4*	2.7*	1.9*	1.7*	1.9*
	2011–2014	1.3*	2.6*	1.8*	2.0*	1.9*
	2015–2018	1.4*	3.0*	1.9*	(n.a. – censored)	(n.a. – censored)
5. Birthweight						
Low birthweight	2005–2010	18.1	7.8	25.9	1.1	27.0
	2011–2014	16.5	6.8	23.3	1.1	24.4
	2015–2018	11.5	6.1	17.6	(n.a. – censored)	(n.a. – censored)
Normal birthweight	2005–2010	0.4	0.8	1.1	0.6	1.7
	2011–2014	0.3	0.7	1.0	0.5	1.5
	2015–2018	0.2	0.5	0.8	(n.a. – censored)	(n.a. – censored)
Rate ratio#	2005–2010	45.3*	9.8*	23.1*	2.0*	16.2*
	2011–2014	55.0*	9.7*	23.6*	2.2*	16.3*
	2015–2018	57.5*	12.2*	23.2*	(n.a. – censored)	(n.a. – censored)

(continued)

n.a. = data not available for this period.* indicates a statistically significant ($p<0.05$) difference in the mortality rate within the categories of a perinatal outcome indicator for a given age at death and study period.

Note: Rate ratio (denoted by #) represents the ratio between the computed mortality rates per 1,000 children between the 2 specified categories. For instance, the rate ratio under sex of child is the male child mortality rate divided by the female child mortality rate.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.2 (continued): Estimated mortality rate (per 1,000 live births) by maternal and baby characteristics, age at death and birth year period, all children

Perinatal outcome indicators:	Birth cohort	Age at death				
		<7 days	7 days <1 yr	<1 yr (total)	1–4 yrs	0–4 yrs (total)
6. Preterm birth						
Preterm birth under 32 weeks gestational age	2005–2010	87.2	23.9	111.0	n.p.	112.1
	2011–2014	82.1	19.7	101.8	n.p.	102.1
	2015–2018	63.7	21.0	84.7	(n.a. – censored)	(n.a. – censored)
Preterm birth between 32 and 36 weeks gestational age	2005–2010	2.9	3.5	6.4	0.9	7.3
	2011–2014	2.6	2.5	5.1	0.8	5.9
	2015–2018	1.7	2.7	4.4	(n.a. – censored)	(n.a. – censored)
All preterm birth (under 37 weeks gestational age)	2005–2010	15.6	6.5	22.1	0.9	23.0
	2011–2014	14.0	4.9	18.9	0.7	19.7
	2015–2018	10.7	5.2	15.8	(n.a. – censored)	(n.a. – censored)
Full-term birth (37+ weeks gestational age)	2005–2010	0.4	0.8	1.1	0.6	1.7
	2011–2014	0.3	0.7	1.0	0.5	1.6
	2015–2018	0.2	0.5	0.8	(n.a. – censored)	(n.a. – censored)
Rate ratio# (all preterm birth under 37 weeks vs full-term birth 37+ weeks)	2005–2010	39.0*	8.1*	20.1*	1.5*	13.5*
	2011–2014	46.7*	7.0*	18.9*	1.4	12.3*
	2015–2018	53.5*	10.4*	19.8*	(n.a. – censored)	(n.a. – censored)
Rate ratio# (preterm birth under 32 weeks vs preterm birth 32–26 weeks)	2005–2010	30.1*	6.8*	17.3*	n.p.	15.4*
	2011–2014	31.6*	7.9*	20.0*	n.p.	17.3*
	2015–2018	37.5*	7.8*	19.3*	(n.a. – censored)	(n.a. – censored)
Rate ratio# (preterm birth under 32 weeks vs full-term birth 37+ weeks)	2005–2010	218.0*	29.9*	100.9*	n.p.	65.9*
	2011–2014	273.7*	28.1*	101.8*	n.p.	63.8*
	2015–2018	318.5*	42.0*	105.9*	(n.a. – censored)	(n.a. – censored)
7. Small for gestational age						
Small for gestational age	2005–2010	2.0	2.7	4.7	1.0	5.7
	2011–2014	1.6	2.6	4.2	0.8	5.1
	2015–2018	1.5	1.9	3.3	(n.a. – censored)	(n.a. – censored)
Normal weight for gestational age	2005–2010	1.3	1.0	2.3	0.5	2.8
	2011–2014	1.2	0.9	2.1	0.5	2.6
	2015–2018	0.9	0.8	1.7	(n.a. – censored)	(n.a. – censored)
Rate ratio#	2005–2010	1.5*	2.7*	2.0*	2.0*	2.0*
	2011–2014	1.3*	2.9*	2.0*	1.6*	2.0*
	2015–2018	1.7*	2.4*	1.9*	(n.a. – censored)	(n.a. – censored)

(continued)

n.a. = data not available for this period. n.p. = data not published due to small cell counts. * indicates a statistically significant ($p<0.05$) difference in the mortality rate within the categories of a perinatal outcome indicator for a given age at death and study period.

Note: Rate ratio (denoted by #) represents the ratio between the computed mortality rates per 1,000 children between the 2 specified categories. For instance, the rate ratio under sex of child is the male child mortality rate divided by the female child mortality rate.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.2 (continued): Estimated mortality rate (per 1,000 live births) by maternal and baby characteristics, age at death and birth year period, all children

Perinatal outcome indicators:	Birth cohort	Age at death <7 days	7 days <1 yr	<1 yr (total)	1–4 yrs	0–4 yrs (total)
8. Non-singleton birth						
Non-singleton birth	2005–2010	7.4	2.0	9.4	0.8	10.2
	2011–2014	6.5	1.4	7.9	0.5	8.3
	2015–2018	4.5	2.7	7.2	(n.a. – censored)	(n.a. – censored)
Singleton birth	2005–2010	1.2	1.2	2.4	0.6	2.9
	2011–2014	1.1	1.0	2.1	0.6	2.7
	2015–2018	0.9	0.8	1.7	(n.a. – censored)	(n.a. – censored)
Rate ratio#	2005–2010	6.2*	1.7*	3.9*	1.3	3.5*
	2011–2014	5.9*	1.4	3.8*	0.8	3.1*
	2015–2018	5.0*	3.4*	4.2*	(n.a. – censored)	(n.a. – censored)

n.a. = data not available for this period. n.p. = data not published due to small cell counts. * indicates a statistically significant ($p<0.05$) difference in the mortality rate within the categories of a perinatal outcome indicator for a given age at death and study period.

Note: Rate ratio (denoted by #) represents the ratio between the computed mortality rates per 1,000 children between the 2 specified categories. For instance, the rate ratio under sex of child is the male child mortality rate divided by the female child mortality rate.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A4.3: Maternal and baby characteristics by survival status and age at death, Indigenous children, 2005–2018 combined cohort: mean values or proportion of babies (column per cent)[a]

	Perinatal outcome indicators:	Age at death (years	2005–2018 Died	2005–2018 Survived	2005–2018 Difference
Demographic					
1	Male child	<1	54.5	51.5	3.0
		0–4	55.5	51.5	4.0
2	Mother's age (mean)	<1	25.9	25.7	0.2
		0–4	25.7	25.7	0.0
3	Teenage mother (age <20) indicator	<1	19.4	15.8	3.7
		0–4	18.5	15.8	2.8
4	First pregnancy >20 weeks gestation	<1	36.9	34.9	2.0
		0–4	36.3	34.9	1.4
Pregnancy period care and risk factors					
5	Late antenatal care (1st visit >13 weeks)	<1	31.8	36.8	–5.0
		0–4	33.2	36.8	–3.6
6	Total number of antenatal visits (mean)	<1	6.8	9.5	–2.7*
		0–4	7.1	9.5	–2.4*
7	Smoked during pregnancy (at any time)	<1	49.7	44.5	5.2
		0–4	50.5	44.5	6.1*
8	Smoked during 1st half of pregnancy (2011+)	<1	46.8	39.4	7.3
		0–4	46.3	39.4	6.9*
9	Smoked during 2nd half of pregnancy (2011+)	<1	39.1	35.1	3.9
		0–4	38.3	35.1	3.2

(continued)

n.a. = not available at this time; * indicates a statistically significant ($p < 0.05$) difference on that characteristic between babies who died and babies who survived to the specified ages.

(a) The values in this table are column percentages for characteristics that are categories (such as child's being male or female) and mean value for continuous characteristics, such as mother's age.

Note: The values in the difference column (denoted with #) for categories are percentage point differences in the values in the preceding 'Died' and 'Survived' columns. For continuous variables, they represent differences in the same units as the variable of interest, such as years for age.

Table A4.3 (continued): Maternal and baby characteristics by survival status and age at death, Indigenous children, 2005–2018 combined cohort: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators:		Age at death (years	2005–2018		
			Died	Survived	Difference
Maternal health					
10	Gestational diabetes	<1	3.9	6.8	–2.9*
		0–4	3.9	6.8	–2.9*
11	Pre-existing maternal diabetes	<1	2.3	1.0	1.3*
		0–4	2.3	1.0	1.4*
12	Chronic hypertension	<1	1.6	0.8	0.8
		0–4	1.3	0.8	0.5
13	Pregnancy-induced hypertension	<1	6.7	5.8	0.9
		0–4	6.3	5.8	0.5
14	Maternal hepatitis B (2011+)	<1	0	0.4	–0.4
		0–4	0	0.4	–0.4
15	Mother transferred to another health unit on discharge	<1	9.4	3.6	5.8*
		0–4	8.9	3.6	5.3*
Conditions of birth					
16	Not a singleton birth	<1	9.7	2.7	7.0*
		0–4	8.6	2.7	5.9*
17	Gestational age (mean)	<1	32.2	38.6	–6.4*
		0–4	33.4	38.6	–2.2*
18	Birthweight (mean in grams)	<1	2043	3270	–1227*
		0–4	2237	3270	–1033*
19	Low birthweight (<2.5 kg)	<1	57.3	9.9	47.3*
		0–4	49.3	9.9	39.4*
20	Preterm birth indicator	<1	55.7	10.7	45.0*
		0–4	48.3	10.7	37.6*
21	Small for gestational age indicator	<1	18.8	14.5	4.3*
		0–4	19.1	14.5	4.6*
22	Postpartum haemorrhage requiring blood transfusion	<1	4.3	2.1	2.3*
		0–4	4.1	2.1	2.1*
23	Type of delivery: caesarean	<1	27.8	26.9	0.9
		0–4	27.5	26.9	0.6

(continued)

n.a. = not available at this time; * indicates a statistically significant ($p < 0.05$) difference on that characteristic between babies who died and babies who survived to the specified ages.

(a) The values in this table are column percentages for characteristics that are categories (such as child's being male or female) and mean value for continuous characteristics, such as mother's age.

Note: The values in the difference column (denoted with #) for categories are percentage point differences in the values in the preceding 'Died' and 'Survived' columns. For continuous variables, they represent differences in the same units as the variable of interest, such as years for age.

Table A4.3 (continued): Maternal and baby characteristics by survival status and age at death, Indigenous children, 2005–2018 combined cohort: mean values or proportion of babies (column per cent)[(a)]

Perinatal outcome indicators:		Age at death (years	2005–2018		
			Died	Survived	Difference
Baby's health					
24	APGAR score – 5 min (mean)	<1	5.9	9.0	–3.1*
		0–4	6.5	9.0	–2.5*
25	Indicator for low APGAR score (<7) at 5 minutes	<1	45.5	2.2	43.3*
		0–4	36.8	2.2	34.6*
26	Admitted to special care nursery or neonatal intensive care for 4 hours or more	<1	45.9	21.7	24.2*
		0–4	43.2	21.7	21.4*
27	Admitted to special care nursery or neonatal intensive care (for any length of time)	<1	45.1	21.6	23.5*
		0–4	42.5	21.5	20.9*
28	Baby feeding on discharge	<1	35.3	92.2	–56.9*
		0–4	43.3	92.2	–48.9*
29a	Of babies feeding on discharge: feeding on breast milk or expressed breast milk	<1	72.5	72.8	–0.4
		0–4	69.9	72.8	–3.0
29b	Of babies feeding on discharge: feeding on infant formula	<1	36.7	33.8	2.9
		0–4	37.3	33.7	3.6
Area-level socioeconomic indicators					
30a	2011 SEIFA index decile for SA2 of mother's usual residence in top 3 deciles	<1	8.1	5.8	2.3
		0–4	7.1	5.8	1.3
30b	2011 SEIFA index decile for SA2 of mother's usual residence in middle 4 deciles	<1	30.1	31.4	–1.3
		0–4	30.8	31.4	–0.6
30c	2011 SEIFA index decile for SA2 of mother's usual residence in bottom 3 deciles	<1	60.2	61.8	–1.6
		0–4	60.8	61.8	–0.9
31	IRSEO score for the SA2 of mother's usual residence (mean, higher indicates greater disadvantage)	<1	40.5	41.9	–1.4
		0–4	40.7	41.9	–1.3

n.a. = not available at this time; * indicates a statistically significant ($p < 0.05$) difference on that characteristic between babies who died and babies who survived to the specified ages.

(a) The values in this table are column percentages for characteristics that are categories (such as child's being male or female) and mean value for continuous characteristics, such as mother's age.

Note: The values in the difference column (denoted with #) for categories are percentage point differences in the values in the preceding 'Died' and 'Survived' columns. For continuous variables, they represent differences in the same units as the variable of interest, such as years for age.

Table A4.4: Estimated mortality rate (per 1,000 live births) by maternal and baby characteristics and age at death, Indigenous children, 2005–2018 combined cohort

Perinatal outcome indicators:	Age at death (years)	
	<1	0–4
1. Sex of child		
Male	5.4	6.8
Female	4.8	5.8
Rate ratio#	1.1	1.2
2. Remoteness area for mother's usual place of residence		
Major cities	6.3	7.7
Regional	4.4	5.6
Remote/Very remote	2.8	3.2
Rate ratio# (Major city vs Inner/Outer regional)	1.4*	1.4*
Rate ratio# (Remote/Very remote vs Inner/Outer regional)	0.6	0.6
Rate ratio# (Remote/Very remote vs Major city)	0.4*	0.3
3. Smoking		
Mother smoked during pregnancy (2005–2012 births) or during second half of pregnancy (2013+ births)	5.6	7.1
Mother did not smoke during pregnancy (2005–2012 births), or did not smoke during second half of pregnancy (2013+ births)	4.7	5.7
Rate ratio#	1.2	1.2*
4. Birthweight		
Low birthweight	28.8	30.8
Normal birthweight	2.4	3.6
Rate ratio#	11.8*	8.6*

(continued)

Table A4.4 (continued): Estimated mortality rate (per 1,000 live births) by maternal and baby characteristics and age at death, Indigenous children, 2005–2018 combined cohort

Perinatal outcome indicators:	Age at death (years)	
	<1	0–4
5. Preterm birth		
Preterm birth (under 37 weeks gestational age)	26.2	28.2
Full-term birth (37+ weeks gestational age)	2.6	3.7
Rate ratio#	10.3*	7.6*
6. Born small for gestational age		
Small for gestational age	6.6	8.3
Normal weight for gestational age	4.9	6.0
Rate ratio#	1.4*	1.4*
7. Non–singleton birth		
Non–singleton birth	18.3	20.1
Singleton birth	4.8	6.0
Rate ratio#	3.8*	3.4*

Note: *indicates a statistically significant ($p < 0.05$) difference in the mortality rate within the categories of a perinatal outcome indicator for a given age at death and study period.

#rate ratio represents the ratio between the computed mortality rates per 1,000 children between the 2 specified categories. For instance, the rate ratio under sex of child is the male child mortality rate divided by the female child mortality rate.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Appendix A.2 – Appendix to Chapter 5

This appendix has 3 components:

- additional discussion of the key terms and concepts behind the logistic regression models used in this report, and a guide to interpreting the different set of results from these models (boxes A5.1, A5.2 and A5.3)
- tables on the full results of the regression models that were estimated to identify factors related to child deaths in these 3 different age groups (tables A5.1 to A5.5):
  - all deaths under age 1
  - deaths under age 1, excluding deaths that occur in the first 7 days after birth
  - deaths between ages 1 to 4 (before reaching age 5, among babies who survived to age 1)
- charts of the frequency distribution of age at death in days, for all deaths under age 1 (figures A5.1 and A5.2).

Guide to key terms and concepts related to logit regression models

Regression analyses estimate a statistical relationship between an outcome (or response) variable and a set of explanatory variables that help to predict the level of that outcome. When the outcome of interest is discrete, such as whether a particular child has survived to age 1 or not, a special type of regression analysis – called logistic regression – is the commonly used statistical approach (Long and Freese 2014). The logit regression model has alternative ways to estimate the role of the explanatory variables in contributing to that outcome (that is, the statistical significance and relative importance of that variable in contributing to the risk of a child's dying before age 1).

This chapter presents 2 types of logistic regression results that are commonly used:

1. estimated odds ratios (ORs) associated with a specific characteristic included in the model (perinatal characteristics or area-level indicators for the usual residence of the mother when giving birth)
2. estimated 'marginal effects' on the risk of dying that are associated with changes in each of the characteristics included in the model.

See also Box A5.1 for more information.

The multivariate regression analyses for this report were mainly carried out using the STATA statistical package (version 17). The 'marginal effects' estimates are derived from the post estimation 'margins, dy/dx (*)' command in STATA following the logit regression procedure.

Box A5.1: Logistic regression modelling: key terms and concepts

Odds: A measure of the likelihood of a particular outcome (for example, death before age 1) occurring in a reference population. Odds are calculated as the ratio of the number of events associated with the outcome (for example, died before age 1) to the number of events that are not associated with the outcome (survived to age 1).

Odds ratio (OR): The ratio of the odds of an outcome's occurring in one population subgroup (for example, death before age 1 among male babies) compared with the odds of that outcome's occurring in a separate group (or reference group) (for example, death before age 1 among female babies).

Risk ratio (RR): The ratio of the actual probability of an outcome's occurring in one population group (for example, deaths before age 1 among male babies) compared with the probability of that outcome's occurring in a separate group (for example, deaths before age 1 among female babies).

Odds ratios are closely related to risk ratios, but they are not the same statistical concept. Usually, risk ratios are the key statistical inference of interest

> ORs and RRs are related though the formulas:
>
> OR = RR times Adjustment factor, *where the*
>
> Adjustment factor = (1 minus the probability of the event's occurring in one group) divided by (1 minus the probability of the event's occurring in the other group).

For events that occur rarely, such as deaths in a birth cohort, the Adjustment factor related to the ratio of '1 minus the probability of the event's' occurring in 2 different groups will be close to a value of 1. In these instances, the computed odds ratio will be around the same value as the risk ratio (ratio of the probability of the event) in the 2 groups.

A common rule of thumb is that, when the outcome being studied (for example, death before age 1 or death between ages 1 to 4, as in this study) is rare enough to occur at less than 10% in both groups, the odds ratio can be treated as being approximately equivalent to the risk ratio. In such cases, the odds ratios closely reflect the actual probability of how much more likely the outcome being studied occurs in one group than in the other group (Ranganathan et al. 2015).

Odds ratios are the more common way to present the main results of logistic regression analyses, even though the marginal effects of the regression variables (the change in the probability of the child's dying associated with a change in one of the characteristics of the child or of the birth mother, which have also been computed in this study) is the more intuitive concept of interest.

This is mainly because the estimates of ORs in a logistic regression are uniquely determined and do not depend on the level of the other variables used in the estimation model, whereas the estimates of the marginal effects are not unique and depend on the level of that variable as well as the level of other variables used in the estimation model.

See also Box A5.3 for further details on the 'marginal effects' estimation from a logistic regression.

Box A5.2: Logistic regression modelling: interpreting odds ratio estimates

A key statistical inference from logistic regression models is testing whether the estimated odds ratio for a variable used in the model is significantly higher or lower than a value of 1:

- An odds ratio that is greater than 1 means that the associated variable or characteristic increases the odds of the outcome's (child death) occurring.
- An odds ratio less than 1 means that the associated variable or characteristic decreases the odds of the outcome's occurring.
- An odds ratio close to or equal to 1 means that the associated variable or characteristic (for example, baby's sex or mother's age at giving birth) has little or no effect on the odds of the outcome's occurring that is being studied (child death).

Standard statistical procedures are applied to test if the estimated odds ratio for each variable or characteristic included in the regression model is statistically significantly higher than 1 or significantly less than 1, or no different from 1.

All the odds ratio results in this report are technically adjusted odds ratios, in that they are odds ratios estimated in a multivariate modelling framework that includes other risk factors in addition to the specific factor with an associated odds ratio estimate of interest.

Some authors use the simpler form of 'odds ratio' to apply only to estimates derived from univariate logistic regression models where only 1 factor or variable is included in the estimated model. Since this report does not present any estimates of the odds ratios from a univariate model, for the sake of simplicity, all multivariate or adjusted odds ratio estimates are referred to simply as 'odds ratios' in this report.

Box A5.3: Logistic regression modelling: What are marginal effects?

Logistic regression can also directly estimate the difference in the probability of an outcome (for example, dying before a specific age) between 2 groups, say between male and female babies. The estimated difference in the sub-group probabilities is the 'marginal effect' of sex.

'Marginal effects' estimates, which are in the units of the change in the probability of observing the outcome being analysed, are the more intuitive aspect of logit regression results. However, the estimates of marginal effects (of either categorical or continuous variables) are not uniquely determined. Their values depend on the actual values of the variables included in the estimated model, such as mother's age or baby's birthweight.

The estimated marginal effects in tables A5.2 are calculated by the conventional approach of averaging the marginal effects over all observations in the data set used to estimate the regression model. The units in this table are percentage point changes in the probability of dying, multiplied by 10 (which is equivalent to measuring the extra number of deaths that would occur in a reference population of 1,000 children). The marginal effects as percentage point changes are very low values close to zero, hence the times 10 adjustment.

The test of statistical significance for the marginal effect is a test for its value's being different from zero (in contrast to the test for odds ratio estimates being significantly different from 1).

A positive value of the marginal effect that is significantly different from zero indicates that variable (or category within a variable) will increase the probability of dying. A negative value of the marginal effect that is significantly different from zero indicates that variable (or category) will decrease the probability of dying.

Another reason for deriving the marginal effects is that the absolute size of the change in probability reflected by the marginal effects estimate is a convenient basis for ranking the relative importance of the explanatory variables.

Guide to presentation of the full regression results

The full regression results from the chapter 5 analyses are presented in tables A5.1 to A5.5. These tables use asterisks (*) and colour coding to identify which of the variables used (or which specific category within a variable, such as a specific age group among several age groups) is a significant risk or protective factor.

Asterisks denote whether an estimated odds ratio is statistically significantly different from 1 in any direction (either increasing or decreasing the odds of dying under age 1, when compared to the children in the reference category).

Statistically significant differences at the 1% test level (marked with a double asterisk, **, in these tables) are a more robust result than significant differences at the 5% test level (marked with a single asterisk, *).

The colour scheme used in Table A5.1 and other tables that follow indicates the direction of the statistically significant effect:

- variables in orange-shaded cells are statistically significant *risk factors* that increase the odds of dying (they have odds ratios greater than 1 at least at the 5% test level)
- variables in green-shaded cells are statistically significant *protective factors* that reduce the odds of dying (with odds ratios less than 1 at least at the 5% test level).

A significance test level of 1% corresponds to a 99% confidence interval around the estimated odds ratio value. A significance test level of 5% corresponds to a 95% confidence interval.

Table A5.1: Estimated odds ratios for risk of dying under age 1: all children by birth cohort periods (cohort birth year) and model type (with and without area-level socioeconomic status variables)

	2005–2010		2011–2014		2015–2018	
	Model type		Model type		Model type	
Risk factor	PDC + Area-level	PDC only	PDC + Area-level	PDC only	PDC + Area-level	PDC only
Demographic and geographic variables						
Mother was a teenager at time of giving birth (age 19 or under) (vs age 26–30)	1.54**	1.57**	1.44*	1.46*	1.74*	1.74*
Mother was aged 20–25 at time of giving birth (vs age 26–30)	1.22*	1.23*	1.18	1.20	1.21	1.21
Mother was aged 31–35 at time of giving birth (vs age 26–30)	1.14	1.10	0.95	0.94	1.19	1.18
Mother was aged 36+ at time of giving birth (vs age 26–30)	1.02	0.97	1.07	1.04	1.19	1.18
Mother lived in a remote area at time of giving birth (vs regional area)	0.59	0.57	0.41	0.42	0.75	0.75
Mother lived in a major city at time of giving birth (vs regional area)	1.14	1.05	0.91	0.88	0.97	0.96
Indigenous baby (based on mother's or baby's Indigenous status)	1.77**	1.75**	1.52**	1.55**	1.09	1.09
Variables present at onset of pregnancy						
Mother pre-existing diabetes	0.95	0.98	0.56	0.57	1.44	1.45
Mother chronic hypertension	0.95	0.96	1.22	1.25	1.35	1.36
First pregnancy greater than 20 weeks gestation	1.01	0.98	0.81**	0.81**	0.91	0.91
Variables arising during pregnancy						
Male baby	1.18*	1.18*	1.18*	1.18*	1.05	1.05
Late antenatal care visit (after 13 weeks gestation) (vs on-time visit by 13 weeks	1.09	1.09	0.98	0.99	1.03	1.03
No antenatal care received (vs on-time visit by 13 weeks)	0.61	0.62	1.08	1.10	0.69	0.70
Antenatal care status not stated (vs on-time visit by 13 weeks)	1.45	1.48	1.19	1.20	0.62	0.63

(continued)

Table A5.1 (continued): Estimated odds ratios for risk of dying under age 1: all children by birth cohort periods (cohort birth year) and model type (with and without area-level socioeconomic status variables)

Risk factor	2005–2010		2011–2014		2015–2018	
	Model type		Model type		Model type	
	PDC + Area-level	PDC only	PDC + Area-level	PDC only	PDC + Area-level	PDC only
Mother smoked during pregnancy (2005–2012 births) or during second half of pregnancy (2013+ births)	1.12	1.16	0.88	0.88	1.02	1.02
Non singleton birth	0.86	0.85	0.80	0.81	0.69	0.69
Variables determined at the end of pregnancy						
Preterm birth <32 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	211.06**	216.37**	280.21**	283.35**	267.72**	268.81**
Preterm birth 32–36 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	4.83**	4.87**	4.58**	4.58**	4.85**	4.86**
Baby small for gestational age	2.72**	2.74**	2.74**	2.75**	2.56**	2.57**
Caesarean delivery (full-term birth) (vs vaginal delivery full-term baby)	1.28*	1.28*	1.97**	1.97**	1.33*	1.33*
Postpartum haemorrhage requiring a blood transfusion	1.45	1.43	1.64**	1.65**	2.65**	2.64**
Interaction effects						
Preterm (<32 weeks)*caesarean delivery interaction	0.28**	0.27**	0.14**	0.14**	0.19**	0.19**
Preterm (32-36 weeks)*caesarean delivery interaction	1.33	1.32	1.06	1.06	1.17	1.17
Non singleton*caesarean delivery interaction	0.38**	0.38**	0.51**	0.50**	0.80	0.80
Area-level variables						
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (vs highest 3 deciles)	1.22*	n.a.	1.07	n.a.	1.06	n.a.
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (vs highest 3 deciles)	1.46**	n.a.	1.11	n.a.	1.02	n.a.
Percentage of children vulnerable on one or more AEDC domain in mother's SA2 of usual residence	0.99	n.a.	1.00	n.a.	1.00	n.a.
Estimation sample – total observations	409,593	411,789	379,380	381,128	367,696	369,240
of which number of deaths	994	999	855	858	643	643

n.a. = not applicable; ** indicates significantly different from 1 at 1% test significance level and * indicates significantly different from 1 at the 5% test significance level.

🟩	Statistically significant protective factors (with odds ratios less than 1) at least at the 5% test level.
🟧	Statistically significant risk factors (with odds ratios greater than 1) at least at the 5% test level.
⬜	Risk factors that are not statistically significant at the 5% test level.

Table A5.2: Selected estimated marginal effects on the probability of a baby's dying under age 1 among all NSW-born babies, 2005 to 2018 cohorts by 3 time periods

Units are percentage points increase/decrease multiplied by 10, which corresponds to change in the number of deaths per 1,000 children.

Risk factor	2005–2010	2011–2014	2015–2018
	Marginal effect *1,000	Marginal effect *1,000	Marginal effect *1,000
Demographic and geographic variables			
Mother was a teenager at time of giving birth aged (age 19 or under) (vs age 26–30)	1.07*	0.88	1.04*
Mother aged was aged 20–25 at time of giving birth (vs age 26–30)	0.44	0.37	0.30
Mother was aged 31–35 at time of giving birth (vs age 26–30)	0.29	–0.11	0.27
Mother was aged 36+ years at time of giving birth (vs age 26–30)	0.05	0.14	0.27
Mother lived in a remote area at time of giving birth (vs regional area)	–0.96	–1.30*	–0.42
Mother lived in a major city at time of giving birth (vs regional area)	0.29	–0.20	–0.06
Indigenous baby (based on mother's or baby's Indigenous status)	1.61**	1.03**	0.15
Variables present at onset of pregnancy			
Mother pre-existing diabetes	–0.10	–0.96	0.70
Mother chronic hypertension	–0.12	0.46	0.57
First pregnancy greater than 20 weeks gestation	0.01	–0.43**	–0.15
Variables arising during pregnancy			
Male baby	0.38*	0.35*	0.08
Late antenatal care visit (after 13 weeks gestation) (vs on-time visit by 13 weeks)	0.20	–0.04	0.06
No antenatal care received^^ (vs on-time visit by 13 weeks)	–0.89*	0.17	–0.51
Antenatal care status not stated (vs on-time visit by 13 weeks)	0.98	0.40	–0.63
Mother smoked during pregnancy (2005–2012 births) or during second half of pregnancy (2013+ births)	0.27	–0.26	0.03

(continued)

Table A5.2 (continued): Selected estimated marginal effects on the probability of a baby's dying under age 1 among all NSW-born babies, 2005 to 2018 cohorts by 3 time periods

Risk factor	2005–2010 Marginal effect *1,000	2011–2014 Marginal effect *1,000	2015–2018 Marginal effect *1,000
Variables determined at the end of pregnancy			
Baby small for gestational age	3.14**	2.96**	2.13**
Mother had postpartum haemorrhage requiring blood transfusion	0.99	1.28*	2.49**
Preterm birth <32 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	173.74**	177.37**	154.16**
Preterm birth 32–36 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	4.01**	2.87**	2.70**
Preterm birth <32 weeks gestational age (caesarean delivery) (vs full-term, caesarean delivery birth)	64.16**	53.18**	43.44**
Preterm birth 32–36 weeks gestational age (caesarean delivery) (vs full-term, caesarean delivery birth)	6.55**	5.69**	4.25**
Caesarean birth, in combination with:			
– preterm birth <32 weeks (vs vaginal delivery <32 weeks preterm birth)	–111.81**	–122.49**	–106.36**
– preterm birth 32–36 weeks (vs vaginal delivery 32–36 weeks preterm birth)	2.44*	3.21**	1.66
– full–term birth (vs vaginal delivery full-term birth)	0.28*	0.76**	0.23*
– non-singleton birth (vs vaginal delivery non-singleton birth)	–12.09**	–10.94**	–7.42**
– singleton birth (vs vaginal delivery singleton birth)	–0.31	0.01	–0.47**
Area-level variables			
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (vs highest 3 deciles)	0.40*	0.15	0.10
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (vs highest 3 deciles)	0.84**	0.22	0.03
Percentage of children vulnerable on one or more AEDC domain in mother's SA2 of usual residence	–0.02	0.01	0.00
Estimation sample – total observations	409,593	379,380	367,696
of which number of deaths	994	855	643

** indicates significantly different from 0 at 1% test significance level and * indicates significantly different from 0 at the 5% test significance level.

^^This is a change in the marginal effects estimate being statistically significant while the odds ratio effect was not. The significantly protective marginal effect of 'No antenatal care received' category observed only in period 1 is not reliable estimate. This results can be caused by the very small number of babies whose mothers did not receive antenatal care.

🟩	Statistically significant protective factors (with marginal effect greater than 0) at least at the 5% test level.
🟧	Statistically significant risk factors (with marginal effect less than 0) at least at the 5% test level.
⬜	Risk factors that are not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A5.3: Estimated odds ratios for the risk of dying under age 1, excluding deaths under 7 days, all children by birth cohort periods

Risk factor	2005–2010	2011–2014	2015–2018
	PDC + Area-level	PDC + Area-level	PDC + Area-level
Demographic and geographic variables			
Mother was a teenager at time of giving birth (age 19 or under) (vs age 26–30)	2.26**	2.17**	1.89*
Mother was aged 20–25 at time of giving birth (vs age 26–30)	1.51**	1.43*	1.09
Mother was aged 31–35 at time of giving birth (vs age 26–30)	1.03	0.97	1.00
Mother was aged 36+ at time of giving birth (vs age 26–30)	0.98	1.00	0.95
Mother lived in a remote area at time of giving birth (vs regional area)	0.61	0.46	0.61
Mother lived in a major city at time of giving birth (vs regional area)	1.40**	0.92	0.87
Indigenous baby (based on mother's or baby's Indigenous status)	1.58**	1.41*	1.42
Variables present at onset of pregnancy			
Mother pre-existing diabetes	1.15	0.35	1.32
Mother chronic hypertension	1.08	1.99*	1.58
First pregnancy greater than 20 weeks gestation	0.80*	0.78*	0.86
Variables arising during pregnancy			
Male baby	1.21*	1.19	0.97
Late antenatal care visit (after 13 weeks gestation) (vs on-time visit by 13 weeks)	1.18	1.24*	1.12
No antenatal care received (vs on-time visit by 13 weeks)	0.90	1.85	0.33
Antenatal care status not stated (vs on-time visit by 13 weeks)	2.02*	0.62	n.a.
Mother smoked during pregnancy (2005–2012 births) or during second half of pregnancy (2013+ births)	1.72**	1.30	1.53*
Non singleton birth	0.85	0.62	1.01

(continued)

Table A5.3 (continued): Estimated odds ratios for the risk of dying under age 1, excluding deaths under 7 days, all children by birth cohort periods

	2005–2010	2011–2014	2015–2018
Risk factor	PDC + Area-level	PDC + Area-level	PDC + Area-level
Variables determined at the end of pregnancy			
Preterm birth <32 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	31.65**	34.74**	40.42**
Preterm birth 32–36 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	3.61**	3.26**	3.40**
Baby small for gestational age	2.77**	3.05**	2.23**
Caesarean delivery (full-term birth) (vs vaginal delivery full-term baby)	1.34*	1.79**	1.32
Postpartum haemorrhage requiring a blood transfusion	0.88	0.83	1.33
Interaction effects			
Preterm (<32 weeks)*caesarean delivery interaction	1.02	0.59	0.85
Preterm (32–36 weeks)*caesarean delivery interaction	1.35	1.08	1.59
Non singleton*caesarean delivery interaction	0.36*	0.36	0.56
Area-level variables			
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (vs highest 3 deciles)	1.23	0.97	0.94
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (vs highest 3 deciles)	1.68**	1.20	0.90
Percentage of children vulnerable on one or more AEDC domain in mother's SA2 of usual residence	0.99	1.00	1.03*
Estimation sample – total observations	409,593	379,380	366,194
of which number of deaths	470	390	307

n.a. = data not available for this period; ** indicates significantly different from 1 at 1% test significance level and * indicates significantly different from 1 at the 5% test significance level.

🟩	Statistically significant protective factors (with odds ratios less than 1) at least at the 5% test level.
🟧	Statistically significant risk factors (with odds ratios greater than 1) at least at the 5% test level.
☐	Risk factors that are not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Table A5.4: Estimated odds ratios for the risk of dying between ages 1 to 4: all children by model type (with and without area-level variables), all birth cohorts combined, 2005 to 2018(a)

Risk factor	Model type	
	PDC + Area-level	PDC only
Demographic and geographic variables		
Mother was a teenager at time of giving birth (age 19 or under) (vs age 26–30)	1.25	1.30
Mother was aged 20–25 at time of giving birth (vs age 26–30)	1.38*	1.42**
Mother was aged 31–35 at time of giving birth (vs age 26–30)	0.79	0.78
Mother was aged 36+ at time of giving birth (vs age 26–30)	1.01	0.97
Mother lived in a remote area at time of giving birth (vs regional area)	0.79	0.90
Mother lived in a major city at time of giving birth (vs regional area)	1.04	1.00
Indigenous baby (based on mother's or baby's Indigenous status)	2.25**	2.29**
Variables present at onset of pregnancy		
Mother pre-existing diabetes	0.84	0.86
Mother chronic hypertension	1.45	1.46
First pregnancy greater than 20 weeks gestation	0.85	0.83
Variables arising during pregnancy		
Male baby	1.32**	1.34**
Late antenatal care visit (after 13 weeks gestation) or antenatal care not received (vs on-time visit by 13 weeks)	1.04	1.05
Antenatal care status not stated (vs on-time visit by 13 weeks)	1.53	1.52
Mother smoked during pregnancy (2005–2012 births) or during second half of pregnancy (2013+ births)	1.33*	1.35*
Non-singleton birth	1.11	1.09
Variables determined at the end of pregnancy		
Preterm birth <32 weeks gestational age (vs full-term birth)	1.22	1.23
Preterm birth 32–36 weeks gestational age (vs full-term birth)	1.35	1.34
Baby small for gestational age	1.66**	1.70**
Caesarean delivery (vs vaginal delivery baby)	1.01	1.03
Postpartum haemorrhage requiring a blood transfusion	0.75	0.75
Area-level variables		
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (vs highest 3 deciles)	1.07	n.a.
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (vs highest 3 deciles)	1.02	n.a.
Percentage of children vulnerable on one or more AEDC domain in mother's SA2 of usual residence	1.02	n.a.
Estimation sample – total observations	787,124	791,060
of which number of deaths	432	436

n.a. = not applicable; ** indicates significantly different from 1 at 1% test significance level and * indicates significantly different from 1 at the 5% test significance level.

(a) Estimation is done among all children who have survived to age 1 and then either died before reaching age 5 or survived to age 5 years. In the data linkage for this project, death records were matched to the end December 2019. Those born in 2015 and later cannot be classified as having survived to age 5 and are excluded from the data (i.e., they are 'censored observations' for which the data on survival to age 60 months are incomplete).

🟩 Statistically significant protective factors (with estimated odds ratios less than 1) at least at the 5% test level,

🟧 Statistically significant risk factors (with estimated odds ratios greater than 1) at least at the 5% test level.

⬜ Risk factors that are not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Figure A5.1: Frequency distribution of age at death in days (%), all deaths under age 1, all births 2005 to 2018

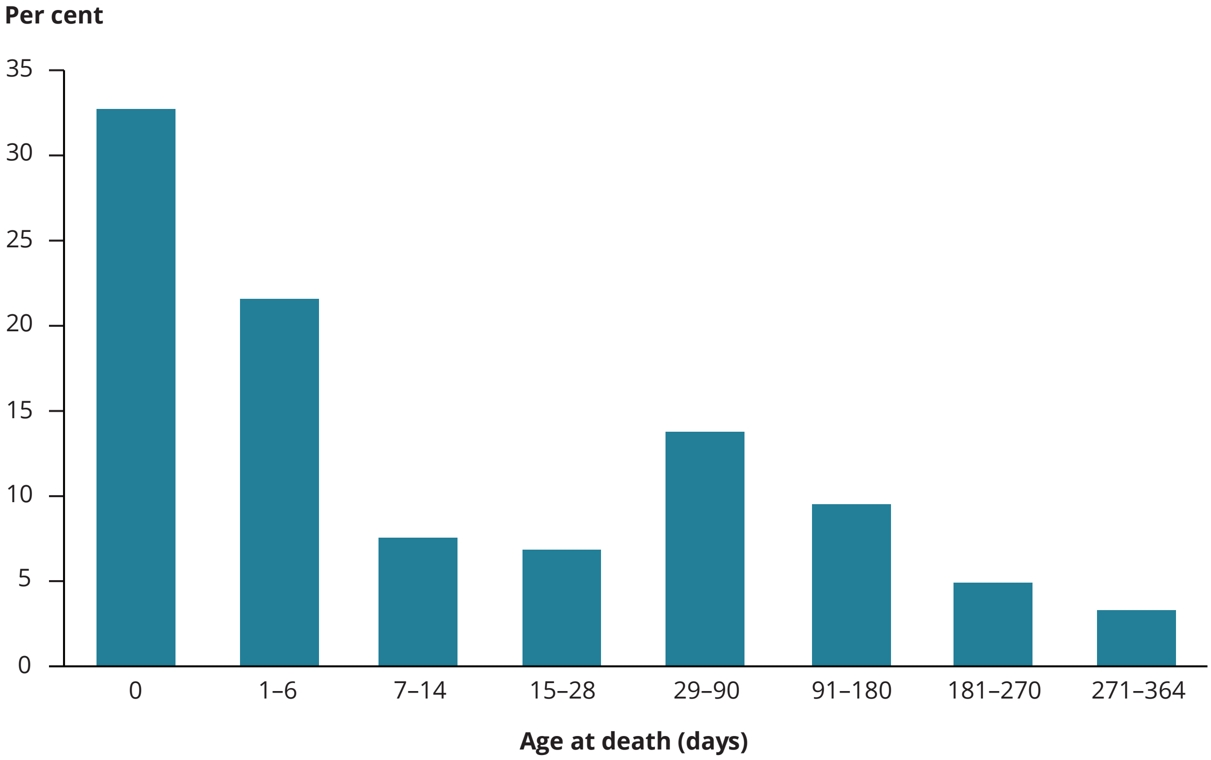
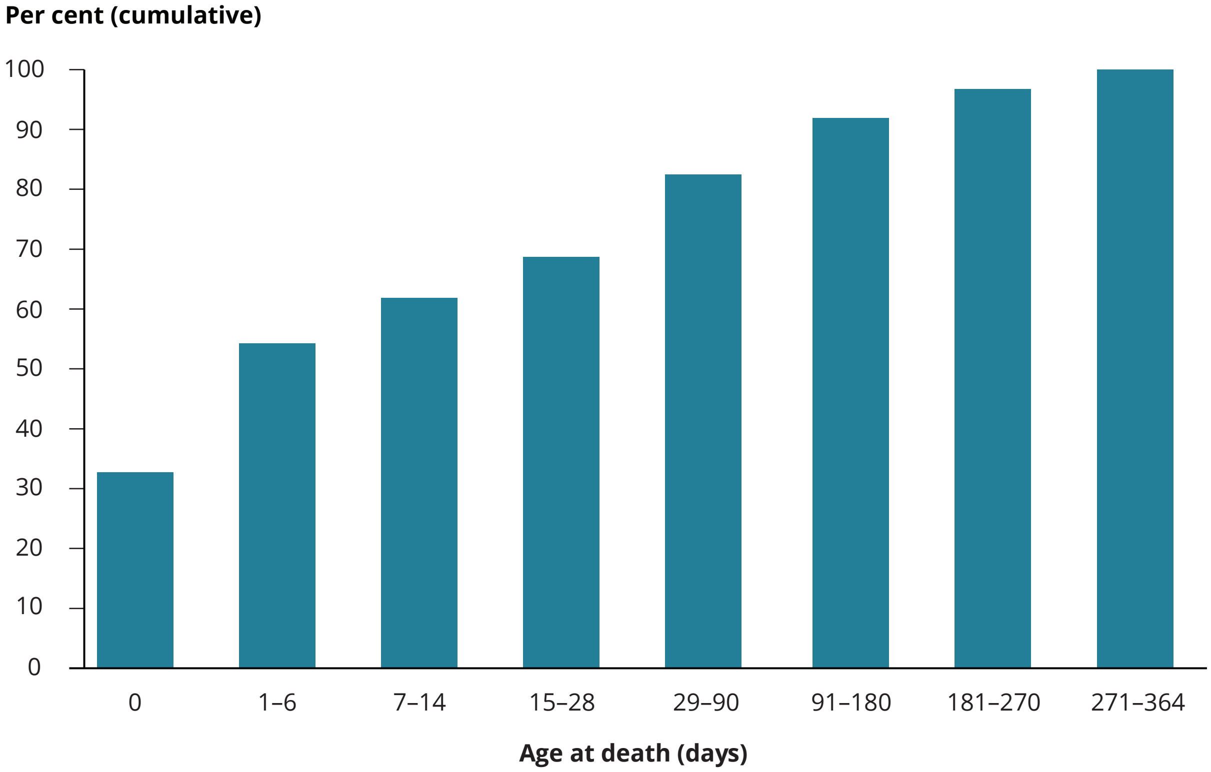


Figure A5.2: Cumulative distribution of age at death in days (cumulative %), all deaths under age 1, all births 2005 to 2018



Appendix A.3 – Appendix to Chapter 6

This appendix contains a set of tables on the full regression model results that were estimated to identify factors related to Indigenous child death under age 1 (Table A6.1). The related marginal effects estimates of these same factors are not reported due to small sample size concerns for Indigenous child death under age 1.

Table A6.1 uses the same approach as in the appendix tables for chapter 5, based on using both asterisks (*) and colour coding to identify which of the variables used (or which specific category within a variable) is a significant risk or protective factor.

See Appendix A.2, which has a guide to presentation of the full regression results in tables A5.1 to A5.5, for more details on how to read the results in table A6.1 in this appendix.

Table A6.1: Estimated odds ratios for the risk of dying under age 1: Indigenous children by model type (with and without area-level variables), all birth cohorts combined, 2005 to 2018

Risk factor	Model type	
	PDC + Area-level	PDC only
Demographic and geographic variables		
Time period: birth cohorts 2012–2018 (vs 2005–2011)	0.55**	0.55**
Mother was a teenager at time of giving birth (age 19 or under) (vs age 26–30)	1.57*	1.57*
Mother was aged 20–25 at time of giving birth (vs age 26–30)	1.26	1.26
Mother was aged 31–35 at time of giving birth (vs age 26–30	1.05	1.06
Mother was aged 36+ at time of giving birth (vs age 26–30)	1.54	1.57
Mother lived in a remote area at time of giving birth (vs regional area)	0.41	0.43
Mother lived in a major city at time of giving birth (vs regional area)	1.40*	1.38*
Variables present at onset of pregnancy		
Mother pre-existing diabetes	1.43	1.43
Mother chronic hypertension	1.47	1.44
First pregnancy greater than 20 weeks gestation	0.81	0.82
Variables arising during pregnancy		
Male baby	0.98	0.98
Late antenatal care visit (after 13 weeks gestation) or antenatal care not received (vs on-time visit by 13 weeks)	0.77	0.78
Antenatal care status not stated (vs on-time visit by 13 weeks)	1.50	1.52
Mother smoked during pregnancy (2005–2012 births) or during second half of pregnancy (2013+ births)	0.70	0.70
Non singleton birth	0.89	0.90
Variables determined at the end of pregnancy		
Preterm birth <32 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	102.85**	103.28**
Preterm birth 32–36 weeks gestational age (vaginal delivery) (vs full-term, vaginal delivery birth)	2.29**	2.28**
Baby small for gestational age	2.03**	2.03**
Caesarean delivery (full-term birth) (vs vaginal delivery full-term baby)	1.01	1.01
Postpartum haemorrhage requiring a blood transfusion	1.53	1.52
Interaction effects		
Preterm (<32 weeks)*caesarean delivery interaction	0.23**	0.22**
Preterm (32-36 weeks)*caesarean delivery interaction	1.87	1.87
Birth cohorts 2012–2018*mother smoked during pregnancy interaction	1.29	1.29
Area-level variables		
SEIFA index of mother's SA2 of usual residence in lowest 3 deciles (vs highest 3 deciles)	0.70	n.a.
SEIFA index of mother's SA2 of usual residence in middle 4 deciles (vs highest 3 deciles)	0.72	n.a.
IRSEO score category: lowest 3 deciles (vs highest 3 deciles)	1.06	n.a.
IRSEO score category: middle 4 deciles (vs highest 3 deciles)	1.14	n.a.
Estimation sample – total observations	55,555	55,560
of which number of deaths	262	262

n.a. = not applicable; ** indicates significantly different from 1 at 1% test significance level and * indicates significantly different from 1 at the 5% test significance level.

🟩	Statistically significant protective factors (with estimated odds ratios less than 1) at least at the 5% test level,
🟧	Statistically significant risk factors (with estimated odds ratios greater than 1) at least at the 5% test level.
⬜	Risk factors that are not statistically significant at the 5% test level.

Source: AIHW analyses of the Linked NSW Perinatal and Deaths data.

Appendix B – Summary of data linkage processes and outcomes

This project involved obtaining and linking data from the following 4 main data sources:

1. NSW PDC for the period 2005–2018
2. NSW BRC for the period 2005–2018
3. NSW CDRT child death data collection 2005–2019
4. AIHW NDI for the period 2005–2019.

There were 2 steps in the data linkage of these sources above:

- Step 1: identify the full cohort of babies born in New South Wales between 2005 and 2018 by linking source 1 and 2.
- Step 2: identify which of these babies had died by the end of 2019 by linking their birth cohort records to death records.

The AIHW HDLU carried out both parts of these linkages.

In addition, some selected area-level indicators on the average socioeconomic status of the SA2 of the mother's usual place of residence at the time of giving birth, were derived from:

5. the SEIFA indices, developed by the ABS from the periodic censuses, that rank areas in Australia according to the average level of relative socioeconomic advantage or disadvantage of all individuals living in that area (ABS 2013)
6. the AEDC collection managed by the Australian Government Department of Education, which contains assessments of child development vulnerabilities in 5 test domains when children begin their first full year of schooling (DET 2019, 2022)
7. The IRSEO index developed in Biddle (2013). The IRSEO is an Indigenous-specific index of socioeconomic factors that reflect the average level of socioeconomic advantage or disadvantage experienced on average among Indigenous Australians living in a particular area.

The Step 1 data linkage process related to data sources 1 to 4 was completed by the AIHW Data Linkage Unit (HDLU) in May 2021. The subsequent addition of variables to the linked data from data sources 5 to 7 was done by the project study team. The area-level data from these sources were added to the individual birth cohort linked data based on the usual place of residence of the mother as defined at the SA2 level geography in the PDC.

Study cohort

The study population of NSW-born babies was created by the AIHW HDLU by linking the PDC data set for 2005–2018 to the NSW BRC data set for 2005–2018.

The NSW BRC records used for this study consist of all babies born during 2005–2018 and registered with the NSW Registrar General. Each record contains the mother's, father's and the baby's full names; date of birth; address; state and postcode. There were 1,336,126 records.

The PDC records used for this study contain information on mothers who gave birth between 2005 and 2018 and their babies. Each record contains the mother's and their baby's full names, date of birth, address, state and postcode. The PDC data extract provided by NSW Health to the AIHW consisted only of live births during 2005 and 2018. There were 1,338,145 records in total.

To create the final cohort, the AIHW HDLU linked the PDC data set to the BRC data set. The union of these 2 data sets formed the full study cohort (or spine for data linkage for this project). It consisted of 1,393,488 unique records of babies born in New South Wales between 2005 and 2018. (See Figure B1.)

The final analyses in this report are based on a slightly lower unique record of babies born in New South Wales (1,337,341) for whom there was a valid perinatal record because the main components of the analyses in this report use data on the characteristics of the mother and baby from the PDC. Also excluded from the analyses are the very few records of babies who did not have the full details on date of birth and age at death in the linked data, which meant that an accurate age at death could not be computed for them.

The distribution of this final 1,337,341 PDC-based cohort of babies analysed in this report, by year of birth, was shown in Table 2.1 in chapter 2.

Summary of data linkage to identify babies who died

The Step 2 linkage was the main linkage task carried out for this project. The objective of this step was to identify which of the NSW-born babies, recorded in either or both of the PDC and BRC records from Step 1, had died by the end of 2019 by linking their personal identifier variables with the personal identifier variables found in the death records of either the NDI or the CDRT Register of Deaths.

The NDI is an administrative collection managed by the AIHW. It was the main data source used to identify which of the NSW-born children had died by the end of December 2019.

The NDI contains records of all deaths registered in Australia since 1980. Data come from the Registrars of Births, Deaths and Marriages in each jurisdiction; the National Coronial Information System; and the ABS; and it is updated frequently.

NDI linkage

The linkage with the NDI identified 5,312 record pairs between the PDC–BRC birth cohorts and deaths recorded in the NDI, no matter in which jurisdiction that death was recorded.

CDRT linkage

The NSW CDRT provided its administrative data set on deaths of children in New South Wales up to age 17 registered between 2005 and 2019. This data set had 8,307 unique personal records of deaths.

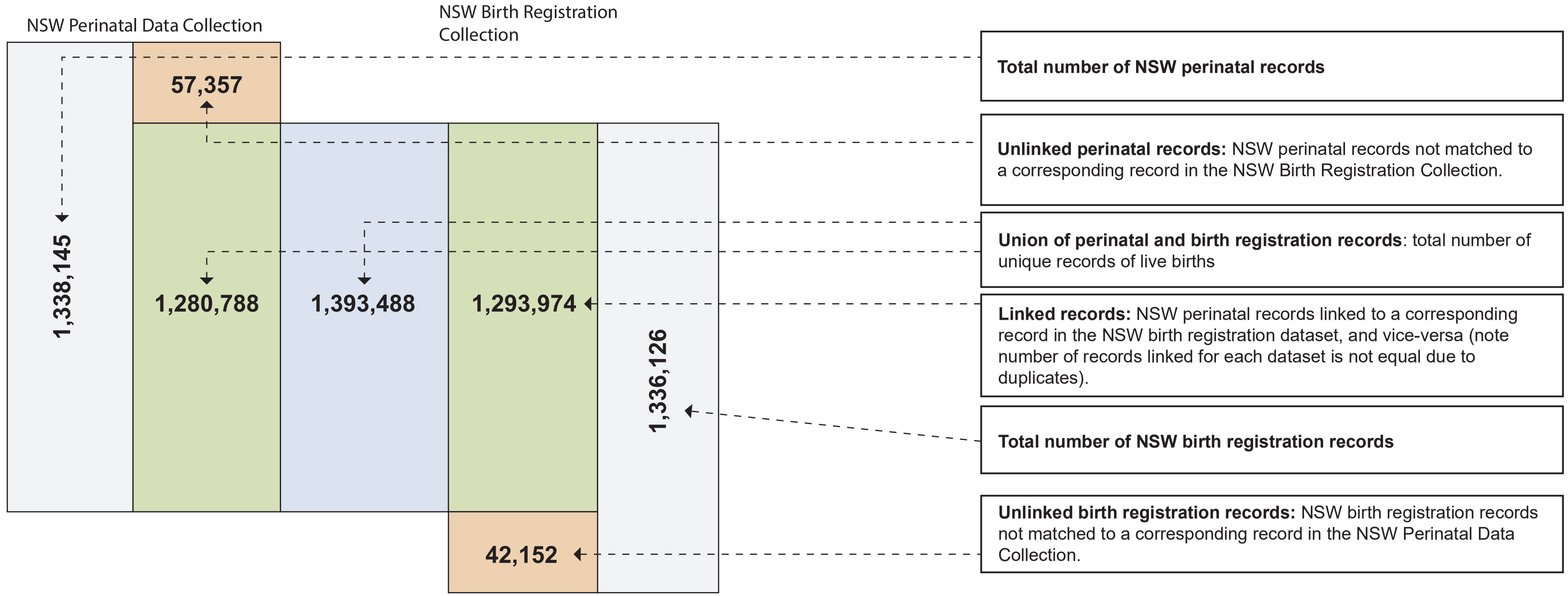
As the scope of the birth cohorts being analysed for this project consists of NSW babies born between 2005 and 2018, only 4,987 of the CDRT records were associated with a NSW BRC–PDC baby born during this period.

There were around 6,260 deaths recorded in the CDRT for individuals born in 2005–2018, but not all of them would have been born in New South Wales. The groups of children missing from the CDRT PDC–BRC linkage would be children born overseas, or born in other jurisdictions but whose deaths were registered in New South Wales.

The steps and counts of children involved in linking to the child death records are outlined in Figure B2 (which is the same as Figure 2.1 in chapter 2).

Adjustments to the number of deaths in the linked data that are included in this study relate to several factors, including that only deaths among babies that have a link to a PDC record and a valid computation of the exact age at death are relevant for this study. These adjustments reduce the final number of deaths in the linked data among the 2005 to 2018 birth cohorts to 4,057 (Figure B2); and of these 3,715 were under age 5 (Table 2.1).

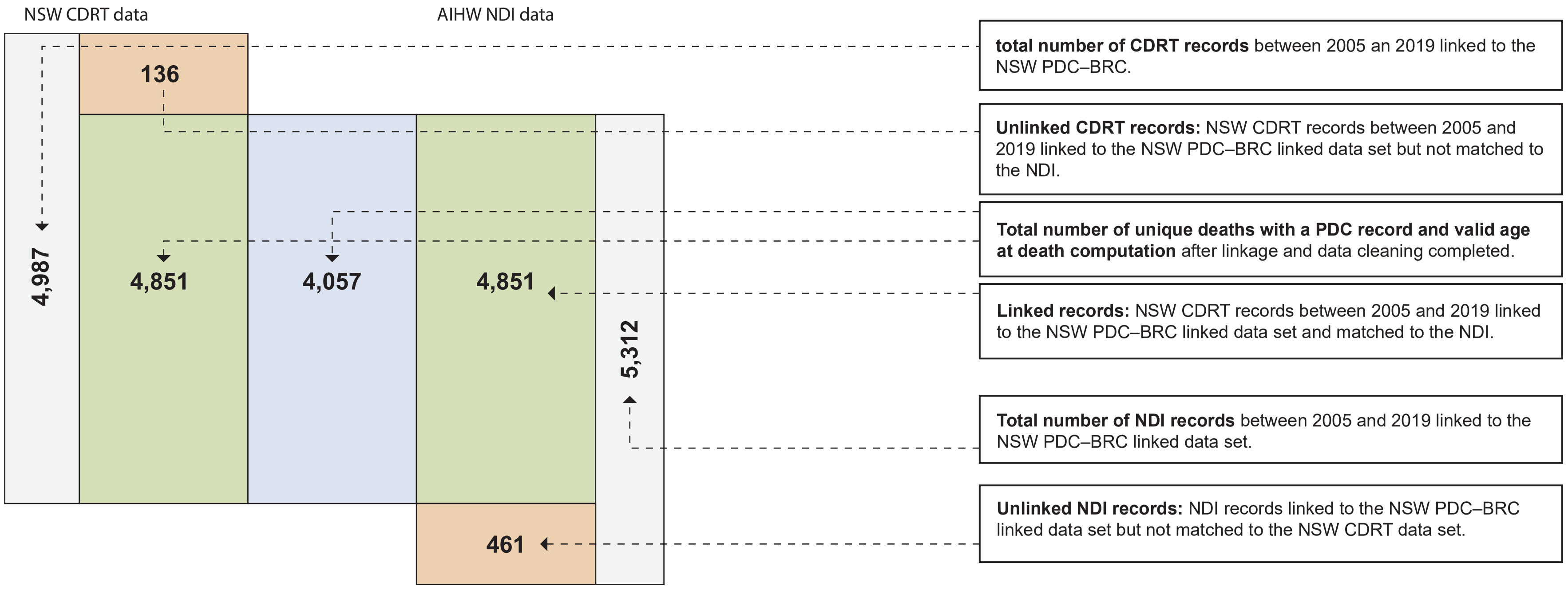
Figure B1: Linkage of NSW perinatal (PDC) and birth registrations (BRC) records, all live births in 2005 to 2018



Note: Diagram is not drawn to scale.

Source: Linked Perinatal and Births data set.

Figure B2: Linkage of NSW CDRT and NDI records to the NSW PDC–BRC based birth cohorts of 2005 to 2018



Note: Diagram is not drawn to scale.

Source: Linked Perinatal, Births, CDRT and NDI data set.

Summary of data linkage algorithm

The data linkage method used by the AIHW HDLU was name-based probabilistic linkage. In this approach, the linkage of records in 2 files is based on the probabilities of agreement and disagreement between the set of the linkage variables. Probabilistic linkage allows for some variation in the reporting of the linkage variables, including variations in the full name and the way it is spelled across the different data sources being linked.

The probabilistic linkage procedure involves creating record pairs – one from each data set –by running a series of passes that allow for variation in full name information and demographic data. Each pass consists firstly of deterministic pairwise matching on selected blocking variables; then a weight is calculated based on the probabilities of agreement and disagreement for the blocking and match variables for each respective match pair in the block. In this way, the linkage process creates record pairs by combining records from one data set with records from another data set based on similarities in characteristics, such as surname, given name(s) and day, month and year of birth. A comparison weight is derived for each record pair based on how similar the linkage data are. In the algorithm used by the AIHW, this comparison weight is generally based on names, date of birth and sex.

The results of the probabilistic linkage were further updated through clerical review that involves examining possible match pairs manually and deciding whether to accept or reject the match based on the matching weights created by the linkage algorithm after each pass of the linkage strategy.

Indigenous births and deaths in linked data

Births

A total of around 60,300 babies were identified as Indigenous in the PDC–BRC cohorts of 2005 to 2018, as they met at least one of the following criteria:

- the mother identified as Indigenous in the PDC
- the child identified as Indigenous in the PDC (this is collected from 2011 only)
- among children who have died, the child is identified as Indigenous in the CDRT data
- among children who have died, the child is identified as Indigenous in the NDI.

Note that Indigenous status of children who have not died can be based only on the first 2 criteria from the perinatal data; the Indigenous status of those who have died can be derived from any of the 4 criteria listed above. Among children who have died, some were identified as Indigenous only in the birth records but not in either source of the death records, and vice versa. Since there is no clear basis to assess which of the different sources for Indigenous status are more reliable, the approach taken was to assign Indigenous status to a birth record in the linked file if any of the above 4 criteria applied. The reasonableness of this approach was not further tested in this study.

The data source for the Indigenous identification of these approximately 60,300 babies is as shown below:

- 47,012 mothers identified as Indigenous in the PDC 2005 to 2018
- 40,058 babies identified as Indigenous in the PDC 2011 to 2018
  - (of which 13,122 are babies where the mother is not identified as Indigenous)
- 142 babies from among those who have died identified as Indigenous in the CDRT records (even without the mother or baby being identified as Indigenous in the PDC).

Indigenous status in the CDRT Register of Child Deaths is collected from several other sources in addition to the PDC (NSW CDRT 2021).

The sum of these non-overlapping categories is 60,276 babies who are given an Indigenous status in the linked data file for this project.

This change in PDC data collection method for Indigenous status from 2011 onwards leads to a higher proportion of babies being identified as Indigenous in the total birth cohorts from 2011 onwards – if Indigenous status is based on either the mother or the baby identified as Indigenous in the PDC. There will be cases where some babies are recorded as being Indigenous while the mother is not recorded as Indigenous. This can refer to instances where the father is Indigenous but not the mother, while the baby has been given an Indigenous identity at birth.

This expected increase in the proportion of the total births assigned an Indigenous status in the linked data for this study from 2011 onwards is shown in Table B1.

Table B1: Total babies identified as Indigenous in linked data by period and PDC source

Birth year cohorts/period	2005–2010 (period 1)	2011–2014 (period 2)	2015–2018 (period 3)	2005–2018 grand total
Total births in linked file	564,905	388,579	383,946	1,337,430[(a)]
Number of births given an Indigenous status	17,067	20,614	22,595	60,276
Proportion of births given an Indigenous status in total births (%)	3.0	5.3	5.9	4.5
Number of births with Indigenous status, based only on mother's status	16,978	13,625	16,409	47,012
Proportion of Indigenous status births in total births, based only on mother's status (%)	3.0	3.5	4.4	3.5

(a) This total counts of births from the PDC records of 2005 to 2018 differs slightly from the total counts of births reported in Table 2.1 in chapter 2 (1,337,341) because the chapter 2 count excludes some cases with inaccurate dates of birth. This meant their survival to specific ages or exact age at death could not be derived, even though they belonged to the 2005 to 2018 birth cohorts.

Note: Indigenous status of a baby at birth was available only from 2011 onwards in the NSW Perinatal Data Collection.

Sources: Linked Perinatal, Births, CDRT and NDI data set.

In the period 1 birth cohorts of 2005–2010, 3.0% of babies were identified as Indigenous, based only on the mother's status. This proportion increased to 5.3% in the period 2 birth cohorts of 2011–2015, and to 5.9% in the period 3 birth cohorts of 2015–2018. Over the entire birth cohorts of 2005 to 2018 included in this study, the proportion of the total births given an Indigenous status was 4.5%.

Table B1 shows that there would have been an increase in the proportion of the total births given an Indigenous status even if a common approach on the Indigenous status of the baby was adopted for this study, based only on the mother's Indigenous status for all birth cohorts from 2005 to 2018.

With this common approach, the total number of babies identified as Indigenous in the linked data for this project would have been 47,012 – and the proportion of total births given an Indigenous status would have increased from 3.0% in period 1 to 3.5% in period 2 and 4.4% in period 3.

Since the addition of the baby's Indigenous status to the PDC from 2011, almost a third of the total babies identified as Indigenous in this linked data did not have an Indigenous mother (34% in 2011–2014 and 27% in 2015–2018).

Deaths

Among these 60,300 babies, over the time period followed up until the end of 2019 in the CDRT and NDI records of deaths:

- 419 (0.7%) died at any age
- 309 (0.5%) died under age 1
- 74 (0.1%) died between ages 1 to 4
- 36 (0.06%) died age 5 or above.

The 383 total deaths of Indigenous children before age 5 in the linked data represent around 10% of the total deaths of all children before age 5 in the selected birth cohorts (3,950). This 10% share is consistent with published CDRT reports on deaths before age 5 by Indigenous status over the 2005 to 2019 period – which is also 10% (NSW CDRT 2019, 2021).

It was estimated that the 383 total deaths of Indigenous children before age 5 in the linked data represent around two-thirds of the total number of deaths of Indigenous children under age 5 registered in the CDRT death records from 2005 to 2019 – if adjustments were to be made to restrict those CDRT death counts to Indigenous babies born in New South Wales between 2005 and 2018.

The two-thirds coverage obtained in the linked data for Indigenous deaths before age 5 in the selected birth cohorts – together with the consistent 10% share of Indigenous deaths in total deaths between the fuller CDRT Register of Child Deaths and the linked data – strongly indicate that the data linkage carried out for this project has worked well by Indigenous status. The totals for Indigenous identified deaths in the project linked data are lower than the expected counts from the CDRT Register of Child Deaths, but the age structure and proportionality with total deaths is maintained. Hence, a separate analysis of the total deaths of Indigenous children and the specific risk factors behind these deaths is supported by the data linkage outcome on Indigenous children.

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