Mortality of Children and Parental Disadvantage

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Abstract

This paper investigates the underlying influencing factors of the premature death of children, specifically looking at the correlation between mortality risk of children and parental disadvantage at an individual level. Largely due to lack of appropriate data, this issue is not well explored in Australia. This paper tries to fill in the gap by creatively using a unique administrative dataset of FaCSIA, which contains approximately a whole birth cohort of Australian children. The findings indicate that the mortality of children is significantly correlated with several indicators of parental disadvantage, such as Indigenous status, low income, long duration of income support, teenage motherhood, and living in socio-economically disadvantaged areas. This paper discusses how some measures of disadvantage, such as unemployment or income support reliance used in isolation, may underestimate the extent of intergenerational transmission of disadvantage, because children from disadvantaged families are underrepresented in the samples of adults due to their high premature mortality.

JEL Classification: J13; C41

Key Words: mortality; premature death; children; parent; disadvantage; socio-economic; income support; Indigenous; Australia; intergenerational; non-parametric

1. Introduction

Premature death of children is a very adverse outcome and has significant impacts on families. Children are the future of society; improving their health and especially reducing their mortality not only directly affects the current wellbeing of children and individual families, but also has long-lasting effects on their future prosperity, thus contributes to the sustainable social and economic development of the nation as a whole.

Australian children generally have good health and the mortality of children has been falling for decades. In the last two decades, the death rates of children aged between 0-14 years have approximately halved (AIHW 2006).

However, compared with other countries in the Organisation for Economic Co-operation and Development (OECD), the Australian infant mortality rates were only at the middle level in 2003, and the ranking had even fallen since 1987. The 'health expenditure-to-GDP-ratio' of Australia (11.6%) and health expenditure per person ($3,855) were both below the OECD weighted averages (11.6% and $4,035), and governments' contribution to total health expenditure (67.8%) was also four percentage points below OECD unweighted average in 2003 (AIHW 2006).

To improve the health and reduce the mortality of children requires good knowledge of the determinants of health and causes of mortality of children, while understanding better the underlying influencing factors of mortality of children has more important policy implications. The latter helps identify the high risk (focus) groups within the population, and can help to find well-targeted solutions in preventing the occurrence of the fatal diseases and injury, improving the response, and ultimately reducing the mortality risk after the occurrence of the fatal diseases and injury.

Research shows that the incidence of diseases, injuries and mortality of children is not randomly distributed; certain groups of the population, mostly the socio-economically disadvantaged groups, are suffering significantly higher child mortality. For instance, between 1999 and 2003 the mortality of Indigenous children was two to three times higher than other children (ABS 2007), and children in very remote areas also had approximately two times higher mortality than children in major cities (AIHW 2006).

The effects of family and social environment on health are well documented, but unfortunately current data available in Australia is still very limited, which hinders the ability to fully explain the influences of environmental factors on the health of children (AIHW 2006). Aggregate data is mostly used in the existing studies and findings are commonly based on direct tabulation without controlling for other important influencing factors. Therefore, relative importance of the factors cannot be compared.

One contribution of the current research is the use of a unique dataset – the Second Transgenerational Data Set (TDS2) – to investigate the effects of family and social environment on the mortality of children at an individual level. TDS2 consists of nearly a whole birth cohort of Australian children, and contains rich information on parents and children, including date of birth, date of death and welfare history. This provides a very good opportunity for analysing influencing factors of premature deaths of children and locating the leading factors.

Understanding the underlying influencing factors resulting in the premature death of children is also important for other reasons. There is evidence of an intergenerational transmission of disadvantage; that is, children brought up in disadvantaged families are commonly observed to be more likely to experience adverse outcomes themselves, such as poor education attainment, poor health, high unemployment, low income and welfare reliance (Beaulieu et al 2001; Corak et al 2000; Gottschalk 1992; 1996; Maloney and Pacheco 2003; Rank and Cheng 1995). In Australia, there are relatively fewer studies on this issue, but there is similar evidence of intergenerational transmission of disadvantage (McCoull and Pech 2000; Pech and McCoull 1998; 2000).

One problem about the current literature on intergenerational transmission of disadvantage is that if the premature death of children is significantly correlated with parental disadvantage, then the extent of intergenerational transmission of disadvantage tends to be underestimated by indicators such as income support (IS) reliance and unemployment. This is because premature deaths of children preclude them from being unemployed or receiving income support as adults.

The results of the research reported in this paper show that the risk of premature death is significantly higher for children from disadvantaged families, as indicated by

certain characteristics of parents, such as long income support duration, low income, Indigenous status, teenage motherhood, disability, and living in socio-economically disadvantaged or remote areas.

Overall, the findings suggest that premature death of children should not be neglected as a significant adverse outcome of children in the research on intergenerational transmission of disadvantage and in the policy arena. If we want to break the cycle of intergenerational transmission of disadvantage, we should strive to reduce the mortality of children from disadvantaged families in the first place.

The rest of the paper is structured as follows. The next section reviews relevant literature and proposes a conceptual framework for this study. Section 3 briefly introduces the data and the sample used for the research. Section 4 undertakes descriptive analyses. Sections 5 and 6 report estimation results of logistic and duration models, respectively. The last section concludes the paper with a summary and discussion.

2. Literature Review and Conceptual Framework

While the health of Australian children has been continuously improving, the mortality of children has been continuously falling for all age groups, with boys generally having higher mortality rates than girls. According to the Australian Bureau of Statistics (ABS 2007), the proportion of children (under 15 years) with a long-term health condition decreased from 44 percent in 2001 to 41 percent in 2005. From 1985 to 2005, the male infant mortality rates dropped from 11.4 to 5.4 per 1,000 live births; the death rates of boys aged 1-4 years and 5-14 dropped from 0.6 to 0.3 and from 0.3 to 0.1 per 1000 population, respectively; and for young men aged 15-19 years the death rates dropped from 1.1 to 0.5 (ABS 2006). The mortality rates of girls also halved during the same period; the corresponding changes for girls in the four age groups are respectively from 8.9 to 4.8, from 0.4 to 0.2, from 0.2 to 0.1, and from 0.4 to 0.2 (ABS 2006).

Mortality of children generally falls with age, with infants (under one year old) having the highest mortality. In 2004, infant deaths accounted for 68 percent of all childhood deaths (0-14 years); another 15 percent of deaths happened among children aged 1-4 years; and the remaining 17 percent were among children aged 4-14 years (ABS 2007).

2.1 The Direct Causes of Premature Death of Children

A better understanding of the causes of death helps find better approaches for reducing mortality and increasing life expectancy. This is especially important for children, for whom most deaths are preventable.

Generally speaking, diseases and injury are the two main direct causes of premature deaths of Australian children, while the causes of infant deaths are different from those of older children.

For infant deaths in 2004, the leading causes included certain conditions originating in the peri natal period (the period five months before and one month after birth), congenital malformations, deformations and chromosomal abnormalities; in total, these accounted for 71 percent of total infant deaths (ABS 2007). For children aged 1-14 years, external causes (such as traffic accidents and assaults), cancer, and diseases

of the nervous system were the major causes of deaths (ABS 2007). For young people aged 15-24 years, external causes (including traffic accidents and intentional self-harm) were also the main cause of death, accounting for more than half of the total deaths in the age group (AIHW 2006). As a leading cause of mortality and disability of children, injury was identified as a priority issue by the Australian government (AIHW 2006).

The incidences of diseases and injury (the risk factors) are not equally distributed among children; some children are more exposed to fatal diseases and injuries. In addition, the responses of different families also vary after the occurrence of diseases and injuries to their children.

All these factors lead to different health outcomes for children, including mortality. For instance, boys, children of younger and/or less educated mothers, and those living in crowded housing and poorer neighbourhood tend to have a higher risk of injury (Blakemore 2005 and references therein). Similarly, children in socio-economically disadvantaged areas were found to have significantly higher mortality rates (Draper et al. 2004; Turrell and Mathers 2001). Between 1999 and 2003, death rates of Indigenous children were nearly three times higher than those for non-Indigenous children in the same age groups (ABS 2007).

Therefore, it is as important to understand the underlying influencing factors of health and mortality among children as it is to find out the direct causes of death.

2.2 The Underlying Influencing Factors of Premature Death of Children

Generally, the health and mortality of children can be influenced by various factors, including nutrition (breastfeeding and balance of nutrition), physical activity, body weight (low birth weight and over-weight as a child), living style (smoking and drinking), vaccination, family background (parental unemployment and socio-economic status) and social environment (AIHW 2006).

There is evidence showing that these influencing factors are inter-related. For instance, nutrition, access to medical care, the safety of environment, and the quality and stability of care can all be affected by low family income (Shore 1997). People living in socio-economically disadvantaged areas are also more likely to be obese, smoke and drink alcohol at harmful levels (AIHW 2006; Turrell et al 2006). A much

larger proportion of Indigenous children (21.7% between 1998 and 2000) were born to teenage mothers than non-Indigenous children (4.5%) (Eades 2004), and they also had significantly higher rates of premature birth and low birth weight (Zubrick et al 2004).

Therefore, an issue of interest is whether some factors, such as income and lower socio-economic status, are more significant and more fundamental than others in affecting the health and mortality of children. This issue is important for finding well-targeted policy responses and appropriate long-term solutions for improving the health and wellbeing of children and reducing their mortality.

However, for this purpose, current data available in Australia is not adequate and a vast gap in the information still exists (AIHW 2006; Patton et al 2005). The current research tries to fill this gap and also enrich our knowledge about the underlying influencing factors of mortality of Australian children by creatively using an administrative data of children in a half-year birth cohort.

2.3 The Correlation between Mortality and Socio-economic Status (SES) and Intergenerational Transmission of Disadvantage

There is a growing body of literature on the intergenerational transmission of disadvantage[1]. Poor health outcomes, along with low education attainment, high unemployment rate, low income, long welfare reliance, and overall socio-economic status (SES), is often used as an indicator of disadvantage. For adverse health outcomes, mortality is the most robust measure.

Generally, people growing up in disadvantaged families are more likely to have adverse outcomes themselves later on in life (Beaulieu et al 2001; Case et al 2005; Corak et al 2000; Gottschalk 1992; 1996; Maloney and Pacheco 2003; Rank and Cheng 1995).

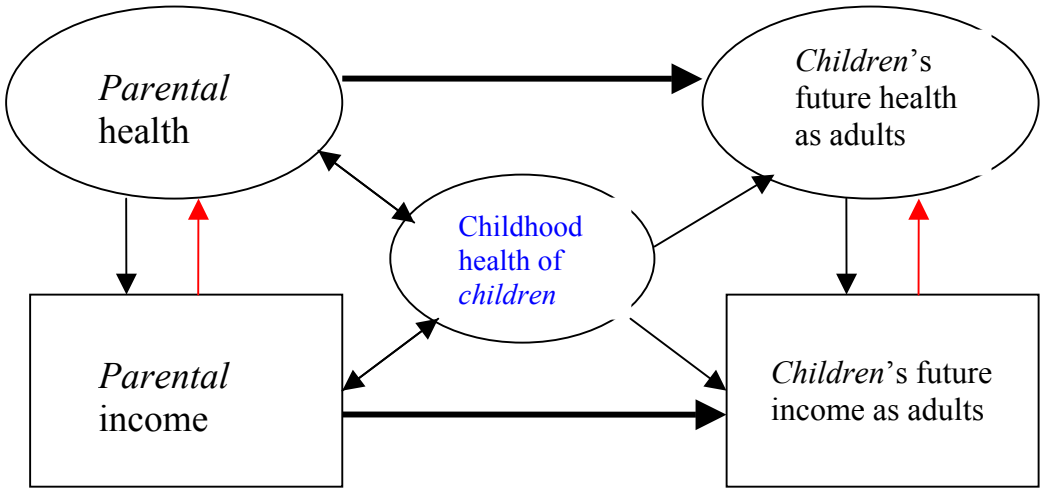
In Australia, similar results were also found. For instance, with the 'Negotiating the Life Course' data set of the Australian National University (ANU) Pech and McCoull (1998) showed that there is significant correlation between education attainment, employment and income support (IS) receipt of parents and children. Studies using the first Transgenerational Data Set of the Department of Families and Community

[1] See Cobb-Clark and Gorgens (2004) and Penman (2005) for a review of literature on intergenerational transmission of disadvantage.

Services (FaCS) also found significant evidence of intergenerational transmission of income support receipt (McCoull and Pech 2000; Pech and McCoull 2000). But the issue is by no means well explored so far. The current research also tries to make contribution in this aspect.

The transmission mechanism of disadvantage over generations is very complex. Figure 1 provides a simple demonstration of a few pathways through which parental income and health can affect children's income and health.

Figure 1. Mechanism of Intergenerational Transmission of Income and Health Disadvantages



Within a pooled sample, it is well documented in the literature that health is correlated with socio-economic status (SES); that is, there exists a so-called health-SES gradient (Case et al 2002; Currie and Stabile 2003). Lower SES children generally have poorer health throughout the world, either because lower SES children have more exposure to health risk factors, or because they are less responsive or less effective in their response to health problems, or for both reasons. There is also evidence of significant effects of income inequalities on health and mortality (Lochner et al 2001; Rodgers 1979; Waldmann 1992), and a framework developed by Wildman (2003) suggests that if the distribution of income affects individual health, any policy aimed at

equalising health but not accounting for income inequality, will lead to unequal distributions of health. In addition, a reverse causality from health to income may also exist (Deaton 2002).

Across generations, parental health can directly affect children's future health, for instance, due to illness of mothers during pregnancy or genetic problems. It can also indirectly influence children's future health through many other ways. For example, parental health conditions may affect care quality, nutrition, stress and living style of children at childhood, and the effects of these factors accumulate over time and lead to poorer health outcomes of children as they become adults (Currie and Stabile 2003); parental health conditions may also affect children's future health through the impacts on their own and their children's incomes. Similarly, parental income can affect children's future income and health through multiple channels; investment in the education of children is one example of intermediate factors. Case et al (2005) found evidence of lasting effects of childhood health and economic circumstances on adult health, employment and socio-economic status using a British longitudinal data.

The transmission mechanism in reality may be far more complex than shown in Figure 1. For instance, it is also possible that the 'transmitted' disadvantages over generations are determined by some unobserved common factor such as culture and environment. These altogether make identifying the main mechanism of transmission very difficult.

Recently, van den Berg et al (2006) used macroeconomic conditions early in life as an 'instrument' for individual conditions to analyse the effects of economic conditions early in life on the individual's mortality. They found that economic status early in life is a crucial determinant of health and mortality in adulthood.

Another issue emerges when the mortality of children is considered. As the most adverse health outcome of children, premature death precludes some children from being observed in studies based on adults. If mortality of children is significantly correlated with parental disadvantage, then the extent of intergenerational transmission of disadvantage is underestimated by measures such as low income and welfare reliance of adults, used in isolation.

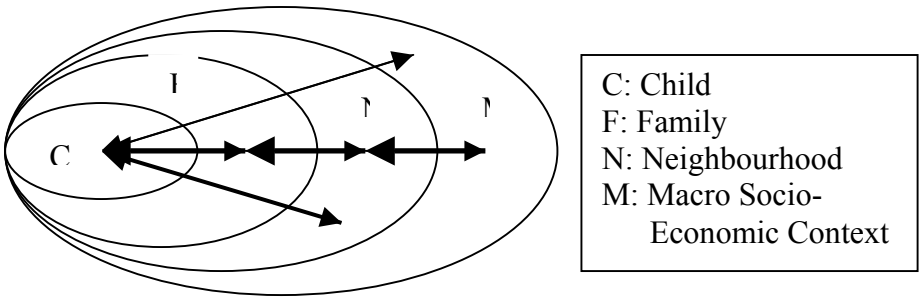
The current research improves our understanding of the intergenerational transmission of disadvantage in Australia by investigating the correlation between mortality of

children and parental disadvantage. However, due to the limitations of data and the complexity of the interrelationships, one must be cautious in interpreting the findings on the correlations as causal relationships.

2.4 Conceptual Framework

As discussed above, mortality of children is influenced by various inter-related factors. A simple conceptual framework would make this complex issue easier to understand; Figure 2 is such a trial. The influencing factors of the mortality of children fall into four layers: (1) own factors of children; (2) family factors; (3) neighbourhood factors; and (4) macro socio-economic factors.

Figure 2. Determinants of Mortality of Children



The factors of the individual children include sex, genetic factors, birthweight, vaccination, physical activity, living style, and other characteristics of the children themselves. These factors comprise the self-protection system against diseases and injury.

Family factors consist of, but are not limited to, family financial situation, housing, characteristics of parents (such as age, health, education, employment status, physical activity, and caring knowledge and skills), family size and structure, and family cultural factors. For health and mortality of children, family factors are the most

important; many of the children's own factors (such as birthweight, vaccination and living style) are influenced and even shaped by family factors, and other broader environmental factors discussed later on often influence health of children through family factors as well.

Some examples of neighbourhood factors are location, characteristics of local population (such as income, occupation and religion), industry, childcare and school quality, and availability of and access to health services. Poor neighbourhood environment can be a big threat to the health and safety of children.

Macro socio-economic context covers all other environmental factors influencing beyond a single neighbourhood, such as the health system (e.g., public health expenditure, health management and monitoring, and medical care), economic growth and prosperity, research and technology, unemployment, income inequality, welfare systems and pollution. These factors often affect many people and even the whole nation, but the health of some groups may be more sensitive to changes in these factors.

The four layers mentioned are not isolated; they interact with each other. In addition, the relative importance of these factors is not constant but changes over time and with the age of a child. Since the focus group of this research is children in a half-a-year birth cohort and they were all less than 18 years old at the end of the sampling period, for simplicity, the macro socio-economic factors are treated as exogenous, and after controlling for observed factors the effects of other factors on the mortality of children are generally assumed to be random. The issue of unobserved factors will be discussed further in later sections.

In this research, particular attention is paid to parental disadvantages in the second layer, and Indigenous status, low income, long income support (IS) duration, teenage motherhood, and disability are used as the main indicators of parental disadvantage.

3. Data

The current research uses an *ad hoc* administrative data, the Second Transgenerational Data Set (TDS2) of the Australian Government Department of Families, Community Services and Indigenous Affairs (FaCSIA). It was created from the Centrelink administrative records for the purpose of doing research on the intergenerational transmission of disadvantage. As a result, a unique characteristic of TDS2 is the linking of the administrative records of parents with those of their children.

The main target group in TDS2 is a cohort of children who were born between 1 October 1987 and 31 March 1988 (referred to as the primary children later on). Another key group is their parents. In addition, siblings, partners and children of the primary children, if they have any, are also included in the data. The TDS2 contains detailed benefit-relevant information of these groups up to April 2005[2], if they have any. The primary children were recorded in TDS2 either because they received government benefits in their own right, or because they were dependent of benefit recipients.

3.1 Primary Children

Table 1 provides a statistical summary of the primary children. In total there are 127,826 primary children in TDS2, and 65,522 (51.3%) are boys. Up to April 2005, 653 deaths were recorded for the primary children with a mortality rate of 0.51 percent.

One point to note is that TDS2 only contains records of people who once received family payments (FTB/FPA) from the Government in their own right (referred to as customer). A precondition for a person to be a customer is being independent, where being independent requires the person to be old enough (usually older than 15 years). As a result, self records, except for date of birth, date of death and sex, are not available for those primary children who were not customers in their own rights. In other words, most variables are missing for primary children who were only registered as dependents in the Centrelink System, accounting for more than half of

[2] Income data are only available between 1991 and 2005, while most other variables can be dated back well beyond 1991. For instance, as recorded in TDS2, there are at least 5000 parents whose first IS spells both started and ended before 1990.

the primary children. Therefore, analysis in this paper is mainly based on information of parents.

Table 1. Characteristics of Primary Children by Sex

	Female	Male	Total	Remarks
# of observations	62,304	65,522	127,826	
Death rates (%)	0.43	0.59	0.51	
Customer (%)	49.85	48.58	49.20	
Indigenous (%)	3.66	3.56	3.61	Self reported
Born abroad (%)	5.25	5.13	5.19	
Never on IS (%)	64.52	66.71	65.64	No IS event
Having no child (%)	98.62	99.91	99.28	own or partner's children
Having 1 child (%)	1.28	0.07	0.66	
Having 2+ children (%)	0.10	0.02	0.06	
No Parents ever on IS (%)	39.32	39.13	39.23	
One parent once on IS (%)	45.59	44.74	45.16	
2+ parents once on IS (%)	13.35	14.37	13.87	
Primary parent had no IS record (%)	42.71	42.52	42.61	Including 2,227 with parent IDs missing

Notes: Parents include all FTB/FPA parents of a primary child in TDS2; primary parent refers to the parent who provided the longest care for the primary child.

Table 2 gives a comparison between birth records in TDS2 and registered births in ABS (Australian Bureau of Statistics) data. The primary children in TDS2 were born between 1 October 1987 and 31 March 1988. Since five percent of the primary children with records in TDS2 (customers) were born abroad and about half of the primary children were customers, it could be estimated that about 10 percent of the total primary children were born abroad[3]. According to the ABS (2003 and 2004b), there are 121,707 registered births between October 1987 and March 1988. Therefore, the primary children who were born in Australia account for about 94.5 percent of the registered births during the same period. As shown in Table 2, the sex ratios are also

[3] In 2002, 8.1 percent of resident children aged 0-14 years and 9.6 percent of resident young people aged 0-19 years were born overseas (ABS 2004).

virtually the same. Generally speaking, TDS2 contains nearly all children belonging to the birth cohort.

One question to be considered is which children are in the birth cohort but not included in TDS2. Considering the nature of the dataset, the best conjecture is children in the birth cohort whose parents never claimed any benefits for them before April 2005. They are most likely to be from wealthier families, with an exception is discussed later.

Table 2. Comparison between Births Records in TDS2 and Registered Births in ABS Data

	ABS (10/87 – 3/88)	**TDS2** (10/87 – 3/88)
# of births	121,707	127,826 (10% born abroad)
Sex Ratio	1.052 (1988)	1.052

Sources: ABS (2003 and 2004b); author's calculation from TDS2.

Table 3 shows a comparison of the registered infant deaths and the deaths recorded in TDS2. Apparently, the differences are much larger than those between births figures (TDS2 figures should time two for comparison). There are very few deaths under one week in TDS2, much fewer than the registered number of deaths. The recorded deaths between one and four weeks are also significantly fewer than the registered deaths, while the gap is smaller. Generally, the deaths were under recorded in TDS2; as the age at death is getting older, the difference from the registered deaths is getting smaller.

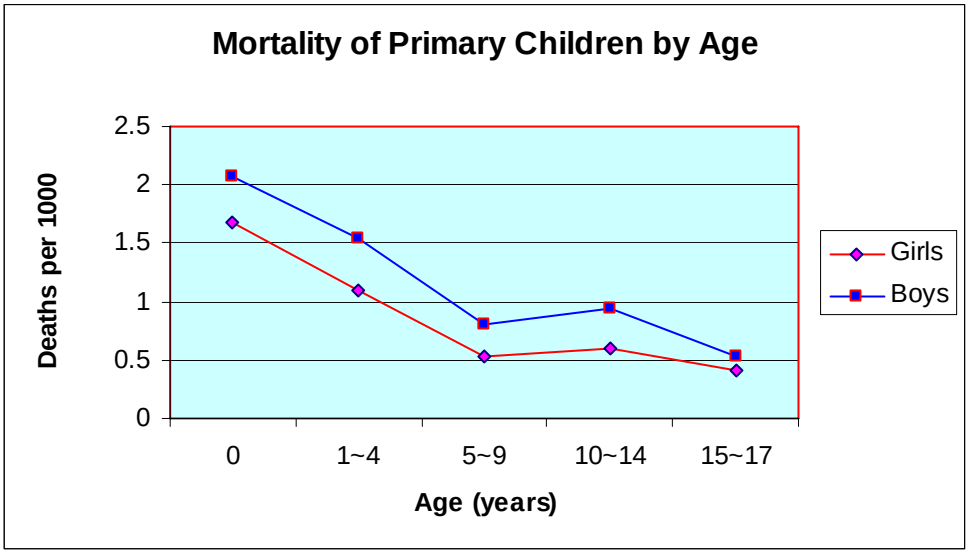
Table 3. Comparison between Deaths Records in TDS2 and Registered Deaths in ABS Data

Age at death	**ABS-1987 (1 year)**	**ABS-1988 (1 year)**	**TDS2 (half a year)**
Under 1 day	677	722	***3*** (much fewer)
1 day – under 1 week	330	341	***1*** (much fewer)
1 week – under 4 weeks	243	232	***22*** (much fewer)
4 weeks – under 1 year	866	837	215 (fewer, OK)

Sources: ABS (2003a; 2004a); author's calculation from TDS2.

Figure 3 shows the mortality of the primary children in TDS2 by age group. The infant death rates of both boys and girls – around two per 1,000 live births – are clearly smaller than those in ABS data – 9.8 and 7.6 per 1,000 live birth of boys and girls, respectively, in 1988 (ABS 2004a). However, comparable ABS figures for other age groups in TDS2 are difficult to find, because the deaths in TDS2 happened over several years whereas ABS figures usually refer to a single year.

Figure 3. Mortality of Primary Children by Age



It is crucial for this research to understand the source of the differences between the recorded number of deaths in the TDS2 and the ABS registered number of deaths.

An important question to ask is whose deaths were not recorded in TDS2? Apparently, the deaths of children who were in the birth cohort but were not included in TDS2 were not recorded. As mentioned above, children from wealthy families are likely to be excluded from TDS2, but the exclusion of their deaths alone can hardly explain the big differences, especially considering their small proportion in the birth cohort and also their likely lower-than-average mortality risks. Another possibility (and a better conjecture) is that children in the birth cohort who died within one or two months were under-recorded in TDS2. These children usually had a serious illness, which kept their parents busy with taking care of them, and therefore did not

have chance to claim benefits for them. Apart from their deaths, their births might not be recorded in TDS2, either; in other words, TDS2 has no records of them at all.

This under-recording of deaths may not be random[4], and because of the small number of total deaths in TDS2, this is a more serious problem than the exclusion of children from wealthy families. For instance, if children from disadvantaged families are significantly more likely to die within one or two months, the analysis based on TDS2 death records will under-estimate the gap in mortality risk between disadvantaged and other families. One solution for this issue is excluding all children who died within two months. Similar robust tests have been undertaken using samples excluding children who died within one or three months, and the key findings are qualitatively the same. The following sections will give a more detailed discussion on this issue.

In addition, for children already included in TDS2, their deaths may also be under-recorded. This happens when the children died after their parents left benefits and did not return till the last recorded date in TDS2 (8 April 2005). This is a right-censoring issue, and can be dealt with using duration models.

3.2 Parents[5]

In TDS2, 2,227 primary children do not have any parent identifies (IDs), so their parents cannot be identified. For the other 125,599 primary children, 152,860 parents are identified, and some of these parents once claimed benefits for more than one primary child. Among the parents, the one who provided the longest care for a primary child is referred to as the primary parent. Except for the 2227 children without parent IDs, each primary child is associated with a primary parent. The analysis in this paper is mainly based on the primary parents, and some duration models use information of all parents.

Characteristics of the 125,599 primary parents and their correlation with mortality of children are discussed in detail in Section 4. Briefly speaking, a vast majority of the primary parents (more than 96%) are female[6], two thirds were born in Australia, and 3.17 percent were identified as Indigenous. Surprisingly, although 41.6 percent of the

[4] For example, births by people currently on benefits are likely to be reported sooner than births by people not on benefits.
[5] In TDS2, parents refer to people who claimed FTB/FPA for the primary children. Therefore, they can be grandparents, older siblings or other guardians, and not necessarily actual parents of the children.
[6] There are 61 parents with sex missing. Among them, 21 have individual IS records, and 18 have family IS records.

parents have individual income support (IS) records, only 40 percent have family IS records in TDS2. This is due to another issue with TDS2: the family IS records were left-censored (starting in 1993), whereas the individual IS records can go back to the 1960s. Therefore, in this research parental IS experience is mainly based on individual IS records; however, preliminary analyses show that using family IS records leads to similar results.

3.3 Issues and Solutions regarding TDS2

TDS2 has several outstanding advantages for the current research. First, it contains nearly a whole birth cohort in the Australian population. Second, it contains detailed benefit-related information of both primary children and their parents. Third, it is a unit record data. Fourth, it is a longitudinal data. Fifth, variables in the dataset, especially key benefit-relevant variables, are generally accurate. The data is not subject to recall errors, which are common to survey data.

However, as an administrative data, TDS2 also has limitations, which should be considered in the analysis.

First, it has a limited number of variables, and information of important factors influencing mortality, such as neighbourhood information, is not available in the dataset. As a result, unobserved heterogeneity is an issue.

To deal with this issue, Socio-Economic Indexes for Areas (SEIFA) disadvantage index and Australian Standard Geographic Classification (ASGC) remoteness classification[7] are merged into the dataset by postcode.

Second, TDS2 only has records for customers when they are receiving benefits from the Government. In other words, people who never receive benefits from the Government are not included in the dataset, and no information is recorded when people are off the benefit[8].

People who have never claimed any benefit are thought to be mostly wealthy people. As discussed above, they only account for a small proportion of the population of interest, thus excluding them from the analysis is not a big issue. The concern

[7] For details regarding the SEIFA index and ASGC remoteness classification, refer to the website of Australian Bureau of Statistics (ABS): www.abs.gov.au.
[8] One exemption is that limited information of dependents, such as date of birth, date of death and sex, is provided by their guardians and also recorded in the dataset.

regarding that no information is recorded when people are off benefit is much bigger, but can be easily tackled with duration models.

Third, not all deaths of children were recorded in TDS2. If the recording of deaths is not random, the estimation based on TDS2 will be biased. As talked above, deaths within two months after birth are likely to be under-recorded in TDS2 and also likely to be non-random. One solution for this issue is to exclude these deaths from the analysis and test the robustness of key findings.

Fourth, some variables, such as family income and SEIFA index, have many missing values. In this research, if the missing values account for a fairly large proportion of the total observations, and/or the mortality of the missing observations is significantly different from the sample mean, a separate category for the missing values is created.

This list does not cover all the issues regarding the dataset (some will be discussed later); even for the listed issues, the solutions talked above are not totally satisfactory. Therefore, various tests have been undertaken to check the robustness of key findings. More detailed discussions can be found in later sections.

3.4 Sample

For most of the analyses in this research, three groups of primary children were excluded. First, children whose parent IDs are missing were excluded, because the correlation between mortality of children and parental disadvantage cannot be analysed without information of the parents.

Second, children who were born abroad were also excluded. Among all premature deaths, infant death rate (especially neonatal mortality) is the highest; only a small proportion of foreign born children were likely to be in Australia as infants. Therefore, the mortality of foreign born children is likely to be underestimated with TDS2.

Third, for reasons discussed above, children who died within two months after birth were excluded. For robust tests, analyses for children who survived to three months and for all primary children in TDS2 were also undertaken and the key findings are generally consistent.

In the following sections, if not otherwise specified, the sample of primary children used for this research is restricted to the primary children whose parents can be

identified and who were born in Australia and did not die within two months after birth. This consists of 119,013 primary children, with 51.3 percent being boys. The mortality rates of the whole sample, boys and girls are 0.49 percent, 0.57 percent and 0.41 percent, respectively.

Each primary child is associated with a primary parent in the sample. Characteristics of primary parents and their correlation with mortality of children are discussed in detail in the next section.

4. Descriptive Analysis

This section undertakes the descriptive analysis. Correlations between mortality of children and observed characteristics of children and their primary parents were investigated with direct tabulation and figures. Particular attention is given to the correlation between mortality of children and several indicators of parental disadvantage, including Indigenous status, teenage motherhood, non-birth-parent, disability, low income, long income support duration, and living in a remote or socio-economically disadvantaged area.

In order to see the significance of various influencing factors, a demographic concept – excess death – is used. Excess death is the difference between the observed number of deaths in a group and the number of deaths that would have occurred in that group if it had the same mortality rate as a reference group. In this section, the least disadvantaged group is usually used as reference. The estimated excess deaths are presented in Table 4.

4.1 Indigenous Status

The Indigenous status in TDS2 is based on self identification. In addition, if a customer chose to receive Family Tax Benefit (FTB) through Australian Tax Office in a lump sum at the end of a financial year, this variable was not recorded in the Centrelink system. Presumably, this is not commonly the case for Indigenous people, and is more likely to happen among less disadvantaged Indigenous people. Nonetheless, Indigenous people were not fully identified in TDS2, and this is also a common issue for most Australian datasets.

As shown in Table 4, the mortality rate of children of non-Indigenous people is 0.47 percent, whereas the rate for Indigenous children[9] is 0.89 percent. In other words, the mortality risk of Indigenous children is 1.89 times as large as that of non-Indigenous children.

[9] In TDS2, some parents of the primary children who are identified as Indigenous are not Indigenous themselves; in the meantime, there are also some children of Indigenous people not being identified as Indigenous. In this paper, for simplicity of expression, Indigenous children refer to children of Indigenous people.

Table 4. Comparison in Mortality of Children between Disadvantaged and Less Disadvantaged Groups, and Estimated Excess Deaths

Influencing factors of mortality	# of deaths	Mortality (%)	Excess deaths	# of Obs.
Total IS Duration since 01/10/87:			***214 (36.8%)*****	
9 or more years	172	0.75	101 (58.7%)	22,927
3-8 years	124	0.54	52 (41.9%)	23,080
2 years or less	126	0.57	58 (46.0%)	21,950
Having no IS records	159	0.31*	0	51,056
Family Income:			***200 (34.4%)*****	
Missing	53	0.74	30 (56.6%)	7,172
Low family income (50% of sample mean or less)	117	0.64	58 (49.6%)	18,420
Middle family income (50-150%)	345	0.48	113 (32.8%)	72,473
High Family income (more than 150%)	66	0.32*	0	20,948
Birth-parents or not:			***188 (32.4%)*****	
Not birth-parents	285	0.97	188 (66.0%)	29,431
Birth-parents	296	0.33*	0	89,582
# of children ever cared for before primary child			***153 (26.3%)*****	
Two or more	164	0.68	78 (47.6%)	23,950
One	197	0.59	75 (38.1%)	33,195
Never cared for any child before	220	0.36*	0	61,868
SEIFA Disadvantage Index of Living Area at First Caring Date:			***129 (22.2%)*****	
Most disadvantaged areas	207	0.61	77 (37.2%)	34,195
Other areas	221	0.48	45 (20.4%)	46,370
Least disadvantaged areas	136	0.38*	0	35,584
Missing	17	0.59	6 (35.3%)	2,864
Country of Birth:			***117 (20.1%)*****	
Born in Australia	487	0.51	116 (23.8%)	95,079
Born abroad	94	0.39*	0	23,934
Sex of Children:			***93 (16.0%)***	
Boys	345	0.57	95 (27.5%)	61,038
Girls	236	0.41*	0	57,975
Marriage Instability:			***81 (13.9%)*****	
Very unstable (5 or more marital events)	139	0.72	57 (41.0%)	19,440
Unstable (3 or 4 marital events)	142	0.51	26 (18.3%)	27,627
Stable (less than 2 marital events)	300	0.42*	0	71,894
Remoteness of Living Area at First Caring Date:			***34 (5.9%)*****	
Missing	24	0.91	12 (50.0%)	2,650
Living in remote/very remote areas	24	0.67	8 (33.3%)	3,563
Living in inner/outer regions	197	0.51	18 (9.1%)	38,966
Living in major cities	336	0.46*	0	73,831
Indigenous Status:			***22 (3.8%)*****	
Indigenous people	35	0.89	16 (45.7%)	3,938
Non-Indigenous people	546	0.47*	0	115,075
Disability:			***22 (3.8%)*****	
With a disability	35	0.90	17 (48.6%)	3,881
With no disability	546	0.47*	0	115,132
Rural/Urban Area at First Caring Date:			***22 (3.8%)*****	
Rural	70	0.58	13 (18.6%)	12,151
Urban	494	0.47*	0	104,000

Teenage motherhood:			***10 (1.7%)*****	
Teenage mothers	42	0.74	15 (35.7%)	5,663
Non-teenage mothers	539	0.48*	0	113,350
Homeownership at First Caring Date:			***10 (1.7%)*****	
Living in government houses	78	0.86	34 (43.6%)	9,065
Homeowners	246	0.48*	0	51,485
Missing	65	0.30	-41 (-63.1%)	22,018
Total	***581***	***0.49***		***119,013***

Notes: * Mortality rates used for calculating excess deaths. ** Estimated excess deaths for the whole sample. Figures in parentheses are percentages of deaths which could be reduced if mortality rates of the reference groups were applied. The factors are ordered by estimated excess deaths for the whole sample. The differences between the estimated excess deaths for the whole sample and the sum of estimated excess deaths of sub-groups are due to rounding of figures in calculation.

The estimated number of excess deaths for the whole sample is 22. This means if the death rate of the whole sample could be reduced to the rate of non-Indigenous children, the total number of deaths would be 22 fewer than observed.

Since Indigenous children only account for a small proportion of the sample, narrowing the gap does not make a big difference for the whole sample – the number of excess deaths is only 3.8 percent of the total observed number of deaths. However, the effect on the most disadvantaged group – Indigenous children – is very significant; the number of deaths of Indigenous children could have been reduced by nearly half if they had the same death rate as non-Indigenous children.

4.2 Country of Birth

As mentioned in the last section, all primary children who were born abroad were excluded from the sample[10], while children whose parents were born abroad were included. In the sample, about 20 percent of primary parents were born abroad[11].

As shown in Table 4, the mortality of children is much lower for immigrants than for Australian born people. The estimated number of excess deaths is 117, accounting for one fifth of the total deaths of children in the sample. Why is the mortality of children necessarily lower for immigrants than the Australian born people? Several reasons are discussed in Section 6 – Summary and Discussion.

[10] It should be noted that not all children who were born abroad were excluded because country of birth was unknown for at least half of the primary children (non-customers). In general, children of immigrants are more likely to be born abroad than other children; this may also partly explain the lower mortality of children for immigrants in the sample.

[11] Among all primary parents in the clean sample, approximately 3% primary parents were born in six main English-speaking countries – US, UK, Canada, New Zealand, Ireland, and South Africa – and 17% were born in other countries. The mortality rates of children for parents born in the main English-speaking countries and parents born in other countries are 0.2% and 0.43%, respectively.

4.3 Disability

In the current study, disability is used as a dummy variable, and is defined as being eligible for the Disability Support Pension (DSP). In the sample, there are approximately 3.3 percent of children whose primary parents have a disability.

Their mortality risk is nearly two times that of other children. Again, because of their small proportion in the sample, reducing their mortality to the level of other children has little effect on the whole sample but the impact is very significant for this disadvantaged group – the number of deaths could have been reduced to half of the observed level.

4.4 Teenage Motherhood

In the current study, a teenage mother refers to a woman who became the primary carer of a primary child as a teenager; in the sample 5,663 women (4.8%) fall into this category[12].

As shown in Table 4, the mortality of children primarily cared for by teenage mothers is also significantly higher than that of others (0.74% in comparison to 0.48%). The estimated number of excess deaths is small for the whole sample but fairly large for the children of teenage mothers.

In addition, the mortality of children generally decreases with the aging of primary parents up to 35, and it slightly goes up when the primary parents are older than 35 years.

4.5 Birth-parent

In the TDS2 there is no information about the actual relationship between a 'primary parent' and a 'primary child', but in most cases the primary parents would most likely be the natural parents. Since there is evidence for differences between birth-parents and non-birth-parents regarding caring for and the outcomes of children[13], a variable of birth-parent is derived to see this difference for Australian children.

In this paper a birth-parent is defined as a primary carer who started taking care of a primary child from the time of birth[14]. Although a birth-parent defined in such a way

[12] According to ABS (1994), in 1988, 5.6 percent babies were born to teenage mothers.
[13] For instance, Case and Paxon (2001) show that stepmothers are not a good substitute of mothers.
[14] Redefining a birth-parent as a primary carer who started taking care of a primary child within 6 months after birth makes little difference on the main findings.

is likely to be the actual birth-parent, in reality it does not cover all actual birth-parents because the caring date in TDS2 is based on the date of claiming benefits for a primary child rather than the actual start of care date. Therefore, an actual birth-parent of a child can be classified as a non-birth-parent here if her first recorded caring date in TDS2 is different from the date of birth of the child.

As shown in Table 4, the mortality of children is nearly three times as large for non-birth-parents as for birth-parents. However, for the above mentioned reasons, to simply attribute the observed differences in mortality of children to the differences between natural birth-parents and non-birth-parents in Australia should be done so with caution.

4.6 Number of Children before a Primary Child

In TDS2 there is a variable of the total number of FTB/FPA children associated with a parent or spouse. However, due to the replacement effect[15], the value of this variable may be affected by the death of a primary child (i.e., potentially endogenous). To avoid this endogeneity problem, a new variable consisting of number of children ever cared for before the primary child (equivalent to the birth order of the primary child in most cases) is generated and used in the analysis.

As shown in Table 4, more than half of the primary children were the first child of their primary parents; their mortality is only 0.36 percent, in comparison to 0.59 percent for the second children, and 0.68 percent for the third and later children.

The estimated excess deaths are fairly significant. If the mortality rate of the whole sample was the same as that of those who are the first child of their primary parents, the total number of deaths could have been reduced by more than one quarter. The effects are even larger for the sub-groups of the second or later children.

4.7 Income Support History

Due to the nature of the data, all parents in TDS2 had once received family payments such as family tax benefits (FTB), but not all of them received income support (43% have no IS records). Compared to those who only received non income support family payments, families on income support are more disadvantaged because their main source of income is the Government benefit. Therefore, the incidence and duration of

[15] Families with high mortality of children tend to have more children than their ideal number in order to reach the desired number of surviving children.

income support may be a good indicator of family economic disadvantage, especially long-term disadvantage.

In TDS2, both family income support history and individual income support history are recorded. However, family income support records are left truncated at 1993, whereas individual records can be traced back to the 1960s. In addition, there are some inconsistent cases in the family income support records and also inconsistent cases between family and individual records. Therefore, individual records are mostly chosen to derive the variables of income support incidence and duration, while family records are used for robust tests; the findings are generally consistent.

There are different ways to generate the variables of income support incidence and duration from different time periods of TDS2 records, and these variables have different implications.

First, they can be derived from total income support records in TDS2. This method is the most straightforward, and the variables indicate the long-term economic disadvantage of the primary parents. However, one issue with this method is that older people are more likely to have an income support spell and also have longer income support duration simply because they are older and thus have been exposed to the system longer.

Second, the variables can be generated from records up to the birth (or the first caring date) of a primary child. Theoretically, the variables derived in this method are least likely to be affected by the birth/care of the primary child, but the problem is that they may not reflect the actual living environment of the child and the issue for the first method still exists here. In addition, a practical problem for this method is that few primary parents had income support records before the birth (or the first caring date) of a primary child.

Third, the variables can be created from the records up to the last caring date, or the records between the first and the last caring dates. In this way the variables can better reflect the actual family economic situation of the child, but they are also correlated with the surviving time of the child, which is significantly correlated with the mortality risk of children. These two correlations may bias the estimated correlation between IS duration and mortality of children. One solution is using the proportion of time on income support while caring for the child instead of the duration variable.

Fourth, a fixed time window (1 October 1987 to 8 April 2005[16]) can be used for all sample members. In this way, the variable of total IS duration is equivalent to the proportion variable because the denominator is the same for all members. In the meantime, a dummy variable is also created to indicate whether a primary parent had income support records before 1 October 1987.

All these methods have their advantages and disadvantages where none of them are perfect, however, the second and the third seem to be the most problematic. In this paper, the fourth method is mostly used, because it is relatively better in reflecting the family (long-term) economic disadvantage of primary children between age zero and age 17. The first method generally leads to very similar results to the fourth. For a comparison between different measures of IS duration, see Table A1 in The Appendix.

As shown in Table 4, mortality is the lowest for children whose parents have no IS records since 1987 (0.31%), whereas it is the highest for those whose parents had been on IS for nine years or longer between 1987 and 2005 (0.75%). The estimated number of excess deaths for the whole sample is 214, accounting for 36.8 percent of the total number of deaths. The effect is the largest among all influencing factors, suggesting that total IS duration is a key indicator of parental disadvantage with regard to mortality of children.

4.8 Family Income

Both family income and individual income are recorded in TDS2. Family income is predominantly used in this research, and individual income is used for robust tests; the findings are qualitatively the same.

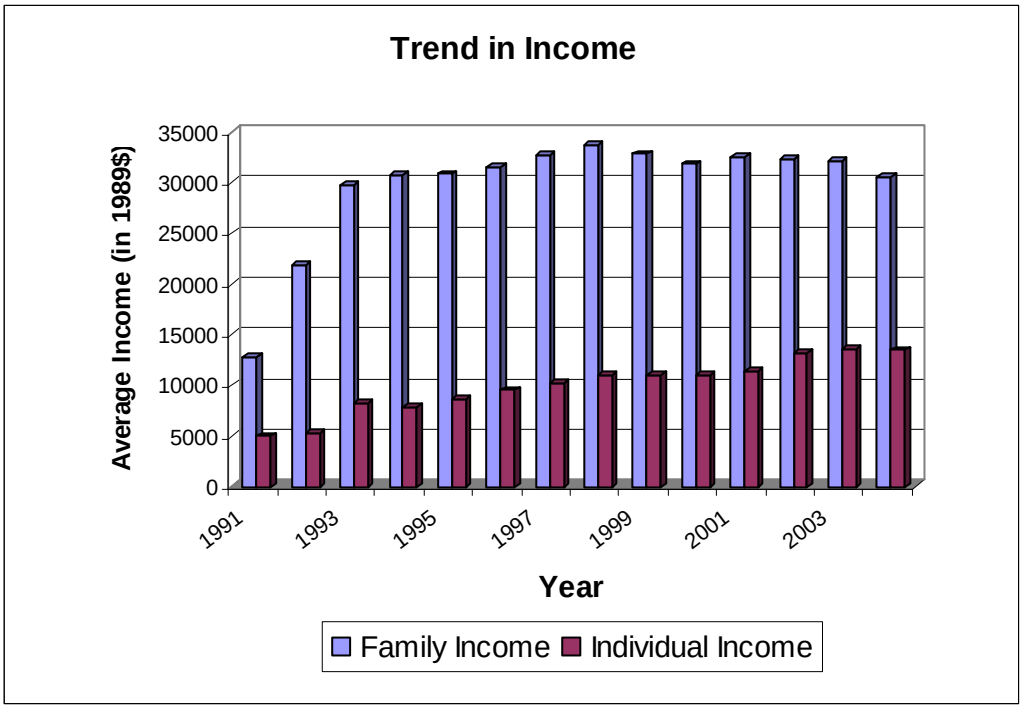
There are several issues about income variables in TDS2. First, incomes are only available for the years between 1991 and 2004. Second, there are many missing values (for more than 6% of the sample). Third, even after the deflation with Consumer Price Index (CPI), there is still an increasing trend (see Figure 4).

To tackle these issues, the following approach is applied: firstly, the sample mean of family income is calculated for each year between 1991 and 2004; secondly, family

[16] The current version of TDS2 was extracted on 8 April 2005. Later on in this paper, both terms of time since 1987 and time between 1987 and 2005 refer to the same period of time, i.e., 1 October 1987 and 8 April 2005.

income is divided by the sample mean in a given year to generate a measure of relative position of family income in the sample; thirdly, the average of relative family income is calculated over all recorded years; finally, the average relative family income is classified into four categories[17]: (1) low family income (50% of sample mean or less), (2) middle family income (50-150% of sample mean), (3) high family income (more than 150% of sample mean), and (4) missing.

Figure 4. Trend in Real Income in TDS2



As shown in Table 4, the mortality of children generally decreases with relative family income: the mortality is 0.32 percent, 0.48 percent, and 0.64 percent for children from high income, middle income and low income families, respectively. Children whose parental family income is missing appear to have the highest mortality, which indicates the missing values in family income are not random. Therefore, the missing values in family income are put into a separated category rather than dropped from the analysis in this research.

[17] Continuous variable of family income and its quadratic form are also used in some preliminary analyses, and the coefficients of other variables are hardly affected.

The estimated number of excess deaths is also very large (the second largest among all variables in Table 4), accounting for 34.4 percent of total deaths of the primary children in the sample. Once again, this suggests a significant role of economic factors in the mortality of children.

4.9 Marriage Instability

Any changes in marital status while on benefits are required to be reported to Centrelink. There is a problem in TDS2 about marital status; that is, the vast majority of people in TDS2 had their first marital status recorded as SINGLE, and a vast majority of the dates recorded for the first marital status were the dates of BIRTH. As a result, the first record on marital status is useless. Another difficulty is that marital status can be correlated with age and also change over time.

Therefore, in this research, a variable of marriage instability is used instead. This is derived from the number of recorded marital events in TDS2: (1) stable, if having only one or two marital events; (2) unstable, if having three or four marital events; and (3) very unstable, if having more than five marital events.

However, one issue remains; that is, if a person stays on benefit longer, she is likely to have more marital events recorded. Therefore, this variable is just a rough measure of marriage instability.

4.10 SEIFA Disadvantage Index

There is no relevant information of location and neighbourhood in TDS2 except postcode. To tackle this problem, in this research, Socio-Economic Indexes for Areas (SEIFA) Index of Disadvantage and the remoteness classification of Australian Bureau of Statistics (ABS)[18] are merged into TDS2 by postcode.

SEIFA Index of Disadvantage provides rankings for a wide range of areas. It is particular useful for this research because it focuses on low income earners, relatively lower educational attainment, and high unemployment, which reflect several key characteristics of socio-economically disadvantaged areas.

Since people change residential addresses from time to time, SEIFA index is merged into TDS2 in several ways: (1) based on the first caring dates; (2) based on the last

[18] For more details of SEIFA index and remoteness classifications, refer to ABS website at www.abs.gov.au.

caring dates; (3) for all relevant dates of interest (for survival analysis). These different ways lead to generally consistent results.

The SEIFA Index of Disadvantage is in continuous form, and the larger the index, the less the relative disadvantage. In this paper the areas are classified into three categories based on the index: (1) most disadvantaged areas (the first thirty percentiles of SEIFA Index of Disadvantage); (2) least disadvantaged areas (the last thirty percentiles of the index); (3) other areas (the middle forty percentiles of the index). In addition, the SEIFA index is not available for 2864 pairs of children and parents, therefore, they are put into a separate category – Missing.

As shown in Table 4, the mortality is significantly lower for children living in the socio-economically least disadvantaged areas (0.38%) than those living in the most disadvantaged areas (0.61%). The estimated number of excess deaths account for more than one fifth of the total number of deaths of children in the sample. In addition, the areas with missing values of SEIFA index also have high mortality of children (0.59%), suggesting that the missing values of SEIFA index are not randomly distributed, and they are more likely to happen among disadvantaged areas.

4.11 Remoteness

Remoteness information comes from the Australian Standard Geographic Classification (ASGC) Remoteness Areas classification of ABS. The classification puts populated localities into six classes: major cities, inner regional, outer regional, remote, very remote, and migratory areas. This information is also merged into TDS2 by postcode.

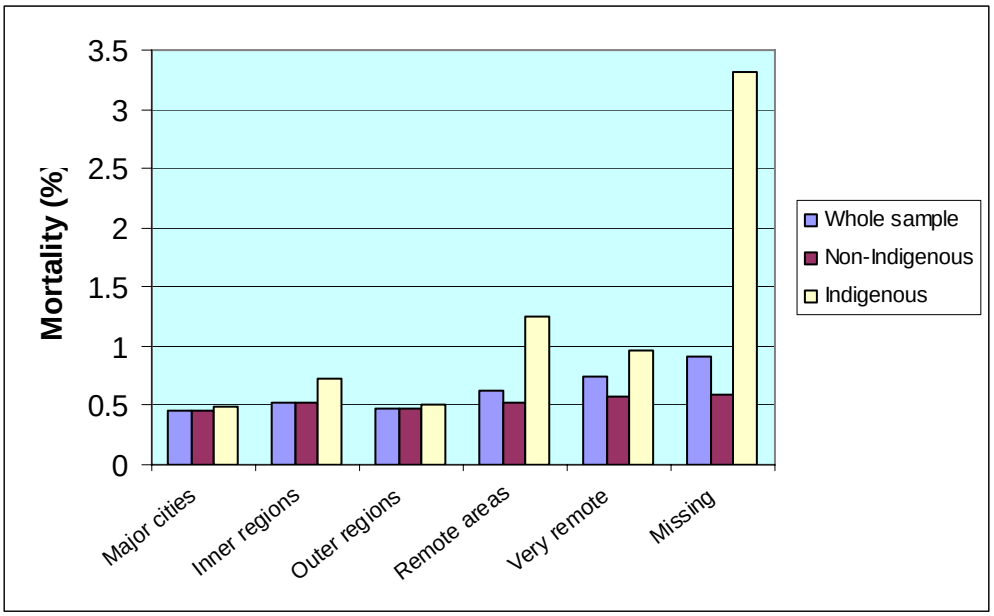
In the sample, 62 percent lived in major cities at the first caring date, 32.7 percent lived in inner/outer regions, only three percent lived in remote/very remote areas and the other 2.2 percent or so have remoteness classification unknown.

As shown in Table 4, remoteness is also found to be positively correlatively with mortality of children. The mortality is 0.46 percent for children in major cities, 0.51 percent for those in inner/outer regions, 0.67 percent for those in remote/very remote areas, and the areas with remoteness unknown have the highest mortality of children – 0.91 percent.

The estimated number of excess deaths is not large for the sample, but for the children living in remote/very remote areas, the number accounts for one third of total observed deaths.

Since Indigenous Australians make up a substantial proportion of rural and (particularly) remote area populations, it is often difficult to tell whether the differences come from the actual location or Indigenous status. From Figure 5 it seems that high mortality of children in remote/very remote areas is mainly driven by high mortality of Indigenous children. Another point to note is that mortality rates of children are extremely high in areas with remoteness missing, indicating that these areas with remoteness missing are likely to be in remote/very remote areas.

Figure 5. Mortality of Children by Remoteness and Indigenous Status



In addition, the rural or urban areas and states of residence can also be identified from postcodes, but they are not given much emphasis because preliminary multivariate analyses show that they are rarely significant. In the sample, only 10 percent lived in rural areas, and more than 92 percent lived in New South Wales, Victoria, Queensland, Western Australia and South Australia. The proportions are approximately the same at the first caring dates as at the last caring dates. Generally,

the mortality of children is higher in rural areas than in urban areas, and it is also higher in Northern Territory than in other states, whereas the Australian Capital Territory has the lowest mortality of children.

4.12 Sex of Children

As mentioned in Section 3, there is very little information available for all primary children in TDS2, apart from sex, date of birth and date of death.

First, the mortality is compared by gender of primary children. As expected, the mortality of boys (0.57%) is higher than that of girls (0.41%).

Second, the mortality is also compared by month of birth. The primary children belong to a half year birth cohort, thus there is little difference in age. However, it is interesting to examine whether different birth months are associated with different mortality rates which could be due to season related factors, such as weather and holiday arrangements of parents and health services. Direct tabulation shows that mortality is the lowest for children born in December (0.44 %), and is the highest for children born in November and January (0.52%). However, birth months are generally insignificant in multivariate analyses and thus mostly excluded.

In Table 4 the influencing factors are ordered by the estimated excess deaths for the whole sample. These factors can be grouped into several broad categories: (1) economic factors (IS duration and family income), (2) care related factors (number of children before the primary child, birth-parent, disability, teenage motherhood and marriage instability), (3) family background (Indigenous status and country of birth), (4) location/neighbourhood factors (SEIFA index, remoteness, rural/urban and state/territory of residence), and (5) children's own characteristics (sex and birth months).

Generally, the descriptive analyses show that disadvantaged groups in the different aspects have higher mortality of children than less disadvantaged groups, where economic and care related disadvantages seem to have the most significant effects.

***4.13** Correlation between the Influencing Factors*

The factors influencing mortality of children are not independent from each other. Table 5 shows the correlation matrix of the main influencing factors. Some factors are

highly correlated; for instance, total IS duration is highly correlated with relative family income, marriage instability, teenage motherhood and disability.

The table also shows that Indigenous status is highly correlated with remoteness, suggesting that Indigenous people are likely to live in remote/very remote areas. They are also more likely to have other disadvantaged characteristics, such as longer IS duration, lower family income, higher marriage instability, being a teenage mother and living in socio-economically disadvantaged areas. All these disadvantages may have contributed to the higher mortality of Indigenous children.

Teenage mothers not only are likely to have longer IS duration and lower family income, but also tend to have more marital events recorded in TDS2 (i.e., their marriage status is less stable). In addition, considering their age, it is not surprising to find that they are less likely to have had any children before the primary child.

Birth-parents are highly correlated with the number of children ever cared for before. This may be because of the definition of birth-parent; that is, primary carers who started to 'take care of' – claiming family payments for – a primary child from the time of birth. If a parent had children (likely to young) before the primary child, she was more likely to be on benefits at the birth of the child, and thus had a higher probability of claiming family payments for the child from the birth time.

People with a disability tend to have longer IS duration and lower family income, be living in remote/very remote areas, and have unstable marriage status. Marriage is very likely to be unstable for people with longer IS duration and lower family income, or living in socio-economically disadvantaged areas. Several location and neighbourhood variables – remoteness, SEIFA index and rural/urban – are also highly correlated, partly due to the fact that they are all derived from postcode.

Table 5. Correlation between Factors Influencing Mortality of Children

	Death of child	Indigenous	Teenage mothers	# of children before	Disabled	Birth-parent	Marriage instability	IS duration	Relative family income	Remoteness	SEIFA index
Death of child	*1.0000*										
Indigenous	*0.0059*	1.0000									
Teenage mothers	*0.0094*	0.1131	1.0000								
# of children before	*0.0174*	0.0682	-0.1376	1.0000							
Disabled	*0.0093*	0.0381	0.0040	0.0491	1.0000						
Birth-parent	*-0.0426*	-0.0184	0.0885	**0.2815**	-0.0009	1.0000					
Marriage instability	*0.0129*	0.1346	0.1808	0.0157	0.1099	0.0002	1.0000				
IS duration	*0.0182*	0.1758	**0.2047**	0.0648	**0.2045**	0.0326	**0.5648**	1.0000			
Relative family income	*-0.0123*	-0.1411	-0.1309	-0.0756	-0.1414	-0.0236	**-0.3344**	**-0.5892**	1.0000		
Remoteness	*0.0049*	**0.2392**	0.0539	0.0697	0.1116	0.0272	0.0652	0.0695	-0.0745	1.0000	
SEIFA index	*-0.0106*	-0.1101	-0.0754	-0.0377	-0.0445	-0.0287	-0.1077	-0.1858	0.1621	**-0.2199**	1.0000
Rural	*0.0032*	0.0826	0.0128	0.0544	0.0027	0.0333	0.0141	0.0257	-0.0629	**0.4008**	0.0105

Notes: Total observations = 108781; Missing values are excluded.

5. Econometric Analysis

5.1 Probability of Having a Primary Child Who Died

In the last section, mortality is found to be different for children from different family backgrounds, and, in particular, economic and care related factors make significant differences. This section estimates the effects of these factors on the mortality risk of children with a logistic model.

For convenience of analysis, the influencing factors are grouped into five categories as discussed in the last section: (1) family background; (2) care related factors; (3) economic factors; (4) location/neighbourhood factors; and (5) children's own characteristics.

The model takes the following general form:

$$Y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon \qquad (1)$$

where Y^* is a latent variable referring to the health conditions of children, X_1 is an array of family background variables, X_2 is an array of variables affecting care of children, X_3 is an array of economic variables, X_4 is an array of location/neighbourhood variables, X_5 is an array of variables about characteristics of children, β_0 is a constant term, $\beta_1 - \beta_5$ are vectors of coefficients for variables in the five categories, and ε is a term of random error.

If the health condition of a child is worse than a certain level, it will lead to death of the child. That is

$$Y = \begin{cases} 1, \ if \ Y^* > 0 \\ 0, \ otherwise \end{cases} \qquad (2)$$

An estimation strategy that was applied consists of starting with a group of factors in one category (baseline model), then including more explanatory variables of other categories in stage (extension models) to check the sensitivity of the coefficients of the factors in the baseline model.

5.1.1 Family Background

There are two variables in this category: Indigenous status and county of birth. These may be associated with certain family values, culture and living style.

As shown in Table 6, in the Baseline Model, when no other variables are included except country of birth, Indigenous status is very significant, and the probability of premature death of an Indigenous child is about 80 percent higher than a non-Indigenous child. However, when more explanatory variables are included in the model, Indigenous status becomes insignificant. This suggests that the higher mortality of Indigenous children may be explained mainly by their parental disadvantage in other aspects, such socio-economic disadvantage, rather than their parental Indigenous status alone.

Country of birth shows significant effects on the mortality of children, and immigrants generally have a lower mortality of children than people born in Australia. In particular, the mortality risk of children is 60-70 percent lower for people born in main English-speaking countries than for Australia born people.

Table 6. Estimated Effects of Family Background Factors on Mortality Risk of Children (odd ratios)

Variables	Baseline Model	Extension 1	Extension 2	Extension 3	Full Model
Indigenous	1.80 (3.35) ***	0.99 (0.05)	1.00 (0.02)	0.88 (0.64)	0.88 (0.64)
Country of birth:					
Australia	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Main English-speaking countries	0.40 (2.43) **	0.29 (3.23) ***	0.29 (3.24) ***	0.28 (3.28) ***	0.28 (3.28) ***
Other countries	0.86 (1.30)	0.72 (2.74) ***	0.72 (2.77) ***	0.65 (3.38) ***	0.65 (3.38) ***

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, five care related variables (number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability) are also included. In Extension 2, a dummy variable for boy is also included. In Extension 3, three economic variables (having IS before 1987, total IS duration since 1987, and relative family income) are also included. In the Full Model, two location/neighbourhood variables (SEIFA index and remoteness) are also included.

5.1.2 Care Related Factors

Several observed factors in TDS2 may directly affect care of children, including teenage motherhood, number of children cared for before the primary child, disability, birth-parent, and marriage instability.

Being taken care of by a teenage mother increases the probability of death. As shown in Table 7, the mortality risk of children whose primary carers were teenage mothers at the first caring date is approximately three times as high as that of other children. The effect hardly changes when more variables are included in the model.

Number of children ever cared for before also shows very significant effects on the mortality risk of children. If a parent had one child before a primary child, the probability of death of the primary child tends to be 2.62-2.84 times higher than if she had no child before; if she had two children before the primary child, the mortality risk of the primary child is even higher (3.3-3.64 times). However, if she had three or more children before the primary child, the mortality risk starts to decrease a little. In particular, if she had four or more children before the primary child, the mortality risk is approximately 2.1-2.4 times as high as if she had no other child before, which is lower than if she had fewer (1-3) children before the primary child.

The coefficient of the birth-parent variable is very significant and also very stable with the inclusion of extra explanatory variables. Generally, the mortality risk of children being taken care of by their birth-parents is only 84 percent lower than that of other children.

Disability of parents also increases the mortality risk of children. The risk is about 45 percent higher if primary parents have a disability than otherwise. However, when economic factors (IS duration and family income) are controlled for, the effect becomes insignificant.

Similarly, instability of marriage is also associated with higher mortality of children. The probability of death is about 40 percent higher for a child whose parent's marriage is very unstable – having five or more marital events in TDS2 – than for a child whose parent's marriage is stable – only having one or two marital events. Again, due to the high correlation between marriage instability and economic factors, the coefficient of this variable is insignificant in Extension 3 and the Full Model, where income support duration and family income are included.

Table 7. Estimated Effects of Care Related Factors on Mortality Risk of Children (odd ratios)

Variables	Baseline Model	Extension 1	Extension 2	Extension 3	Full Model
Teenage motherhood	3.26 (6.70) ***	3.13 (6.39) ***	3.14 (6.39) ***	2.82 (5.74) ***	2.77 (5.64) ***
# of children before the primary child:					
No child	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
1 child	3.84 (10.71) ***	3.73 (10.44) ***	3.75 (10.46) ***	3.63 (10.24) ***	3.62 (10.22) ***
2 children	4.64 (10.49) ***	4.51 (10.25) ***	4.51 (10.25) ***	4.31 (9.98) ***	4.30 (9.94) ***
3 children	4.10 (7.54) ***	3.97 (7.30) ***	3.98 (7.32) ***	3.70 (6.89) ***	3.65 (6.82) ***
4 or more children	2.38 (3.16) ***	2.33 (3.00) ***	2.34 (3.02) ***	2.12 (2.65) ***	2.10 (2.61) ***
Disability	1.45 (2.06) **	1.44 (2.00) **	1.45 (2.02) **	1.23 (1.10)	1.22 (1.06)
Birth-parent	0.17 (15.54) ***	0.16 (15.65) ***	0.16 (15.64) ***	0.16 (15.42) ***	0.16 (15.42) ***
Marriage instability:					
Stable	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Unstable	1.11 (0.99)	1.11 (1.02)	1.11 (1.00)	0.85 (1.46)	0.85 (1.42)
Very unstable	1.41 (3.16) ***	1.40 (3.06) ***	1.39 (3.04) ***	1.01 (0.08)	1.01 (0.10)

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, two family background variables (Indigenous status and country of birth) are included. In Extension 2, a dummy variable for boy is also included. In Extension 3, three economic variables (having IS before 1987, total IS duration since 1987, and relative family income) are also included. In the Full Model, two location/neighbourhood variables (SEIFA index and remoteness) are also included.

5.1.3 Economic Factors

Three variables for economic factors are included in the model: total IS duration since 1987, having IS records before 1987 and relative family income. Both long IS duration since 1987 and low family income are indicators of economic disadvantage, and having IS records before 1987 indicates being even more disadvantaged given the other factors are the same.

As shown in Table 8, primary parents having been on income support since 1987 (when the primary children were about to be born) generally have significantly higher mortality risks of their children. However, interestingly, the mortality risk does not monotonically increase with total IS duration; instead, the correlation shows a rather

complex pattern. Among parents with IS records since 1987, those with total durations of between three and five years have the lowest mortality risk of children (though still 47-55% higher than those without any IS records).

The effect of family income is generally insignificant, due to its high correlation with IS duration. If IS duration is not controlled for, as expected, parents with higher family income have significantly lower mortality of children.

Having IS records before 1987 also tends to increase the mortality risk of children, but the effect is generally insignificant.

A comparison with other measures of IS history is shown in Table A2 in the Appendix.

Table 8. Estimated Effects of Economic Factors on Mortality Risk of Children (odd ratios)

Variables	**Baseline Model**	**Extension 1**	**Extension 2**	**Extension 3**	**Full Model**
Having IS before 1987	1.49 (1.92) *	1.47 (1.83) *	1.16 (0.69)	1.16 (0.48)	1.15 (0.65)
Total IS duration since 1987:					
No records	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Less than 1 year	1.71 (3.39) ***	1.73 (3.46) ***	1.72 (3.39) ***	1.72 (3.40) ***	1.69 (3.28) ***
1-2 years	1.89 (4.22) ***	1.93 (4.30) ***	1.87 (3.94) ***	1.87 (3.92) ***	1.83 (3.78) ***
3-5 years	1.55 (2.78) ***	1.55 (2.77) ***	1.51 (2.43) **	1.51 (2.45) **	1.47 (2.29) **
6-8 years	1.78 (3.64) ***	1.76 (3.55) ***	1.67 (3.00) ***	1.68 (3.02) ***	1.64 (2.85) ***
9-11 years	2.39 (6.02) ***	2.33 (5.76) ***	2.32 (5.03) ***	2.34 (5.04) ***	2.22 (4.72) ***
12 or more years	1.86 (3.56) ***	1.77 (3.25) ***	1.87 (3.28) ***	1.87 (3.30) ***	1.78 (3.01) ***
Family income:					
Low	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Middle	1.00 (0.00)	0.99 (0.10)	1.18 (1.31)	1.18 (1.33)	1.19 (1.37)
High	0.89 (0.64)	0.87 (0.76)	0.97 (0.19)	0.97 (0.18)	0.98 (0.11)
Missing	1.28 (1.48)	1.32 (1.66) *	1.12 (0.66)	1.13 (0.69)	1.12 (0.65)

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, two family background variables (Indigenous status and country of birth) are included. In Extension 2, five care related variables (number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability) are also included. In Extension 3, a dummy variable for boy is also included. In the Full Model, two location/neighbourhood variables (SEIFA index and remoteness) are also included.

5.1.4 Location/Neighbourhood Factors

There are four location/neighbourhood variables derived from postcode in TDS2, including SEIFA Index of Disadvantage, remoteness, rural/urban areas, and state/territory of residence. State/territory variables are mostly insignificant, so they are excluded from the models reported in this paper.

Due to the long sampling window, people are likely to change their postcodes from time to time. As a result, there are different ways of merging these location/neighbourhood variables into TDS2, for instance, by records at the first or the last caring date. These different ways of merging may lead to different results.

Table 9 compares the results using the variables based on the postcodes at the first caring date and those based on postcodes at the last caring date. The results are different but qualitatively consistent. Mostly, the paper reports the results based on the postcodes at the first caring date.

Table 9. Comparison in Estimated Effects of Location/ Neighbourhood Factors Based on Postcodes at the First and the Last Caring Dates (odd ratios)

Variables	On 1st caring dates	On last caring dates	On 1st caring dates	On last caring dates
Remoteness:				
Major cities	*Reference*	*Reference*	*Reference*	*Reference*
Inner regions	1.15 (1.40)	1.03 (0.30)	-	-
Outer regions	1.03 (0.21)	1.20 (1.40)	-	-
Remote areas	1.38 (1.17)	1.41 (1.18)	-	-
Very remote areas	1.66 (1.58)	1.56 (1.31)	-	-
Remoteness unknown	2.00 (3.26) ***	1.91 (2.98) ***	-	-
SEIFA index:				
Most socio-economically disadvantaged areas	*Reference*	*Reference*	*Reference*	*Reference*
Other areas	-	-	0.79 (2.48) **	0.88 (1.32)
Least disadvantaged areas	-	-	0.63 (4.18) ***	0.80 (2.00) **
SEIFA index missing	-	-	0.98 (0.08)	1.39 (1.41)

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID).

Table 10 shows the estimated odd ratios for the SEIFA index and remoteness in five models (Baseline Model, Extensions 1-3 and Full Model). Except for the areas with

remoteness classification unknown, most areas are not significantly different from major cities in terms of mortality of children after controlling for SEIFA index.

Socio-economically disadvantaged areas show significantly higher mortality risks of children. Compared with the most disadvantaged areas, the least disadvantaged areas have 26-36 percent lower mortality risk for children, and other areas also have 15 to 22 percent lower risk. Surprisingly, the death probability of children is about 65 percent lower for the areas with SEIFA index missing than for the most disadvantaged areas. However, this should be interpreted with caution, because the majority of areas with SEIFA index missing also have remoteness missing. The areas with remoteness missing have 2.3-2.4 times higher mortality risk for children than major cities. On balance, areas with SEIFA index and remoteness missing are still likely to have higher mortality risk.

Table 10. Estimated Effects of Location/Neighbourhood Factors on Mortality Risk of children (odd ratios)

Variables	Baseline Model	Extension 1	Extension 2	Extension 3	Full Model
Remoteness:					
Major cities	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Inner regions	1.11 (0.99)	1.06 (0.54)	1.00 (0.02)	1.00 (0.00)	0.97 (0.25)
Outer regions	0.95 (0.34)	0.88 (0.84)	0.84 (1.17)	0.84 (1.18)	0.84 (1.23)
Remote areas	1.27 (0.88)	1.14 (0.46)	1.04 (0.14)	1.04 (0.14)	1.05 (0.16)
Very remote areas	1.44 (1.13)	1.07 (0.20)	0.85 (0.45)	0.85 (0.44)	0.87 (0.38)
Remoteness unknown	3.41 (4.12) ***	3.26 (3.92) ***	3.32 (3.99) ***	3.32 (4.00) ***	3.30 (3.96) ***
SEIFA index:					
Most disadvantaged areas	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Other areas	0.78 (2.58) ***	0.78 (2.49) **	0.81 (2.13) **	0.81 (2.14) **	0.85 (1.69) *
Least disadvantaged areas	0.64 (3.95) ***	0.64 (3.84) ***	0.67 (3.36) ***	0.67 (3.38) ***	0.74 (2.60) ***
Missing	0.37 (2.80) ***	0.36 (2.83) ***	0.35 (2.93) ***	0.35 (2.93) ***	0.36 (2.85) ***

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, two family background variables (Indigenous status and country of birth) are included. In Extension 2, five care related variables (number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability) are also included. In Extension 3, a dummy variable for boy is also included. In the Full Model, three economic variables (having IS before 1987, total IS duration since 1987, and relative family income) are also included.

5.1.5 Child characteristics

Sex and birth month are the only two explanatory variables available for all primary children in the sample. Since birth month is always insignificant in preliminary regressions, it is excluded from the final models reported in this paper.

Gender differences are compared in two ways. First, the model is estimated using the whole sample with a dummy variable of boy included (see the last column in Table 11). Boys appear to have significantly higher mortality risk (about 40% higher) than girls, and the coefficient of boy hardly changes with the inclusion of extra explanatory variables. Second, the models are estimated with sub-samples of boys and girls, respectively. The results are reported in the first two columns of Table 11.

Generally, for both boys and girls, the following characteristics of primary parents are associated with significantly higher mortality risk: being born in Australia, being teenage mothers, having had children before, having a disability, not being birth-parents, having IS records since 1987, and living in socio-economically disadvantaged areas. Other variables are generally insignificant.

However, two patterns are different between boys and girls. First, teenage motherhood seems to have largeger impacts on boys than on girls. Second, unlike for a boy, although having had children before is also associated with higher mortality of a girl, the risk tends to decrease with the number of children her primary parent had before herself. The difference in mortality is insignificant between a girl who had four or more siblings before herself and another girl who is the first child of her primary parent; the difference is still very significant for boys with similar characteristics.

Table 11. Estimated Mortality Risk of Children by Sex (*odd ratios*)

Variables	**Boys**	**Girls**	**Whole sample**
Boy	-	-	1.39 (3.91) ***
Family background:			
Indigenous	0.71 (1.37)	1.22 (0.64)	0.88 (0.64)
Born in Australia	*Reference*	*Reference*	*Reference*
Born in main English-speaking countries	0.28 (2.51) **	0.28 (2.18) **	0.28 (3.28) ***
Born in other countries	0.66 (2.53) **	0.64 (2.27) **	0.65 (3.38) ***
Care factors:			
Teenage motherhood	3.24 (5.08) ***	2.25 (2.78) ***	2.77 (5.64) ***
Having no child before primary child	*Reference*	*Reference*	*Reference*
Having 1 child before primary child	3.67 (7.73) ***	3.58 (6.74) ***	3.62 (10.22) ***
Having 2 children before primary child	5.12 (8.61) ***	3.32 (5.13) ***	4.30 (9.94) ***
Having 3 children before primary child	5.01 (6.97) ***	2.11 (2.12) **	3.65 (6.82) ***
Having 4+ children before primary child	2.89 (3.11) ***	1.20 (0.33)	2.10 (2.61) ***
Disability	1.38 (1.40)	0.98 (0.06)	1.22 (1.06)
Birth-parent	0.16 (11.74) ***	0.15 (10.10) ***	0.16 (15.42) ***
Marriage stable	*Reference*	*Reference*	*Reference*
Marriage unstable	0.78 (1.68) *	0.96 (0.24)	0.85 (1.42)
Marriage very unstable	0.99 (0.05)	1.03 (0.15)	1.01 (0.10)
Economic factors:			
Having IS before 1987	1.41 (1.41)	0.77 (0.64)	1.15 (0.65)
Total IS duration since 1987: no records	*Reference*	*Reference*	*Reference*
Total IS duration since 1987: less than 1 year	2.01 (3.40) ***	1.30 (1.01)	1.69 (3.28) ***
Total IS duration since 1987: 1-2 years	1.39 (1.41)	2.46 (4.01) ***	1.83 (3.78) ***
Total IS duration since 1987: 3-5 years	1.62 (2.16) **	1.31 (1.03)	1.47 (2.29) **
Total IS duration since 1987: 6-8 years	1.89 (2.86) ***	1.32 (1.02)	1.64 (2.85) ***
Total IS duration since 1987: 9-11 years	2.45 (4.07) ***	1.93 (2.46) **	2.22 (4.72) ***
Total IS duration since 1987: 12 or more years	1.98 (2.73) ***	1.54 (1.43)	1.78 (3.01) ***
Low family income	*Reference*	*Reference*	*Reference*
Middle family income	1.23 (1.28)	1.12 (0.57)	1.19 (1.37)
High family income	1.08 (0.31)	0.86 (0.54)	0.98 (0.11)
Family income missing	1.06 (0.28)	1.19 (0.63)	1.12 (0.65)
Location/neighbourhood factors:			
Major cities	*Reference*	*Reference*	*Reference*
Inner regions	0.98 (0.16)	0.97 (0.18)	0.97 (0.25)
Outer regions	0.85 (0.89)	0.81 (0.87)	0.84 (1.23)
Remote areas	1.04 (0.11)	1.07 (0.17)	1.05 (0.16)
Very remote areas	1.30 (0.67)	0.38 (1.20)	0.87 (0.38)
Remoteness unknown	3.21 (3.44) ***	3.40 (2.25) **	3.30 (3.96) ***
Most socio-economically disadvantaged areas	*Reference*	*Reference*	*Reference*
Other areas	0.85 (1.26)	0.83 (1.15)	0.85 (1.69) *
Least socio-economically disadvantaged areas	0.66 (2.67) ***	0.84 (0.92)	0.74 (2.60) ***
SEIFA index missing	0.37 (2.48) **	0.36 (1.59)	0.36 (2.85) ***
Observations	61015	57946	118961
Pseudo R^2	0.0769	0.0669	0.0703

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID).

5.1.6 Robust Tests

Extra robust tests have been undertaken.

First, continuous variables for economic factors (IS duration and family income) and SEIFA index are used instead of category variables; the coefficients of other variables are hardly affected.

Second, children who died after 10 years old are excluded from the sample. Some deaths of children may not be recorded in TDS2 if the primary parents left payments and never came back again. This kind of under-recording may be non-random; for instance, people with higher income may have higher probability. This is also likely to happen when children are older. Nonetheless, the test leads to qualitatively the same findings.

However, there are two unsolved issues for the logistic model; that is, right censored data and delaying in entry (different time of first claiming benefit). Duration model provides a better solution for these issues, and is discussed in Section 5.2.

5.2 Hazard of Death of Primary Children

As administrative data, TDS2 has two outstanding issues that need to be considered for this research: (1) delayed entry – people were only observed in TDS2 when they started to claim benefits from the Government; and (2) right censoring – deaths of children after parents left benefits were not observed. The logistic model in Section 5.1 cannot provide satisfactory solutions to these issues, while they can be easily tackled with the duration model.

The analyses in this section are mainly based on non-parametric (Kaplan-Meier estimator) and semi-parametric (Cox Proportional Hazard estimator) methods to allow for most flexible forms of survival and hazard functions.

A similar estimation strategy is applied as in Section 5.1, that is, starting with a group of factors (Baseline Model), and then including more explanatory variables in stages (Extensions) to check the sensitivity of the coefficients of the factors in the Baseline Model.

For consistency and simplicity, the variables are treated as constant over time in the results reported below, while results of models with time-varying variables and other specifications are discussed in robust tests.

In addition, to be consistent with the analyses in other sections, the sample is still restricted to the primary children who were not born abroad and did not die within two months after birth. One point to note here is that due to this restriction, the earliest entry occurs after two months (from birth); this slightly changes the interpretation of the estimation results (conditional on surviving to two months).

5.2.1 Family Background

Figure 6 shows the estimated Kaplan-Meier survival functions of children with Indigenous and non-Indigenous parents. Apparently Indigenous children (children with Indigenous parents) have significantly lower survival probability than non-Indigenous children.

Figure 6. Kaplan-Meier Survival Estimates by Indigenous Status

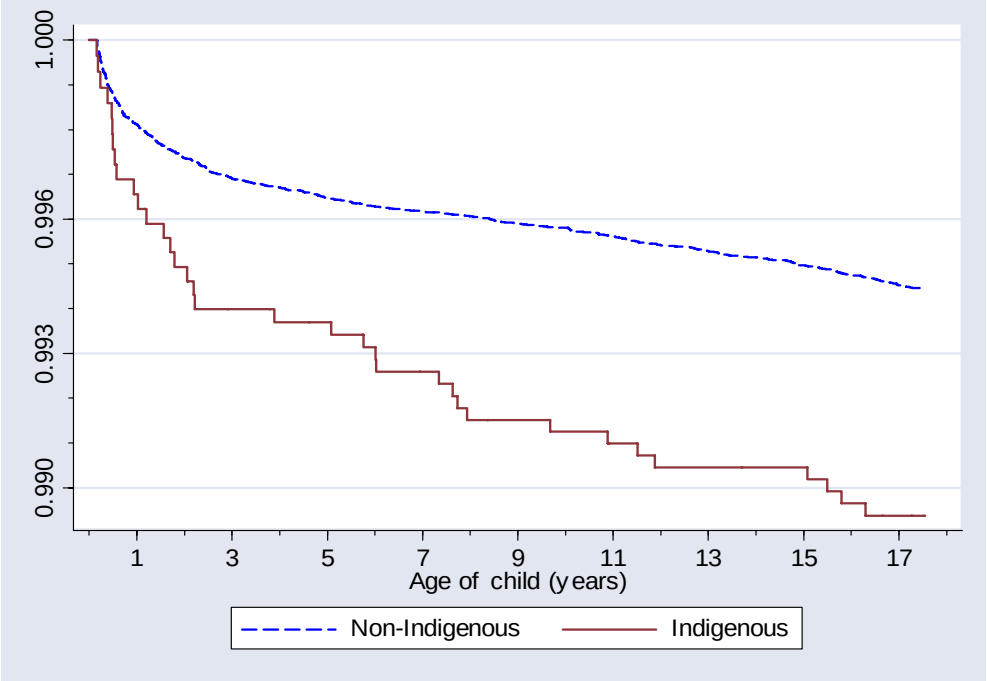


Table 12 lists the estimated hazard ratios for children from different family backgrounds as indicated by parental Indigenous status and country of birth. In the Baseline Model, only indigenous status and country of birth are included; Indigenous status is very significant, and the hazard of premature death of an Indigenous child is about 1.91 times as high as for a non-Indigenous child.

However, when other factors are taken into consideration, Indigenous status does not matter very much. Again, this confirms the finding in Section 5.1; that is, the high mortality of Indigenous children can be mostly explained by other disadvantages of their parents such as low socio-economic status rather than Indigenous status per se.

The Kaplan-Meier estimators of survival functions for children of Australia born people and others are shown in Figure 7. Estimation results in Table 12 are generally consistent with the pattern shown in Figure 7: a child whose primary parent was born abroad tend to have a lower hazard of death; in particular, the hazard of death is 64 percent lower for a child whose primary parent was born in a main English-speaking country than for a child with an Australia born parent. Interestingly, contrary to Indigenous status, country of birth becomes more significant when more explanatory variables are included in the model.

Figure 7. Kaplan-Meier Survival Estimates by Country of Birth

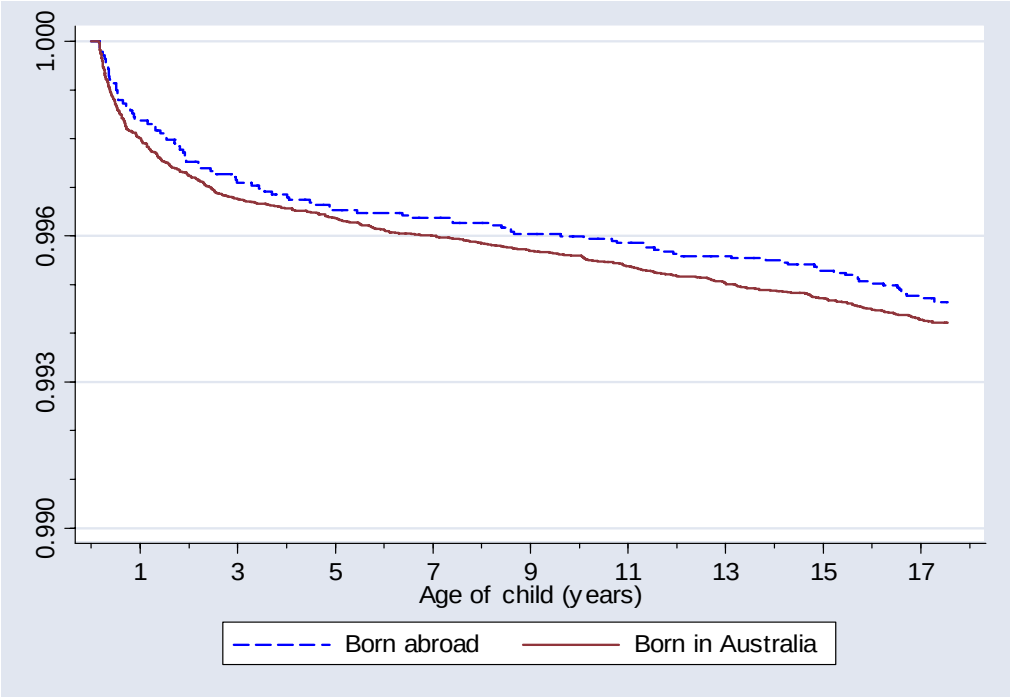


Table 12. Estimated Effects of Family Background on Death Hazards of Children (hazard ratios)

Variables	Baseline Model	Extension 1	Extension 2	Extension 3	Full Model
Indigenous	1.91 (3.71) ***	1.00 (0.02)	1.00 (0.02)	0.92 (0.47)	0.89 (0.61)
Country of birth:					
Born in Australia	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Born in main English-speaking countries	0.55 (1.59)	0.37 (2.59) **	0.37 (2.59) **	0.36 (2.66) ***	0.36 (2.68) ***
Born in other countries	1.02 (0.20)	0.82 (1.65) *	0.82 (1.68) *	0.77 (2.16) **	0.75 (2.30) **

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, five care related variables (number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability) are also included. In Extension 2, a dummy variable for boy is also included. In Extension 3, three economic variables (having IS before 1987, total IS duration since 1987, and relative family income) are also included. In the Full Model, three location/neighbourhood variables (SEIFA index, remoteness, and rural/urban areas) are also included.

5.2.2 Care Related Factors

Several factors, including teenage motherhood, disability, marriage instability, being a birth-parent, and number of children ever cared for before a primary child, are likely to affect the care quality. As shown in Table 13, except for disability, all other factors have significant effects on the mortality risk of children.

Table 13. Estimated Effects of Care Related Factors on Death Hazards of Children (hazard ratios)

Variables	Baseline Model	Extension 1	Extension 2	Extension 3	Full Model
Teenage motherhood	2.61 (5.55) ***	2.53 (5.30) ***	2.55 (5.34) ***	2.36 (4.83) ***	2.33 (4.76) ***
Disability	1.41 (1.89) *	1.40 (1.83) *	1.40 (1.84)	1.21 (1.02)	1.20 (0.98)
Birth-parent	0.06 (18.69) ***	0.06 (18.73) ***	0.06 (18.70) ***	0.06 (18.49) ***	0.06 (18.48) ***
# of children before primary child:					
None	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
One	3.29 (10.18) ***	3.22 (9.93) ***	3.24 (9.96) ***	3.17 (9.77) ***	3.16 (9.75) ***
Two	4.12 (10.17) ***	4.03 (9.93) ***	4.04 (9.93) ***	3.90 (9.69) ***	3.89 (9.65) ***
Three	3.76 (7.24) ***	3.65 (7.00) ***	3.67 (7.02) ***	3.45 (6.65) ***	3.42 (6.60) ***
Four or more	2.75 (3.73) ***	2.70 (3.59) ***	2.72 (3.62) ***	2.48 (3.25) ***	2.45 (3.18) ***
Marriage instability:					
Stable	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Unstable	1.13 (1.14)	1.13 (1.21)	1.13 (1.18)	0.90 (0.95)	0.90 (0.92)
Very unstable	1.39 (3.07) ***	1.39 (3.08) ***	1.39 (3.03) ***	1.08 (0.59)	1.08 (0.61)

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, two family background variables (Indigenous status and country of birth) are included. In Extension 2, a dummy variable for boy is also included. In Extension 3, three economic variables (having IS before 1987, total IS duration since 1987, and relative family income) are also included. In the Full Model, three location/neighbourhood variables (SEIFA index, remoteness, and rural/urban areas) are also included.

Having one, two, three, and four or more children before a primary child is likely to increase the death hazard of the primary child by approximately 2.12, 2.89, 2.42, and 1.45 times respectively (in the Full Model). Therefore, it seems that for an extra sibling, increase in competition for resources (including share of family income and

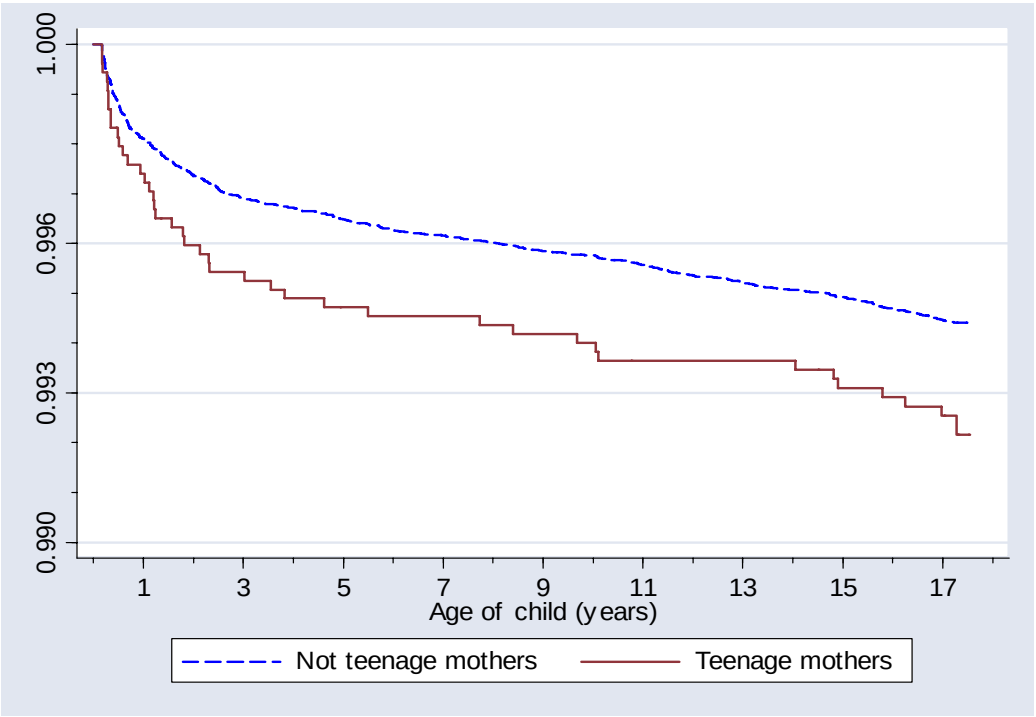
time of parents) predominates over accumulation of the caring experience of parents. However, when the number of children is three or more, the hazards become lower; this may be because in largeger families, older siblings need less care and can also help parents take care of the younger children.

A striking point of the results is that the variable of birth-parent (claiming benefits for a primary child from birth) is very significant in all models and birth-parent is associated with approximately 94 percent lower mortality of children. Using a different definition of birth-parent – claiming benefits for a primary child within three (or 4, 5 or 6) months after birth – leads to qualitatively similar findings, though the difference between birth-parent and non birth-parent is smaller.

Being cared for by a teenage mother is associated with 1.33-1.55 times higher hazard of premature death. Figure 8 shows the difference in estimated Kaplan-Meier survival functions between children of teenage mothers and others.

In addition, marriage instability and parental disability also tend to increase the mortality risk of children, while the effects are not very significant.

Figure 8. Kaplan-Meier Survival Estimates by Teenage Motherhood

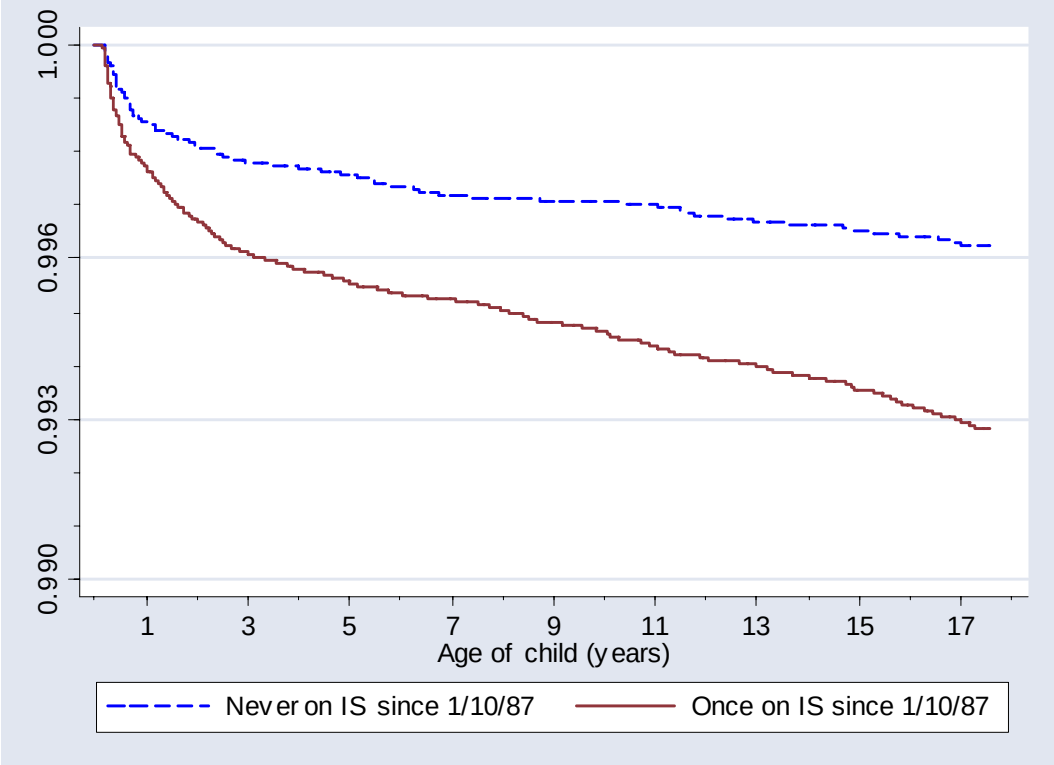


5.2.3 Economic Factors

The income support receipt is a good indicator of low income because to be eligible for income support, a person has to pass strict income test and asset test (for details, refer to Centrelink website at www.centrelink.gov.au). Therefore, total IS duration between 1987 and 2005 reflects how long a primary parent had been on low income in the period, indicating their long-term economic disadvantage.

The estimated Kaplan-Meier survival functions are compared in Figure 9 for children whose primary parents had and had no IS spells since 1987. As expected, having been on IS since 1987 is associated with a significantly higher mortality risk of children.

Figure 9. Kaplan-Meier Survival Estimates by IS Incidence



In Table 14, total IS duration since 1987 is further broken down into seven categories, and the one for people with no IS records is used as the reference group. The six categories for people with IS records since 1987 contain roughly the same number of primary children (about 11,000).

Table 14. Estimated Effects of Economic Factors on Death Hazards of Children (hazard ratios)

Variables	Baseline Model	Extension 1	Extension 2	Extension 3	Full Model
Having IS before 1987	1.49 (1.90) *	1.46 (1.82) *	1.18 (0.77)	1.18 (0.80)	1.15 (0.66)
Total IS duration since 1987:					
No record	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Less than 1 year	1.69 (3.32) ***	1.69 (3.32) ***	1.64 (3.06) ***	1.64 (3.07) ***	1.63 (3.03) ***
1-2 years	1.88 (4.20) ***	1.89 (4.21) ***	1.84 (3.82) ***	1.84 (3.81) ***	1.80 (3.68) ***
3-5 years	1.51 (2.61) ***	1.50 (2.57) ***	1.40 (1.99) **	1.40 (1.99) **	1.37 (1.84) *
6-8 years	1.65 (3.14) ***	1.63 (3.06) ***	1.47 (2.21) **	1.48 (2.25) **	1.43 (2.06) **
9-11 years	2.12 (5.08) ***	2.08 (4.88) ***	1.93 (3.83) ***	1.93 (3.83) ***	1.85 (3.55) ***
12 or more years	1.58 (2.53) **	1.53 (2.34) **	1.50 (2.06) **	1.50 (2.07) **	1.44 (1.83) *
Relative family income:					
Low	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Middle	0.89 (0.92)	0.90 (0.86)	1.04 (0.32)	1.04 (0.34)	1.06 (0.44)
High	0.81 (1.14)	0.81 (1.12)	0.88 (0.72)	0.88 (0.70)	0.90 (0.56)
Missing	1.50 (2.38) **	1.52 (2.49) **	1.24 (1.24)	1.24 (1.27)	1.24 (1.25)

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, two family background variables (Indigenous status and country of birth) are included. In Extension 2, five care related variables (number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability) are also included. In Extension 3, a dummy variable for boy is also included. In the Full Model, three location/neighbourhood variables (SEIFA index, remoteness, and rural/urban areas) are also included.

Although people with IS records generally have 43-85 percent higher mortality risk of children than those with no IS records (in the Full Model), the death hazard of children does not monotonically increase with total IS duration. People who had been on IS for 9-11 years or 1-2 years have the highest mortality risk of children; in contrast, people who had 3-5 years consistently have the lowest hazard; the hazard ratio for these two groups is approximately 1.35 (1.85/1.37). Interestingly, people who had stayed on IS for 12 years or longer since 1987 also had relatively lower mortality of children.

Having income support records before 1987 indicates two characteristics of parents: (1) having low income before the births of primary children; and (2) being older. The

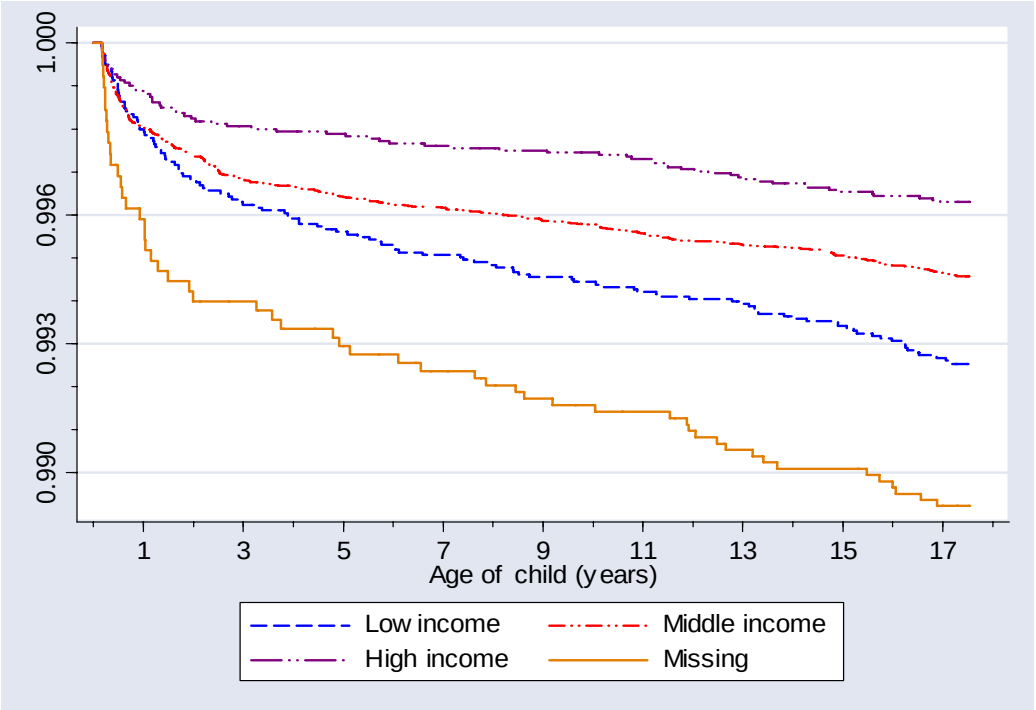
former is associated with higher mortality risk of children, while the latter is the opposite. On balance, having IS before 1987 slightly increases the mortality of children but the effect is insignificant.

In addition, as shown in Figure A1 in the Appendix, contrary to the result based on total IS duration since 1987, having income support between 1987 and the last caring date is associated with higher survival probability of children, indicating that parental income support incidence was more likely to be affected by the death of a child than the other way around. Table A3 in The Appendix provides a comparison of estimated death hazards of children with different measures of IS history, where a similar conclusion can be drawn.

Overall, the results of this paper demonstrate the complexity of the correlation between parental IS experience and mortality of children, and also suggests the necessity of further exploration of this issue.

As shown in Figure 10, lower family income is associated with a higher mortality risk of children; the group with family income missing has the highest mortality. However, after controlling for total IS duration since 1987, the income variable generally becomes insignificant (see Table 14).

Figure 10. Kaplan-Meier Survival Estimates by Family Income



5.2.4 Location/Neighbourhood Factors

As shown in Figure 11, people living in a socio-economically disadvantaged area tend to suffer higher mortality risk of children. Estimation results of Cox PH models generally show the same results (see Table 15): compared with people living in the most disadvantaged areas, those living in the least disadvantaged areas have 36-25 percent lower mortality risks of children, and those in other areas also have 23-17 percent lower risks.

However, unlike the pattern in Figure 11, areas with SEIFA index missing have the lowest hazards in Table 15. This should be interpreted together with the results for the missing categories of remoteness, because the missing categories in both variables basically refer to the same group of areas (based on the same group of postcodes). On balance, the mortality risk in the areas with SEIFA index missing is not significantly different from the most disadvantaged areas.

Figure 12 compares the estimated Kaplan-Meier survival functions of different remoteness categories. Remote areas (including very remote areas) and areas with remoteness classification missing stand out, showing the lowest survival probabilities; differences between other areas are not large. Results in Table 15 generally show that after controlling for SEIFA index (and other variables), except for the missing category, other remoteness categories are not significantly different from each other in death hazards of children. Therefore, high mortality risk of children in remote/very remote areas can be mostly attributed to the socio-economic disadvantage in those areas.

The differences between rural and urban areas are also insignificant, although death hazards are slightly higher in rural areas. State/territory of residence is excluded from the model reported here because it is always insignificant in preliminary regressions.

Figure 11. Kaplan-Meier Survival Estimates by SEIFA Index

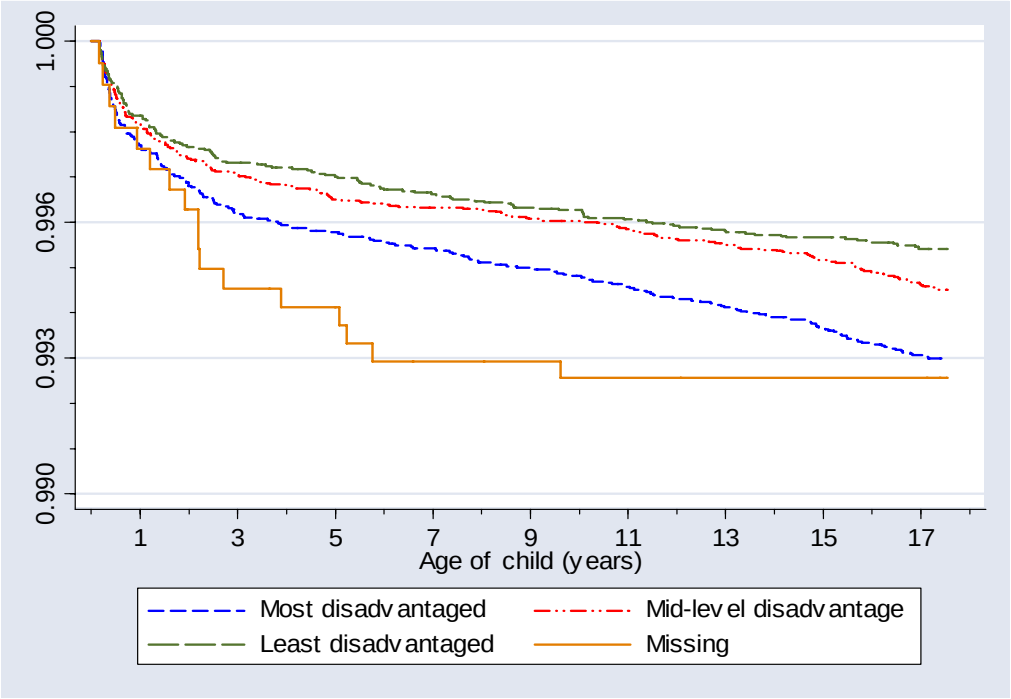


Figure 12. Kaplan-Meier Survival Estimates by Remoteness

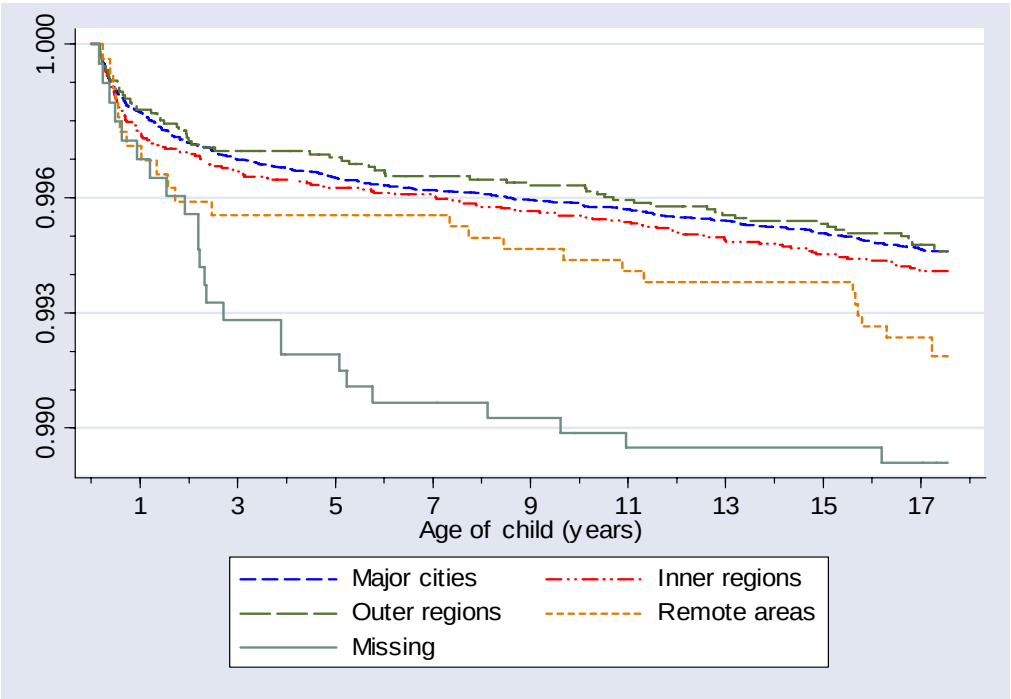


Table 15. Estimated effects of Location/Neighbourhood Factors on Death Hazards of Children (hazard ratios)

Variables	Baseline Model	Extension 1	Extension 2	Extension 3	Full Model
Rural areas	1.16 (1.06)	1.16 (1.04)	1.19 (1.24)	1.19 (1.21)	1.18 (1.14)
***Remoteness*:**					
Major cities	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Inner regions	1.03 (0.30)	1.02 (0.18)	0.96 (0.38)	0.96 (0.35)	0.95 (0.50)
Outer regions	0.88 (0.83)	0.85 (1.08)	0.82 (1.32)	0.82 (1.33)	0.82 (1.33)
Remote areas	1.21 (0.69)	1.12 (0.39)	1.06 (0.20)	1.06 (0.21)	1.07 (0.23)
Very remote areas	1.38 (0.98)	1.03 (0.09)	0.79 (0.65)	0.79 (0.65)	0.82 (0.56)
Unknown	3.12 (3.82) ***	3.06 (2.52) ***	3.05 (3.79) ***	3.03 (3.79) **	3.05 (3.80) ***
SEIFA Index of Disadvantage:					
Most disadvantaged areas	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Other areas	0.77 (2.72) ***	0.78 (2.52) **	0.80 (2.24) **	0.80 (2.27) **	0.83 (1.87) *
Least disadvantaged areas	0.64 (3.88) ***	0.66 (3.63) ***	0.69 (3.13) ***	0.69 (3.16) ***	0.75 (2.48) **
SEIFA index missing	0.48 (1.88) *	0.45 (1.97) **	0.46 (1.98) **	0.46 (1.21)	0.45 (2.00) **

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). In Extension 1, two family background variables (Indigenous status and country of birth) are included. In Extension 2, five care related variables (number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability) are also included. In Extension 3, a dummy variable for boy is also included. In the Full Model, three economic variables (having IS before 1987, total IS duration since 1987, and relative family income) are also included.

5.2.5 Child Characteristics

There are two variables regarding child characteristics available for all primary children that can be used in the regressions – sex and birth month. However, birth month is always insignificant in preliminary regression, so it is excluded in the final model.

To see the differences between boys and girls, three sets of estimations have been undertaken: (1) with the whole sample but including a dummy variable for boys, (2) with boys only, and (3) with girls only. In the first set of estimations, boys on average have 41 percent higher death hazards than girls, and this figure does vary much when extra explanatory variables are included.

Table 16. Estimated Hazard Ratios by Sex of Children

Variables	Boys	Girls	Whole sample
Boy	-	-	1.41 (4.00) ***
Family background:			
Indigenous	0.72 (1.29)	1.21 (0.62)	0.89 (0.61)
Born in Australia	*Reference*	*Reference*	*Reference*
Born in main English-speaking countries	0.36 (2.04) **	0.35 (1.77) *	0.36 (2.68) ***
Born in other countries	0.76 (1.74) *	0.74 (1.56)	0.75 (2.30) **
Care factors:			
Teenage motherhood	2.83 (4.51) ***	1.79 (2.06) **	2.33 (4.76) ***
Having no child before primary child	*Reference*	*Reference*	*Reference*
Having 1 child before primary child	3.28 (7.47) ***	3.01 (6.29) ***	3.16 (9.75) ***
Having 2 children before primary child	4.74 (8.44) ***	2.93 (4.84) ***	3.89 (9.65) ***
Having 3 children before primary child	4.71 (6.83) ***	1.93 (1.91) *	3.42 (6.60) ***
Having 4+ children before primary child	3.32 (3.57) ***	1.39 (0.61)	2.45 (3.18) ***
Disability	1.35 (1.32)	0.97 (0.08)	1.20 (0.98)
Birth-parent	0.06 (13.75) ***	0.05 (12.49) ***	0.06 (18.48) ***
Marriage stable	*Reference*	*Reference*	*Reference*
Marriage unstable	0.82 (1.27)	1.01 (0.08)	0.90 (0.92)
Marriage very unstable	1.06 (0.40)	1.08 (0.38)	1.08 (0.61)
Economic factors:			
Having IS before 1987	1.44 (1.50)	0.76 (0.66)	1.16 (0.72)
Total IS duration since 1987: no records	*Reference*	*Reference*	*Reference*
Total IS duration since 1987: less than 1 year	1.90 (3.10) ***	1.27 (0.92)	1.62 (2.98) ***
Total IS duration since 1987: 1-2 years	1.36 (1.36)	2.41 (3.91) ***	1.80 (3.68) ***
Total IS duration since 1987: 3-5 years	1.48 (1.75) *	1.24 (0.84)	1.37 (1.85) *
Total IS duration since 1987: 6-8 years	1.73 (2.44) **	1.10 (0.34)	1.44 (2.09) **
Total IS duration since 1987: 9-11 years	2.03 (3.15) ***	1.62 (1.78) *	1.85 (3.57) ***
Total IS duration since 1987: 12 or more years	1.63 (1.89) *	1.22 (0.65)	1.44 (1.85) *
Middle family income	1.11 (0.65)	0.97 (0.13)	1.05 (0.42)
High family income	0.99 (0.04)	0.79 (0.83)	0.90 (0.58)
Family income missing	1.18 (0.74)	1.31 (1.01)	1.24 (1.26)
Low family income	*Reference*	*Reference*	*Reference*
Location/neighbourhood factors:			
Major cities	*Reference*	*Reference*	*Reference*
Inner regions	0.98 (0.14)	0.89 (0.63)	0.95 (0.50)
Outer regions	0.84 (0.89)	0.77 (1.04)	0.82 (0.56)
Remote areas	1.09 (0.22)	1.04 (0.10)	1.07 (0.23)
Very remote areas	1.25 (0.56)	0.33 (1.31)	0.82 (1.33)
Remoteness unknown	2.94 (3.39) ***	3.17 (2.11) **	3.05 (3.80) ***
Most socio-economically disadvantaged areas	*Reference*	*Reference*	*Reference*
Other areas	0.84 (1.41)	0.82 (1.26)	0.83 (1.87) *
Least socio-economically disadvantaged areas	0.67 (2.60) ***	0.85 (0.85)	0.75 (2.48) **
SEIFA index missing	0.42 (1.92) *	0.52 (0.92)	0.45 (2.00) **
Rural areas	1.09 (0.48)	1.34 (1.25)	1.18 (1.14)
# of Observations	61005	57937	118942

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID).

The results of the three sets of estimations (from the Full Models) are compared in Table 16. Overall, the estimated effects of key variables are qualitatively similar for boys and girls, but there are also some differences that exist.

Commonly, a higher mortality risk was found for both boys and girls whose parents had the following characteristics: being born in Australia, being teenage mothers, having had child(ren) before, not being the birth-parent, having IS records since 1987, and living in socio-economically disadvantaged areas.

The differences between boys and girls include: (1) parental country of birth is significant for boys but generally insignificant for girls; (2) teenage motherhood shows bigger impacts on boys than on girls; (3) for girls, parents having had three or more children before are not significantly different from parents having had no child before, but for boys the differences are still very significant; and (4) unlike for boys, mortality risks of girls are not significantly different between different parental IS durations, except that the category of IS duration between one and two years is associated with significantly (1.41 times) higher hazards of death than the reference group – having no IS records since 1987.

5.2.6 Robust Tests

Similar robust tests have been undertaken as those shown in Section 5.1; for instance, some category variables, such as total IS duration, family income and SEIFA index, are replaced with continuous variables and their quadratic forms; the coefficients of other variables change little.

Additional tests are undertaken particularly for duration models.

Firstly, so far the variables in the duration models are treated as constant. This is not a big issue when the sampling window is relative short; however, observations in TDS2 spanned more than 15 years (from 1991 or earlier to 2005) and some variables such as marital status, number of children and home address are very likely to change during the period. One robust test that has been undertaken is using the last instead of first records of some time varying variables such as remoteness and SEIFA index, and another and a better choice is directly incorporating time varying variables in the duration model.

Secondly, apart from information of primary parents, TDS2 also contains information of other parents who once claimed family payments for the primary children in the sampling period. This information is used in some models for robust tests.

Thirdly, piecewise constant method is also applied for estimation. In general, the main findings are consistent in all these tests.

Overall, the estimation results of duration models generally confirm the findings in Section 5.1 (using logistic model). A summary of findings and detailed discussion are provided in the next section.

6. Summary and Discussion

Several key findings of this research are summarised and discussed in this section.

(1) The rate of premature death of Indigenous children (0.89%) is nearly twice as high as that of non-Indigenous children (0.47%).

This finding provides further evidence the confirm the higher mortality of Indigenous children in Australia. An issue of interest is why this is the case and what Indigenous status implies.

Previous studies show that compared with non-Indigenous children, Indigenous children are more likely to have low birthweight (13% compared to 6% in 2000-02) (Laws and Sullivan 2005), be less physically active and have poorer nutrition (leading to obesity and diabetes), live in overcrowded housing, and have unsafe drinking water and inadequate waste disposal (AIHW 2006). Indigenous people mostly live in remote and very remote areas, where smoking and drinking alcohol in hazardous quantities are much more common than in other areas in Australia (AIHW 2005). All these factors lead to significantly higher health risks for Indigenous children and can at least partly explain their higher mortality rates.

An interesting discovery of this research is that after taking into consideration other factors, the difference in mortality risk between Indigenous and non-Indigenous children becomes insignificant. The results suggest that higher mortality of Indigenous children may be explained mainly by their disadvantages in other aspects such as low socio-economic status rather than Indigenous status per se.

(2) Children of immigrants generally have a lower mortality rate (0.39%) than other children (0.51%)

Even after controlling for other factors, this conclusion still holds, and is consistent with findings in other studies, such as AIHW (2006).

AIHW (2006) attributes this finding mainly to two 'selection' effects: one refers to self-selection – migrants are usually those who are willing, and are physically and economically able, to migrate; and the other is government selection with certain eligibility criteria (for example, on health and education), which are generally

associated with better health of people and their children. Some research (Fennelly 2005, cited in AIHW 2006) found that the difference between immigrants and others may diminish with length of stay.

Two extra conjectures are proposed here: (1) survival of the fittest – immigrants tend to choose the most favourable place to migrate, and if they find the place is not suitable for them, they are likely to move away; (2) lack of social capital means that immigrants value more their family members, especially children, merely because they are their most important social network in a new country. In addition, sometimes a better living condition for children is the main reason for migration.

(3) Lower income and longer income support duration are associated with significantly higher mortality of children

The mortality rate of children from low income families (income equal or less than 50% of sample mean) is twice as high (0.64%) as that of children from high income families (income more than 150% of sample mean) (0.32%). The mortality of children belonging to parents with nine years or longer on income support since 1987 is 0.75 percent, in comparison with 0.32 percent for people not receiving income support during the same period. Since low family income is one of the key eligibility criteria for receiving income support, it is not surprising that after controlling for income support duration, the income variable becomes insignificant.

Low family income inevitably tightens budget constraint and has the potential to reduce family expenditure on nutritious food, medical care and housing, increases financial stress, affects the quality and stability of care for children. These circumstances ultimately have negative impacts on the health of children.

However, there are two possible effects of income support receipt on the mortality risk of children. First, the increase in family income enables parents to stay at home with their children, which tends to reduce the mortality rate of children. Second, income support incidence is also an indicator of unemployment/underemployment, low income and probably low earning ability, which is likely to be associated with a higher mortality of children.

As family income is controlled for in the model, the variable of total income support duration since 1987 mainly serves as an indicator of long-term economic disadvantage.

The non-linearity of the correlation between total income support duration and mortality of children shows the complexity of the correlation. One point to note is that parental income support incidence is more likely to be a consequence of the death of a child rather than a cause, because estimation of some duration models shows that currently receiving and having ever received income support are both associated with lower death hazard of a child. This issue deserves further exploration.

(4) Birth-parents have significantly lower mortality of children than others (0.33% vs. 0.97%)

Birth-parent in this paper refers to a person who started taking care of a primary child from the time of birth. This definition, as discussed earlier, may put some actual birth-parents into the category of non birth-parents. Using a slightly different definition of birth-parent, such as people who started taking care of a primary child within three or five months after birth, does not qualitatively change the result. The result is not sensitive to controlling for other variables in the model either.

Since mortality of children is significantly higher at a younger age, especially within the first one month, birth-parents should be subject to a higher risk of child mortality. However, this research shows an opposite result, suggesting the existence of more important counter factors, such as higher care quality of birth-parents, which tend to reduce the risk of child mortality. There is evidence in the literature that children living with step-mothers are significantly less likely to have routine doctor visits, or to have a place for usual medical care or for sick care (Case and Paxson 2001).

(5) Teenage mothers are significantly more likely to have higher mortality of children than others (0.74% vs. 0.48%)

Estimation results from both logistic and duration models show starting to take care of a primary child as a teenage mother is associated with 1.3 to 2.3 times higher mortality risk of children. The estimations are not very sensitive with the inclusion of extra variables in the model. This may be explained by the relatively poorer knowledge, skill and experience of teenage mothers in taking care of a child.

(6) Taking care of more children before a primary child is associated with significantly higher mortality risk of the child

In the sample used for this research, the mortality of children for parents who had never taken care of any other children is 0.36 percent, in comparison with 0.59

percent for those who had one child before and 0.68 percent for those who had two or more children before.

The number of children ever cared for before a primary child has two opposite effects on the mortality risk of the primary child. First, having had other children before increases the knowledge, skill and experience of care, and thus tends to reduce the mortality risk of the primary child. Second, having more siblings also means more competition for caring resources including food and parental time; a smaller share of caring resources implies higher mortality risk.

The estimation results show that the second effect – competition for caring resources – dominates. In the meantime, boys are more likely to be affected by the number of siblings than girls, probably because boys need more caring resources to survive.

(7) Parental disability and marriage instability are also associated with higher mortality risk of children

Disability in this paper is defined as being eligible for Disability Support Pension (DSP). People with a disability may have more time to take care of their children but their disability may also limit their ability to care (and may be associated with poorer health of children if the disability is due to genetic reasons). On balance, disability has a negative effect on the health of children. The mortality of children for people with a disability (0.90%) is nearly twice as high as that for others (0.47%) in the sample.

Marriage stability also affects the quality and stability of caring for children. Patton et al (2005) show that the rates of having a diagnosable and mental or behavioural disorder, for children living in sole parent and blended families (ie, families formed by second marriages between parents with children), were twice as high as in other families.

In the sample of TDS2, people whose marriage was very unstable (having five or more marital events in TDS2) have a mortality of children of 0.72 percent, in comparison to 0.42 percent for those whose marriage was stable (having one or two marital events in TDS2). Overall, however, the effects of parental disability and marriage instability are not very significant after controlling for other factors.

(8) Mortality of children is significantly different between most and least disadvantaged neighbourhood

This paper uses the SEIFA Disadvantage Index, remoteness and rural/urban area to capture several aspects of neighbourhood characteristics.

The SEIFA index is a comprehensive measure of relative socio-economic disadvantage of a neighbourhood, with a focus on low income earners, relatively lower educational attainment and high unemployment.

In the TDS2 sample, the mortality of children in the most disadvantaged areas (up to 30th percentiles of SEIFA Disadvantage Index) is 0.61 percent, in comparison to 0.38 percent in the least disadvantaged areas (the top 30 percentiles of SEIFA index). The estimation results of both logistic and duration models confirm this pattern.

The finding is also consistent with those in other Australian studies, such as AIHW (2006), which reports that both infant death rates and childhood death rates are significantly higher in the most disadvantaged areas than in the least disadvantaged areas. A study by Patton et al (2005) shows that poorer families are more likely to report that their neighbourhoods feel unsafe at least some of the time.

In the sample of TDS2, the mortality of children in remote/very remote areas is 0.91 percent, nearly twice as high as that in major cities (0.46%). Rural areas also have higher mortality of children (0.58%) than urban areas (0.47%). People living in rural and remote areas are subject to higher health risks (such as smoking and drinking in hazardous quantities, being physically inactive, and driving in higher speeds), and also have less access to health services (AIHW 2005; Garnaut et al 2001, cited in AIHW 2006). In addition, as discussed in earlier, these differences may reflect the generally higher mortality of Indigenous children.

The current research finds that after controlling for SEIFA index, the differences in mortality of children between remoteness categories and between rural and urban areas become insignificant, indicating that the higher mortality of children in rural and remote areas may be largely explained by the socio-economic disadvantage of people living in the areas.

To sum up, the results of this research generally suggest that the risk of premature death (before the 18th birthday) is significantly higher for children from disadvantaged families as indicated by several characteristics of the primary carer. These include lower income (especially those persistently in low income), Indigenous status, teenage

motherhood, living in socio-economically disadvantaged areas, and having three or more children to care for. The influencing factors are inter-related and the socio-economic factors are particularly important.

Death is the worst health outcome of children, and there are some other less severe health outcomes such as chronic illness and disability. They were unobserved in this study, but lower the current life quality of children and will also affect the productivity of children when they grow up. The significant correlation between higher death rates and parental disadvantage implies potential correlations between poorer general health conditions of children and parental disadvantage. In combination, these indicate evidence of intergenerational transmission of disadvantage in Australia. To break the cycle of intergenerational transmission of disadvantage, reducing the mortality and improving the health of children from disadvantaged families must be given high priority.

Due to the limitations of the data and the complex inter-relationships between mortality of children and the underlying influencing factors, the correlations revealed in this paper can not be interpreted as causal relationships. However, this should not hinder the application of the findings in policy arena; a higher quantity and quality of chickens and eggs can be produced without knowing which one is the origin. Nevertheless, policy responses to this complex issue can hardly be very simple; multiple policies may be required to tackle health problems and economic disadvantages respectively and simultaneously, but both of them should be well-targeted.

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Appendix

Table A1. Mortality Rates by Different Measures of IS History

	# of deaths	Mortality (%)	Excess deaths	# of Obs.
Total	***581***	***0.49***		***119013***
Total IS Duration since 01/10/87:			***214 (36.8%)*****	
Having no IS records	159	0.31*	0	51056
Having IS records:	425	0.62		68226
Two years or less on IS	126	0.57	58 (46.0%)	21950
Three to eight years on IS	124	0.54	52 (41.9%)	23080
Nine or more years on IS	175	0.75	101 (58.7%)	23196
Total IS Duration in TDS2:			***214 (36.8%)*****	
Having no IS records	159	0.31*	0	51031
Having IS records:	419	0.62		67713
Two years or less on IS	126	0.57	58 (46.0%)	21940
Three to eight years on IS	121	0.53	50 (41.3%)	22846
Nine or more years on IS	172	0.75	101 (58.7%)	22927
Proportion of time on IS while caring for a primary child:				
Having no IS records	417	0.80		52065
Having IS records:	164	0.24		66948
19% or less	50	0.23		22062
19-54%	50	0.23		22221
54% or more	64	0.28		22665
Proportion of time on IS between 1/10/87 and last caring date:				
Having no IS records	410	0.79		51639
Having IS records:	171	0.25		67374
18% or less	60	0.26		23220
18-52%	62	0.26		23567
52% or more	49	0.24		20587

Notes: * Mortality rates used for calculating excess deaths. ** Estimated excess deaths for the whole sample, and percentages of deaths which could be reduced if mortality rates of the reference groups were applied (in parentheses). The differences between the estimated excess deaths for the whole sample and the sum of estimated excess deaths of sub-groups are due to rounding of figures in calculation.

Table A2. Estimated Mortality Risks by Different Measures of IS History (logistic model, odd ratios)

	(1)	(2)	(3)	(4)
Having IS before 1987	1.15 (0.65)			
Total IS Duration since 01/10/87:				
Having no IS records	*Reference*			
Having IS records:				
Less than one year on IS	1.69 (3.28) ***			
1-2 years or less on IS	1.83 (3.78) ***			
3-8 years on IS	1.47 (2.29) **			
9-11 years on IS	1.64 (2.85) ***			
12 years or longer on IS	1.78 (3.01) ***			
Total IS Duration in TDS2:				
Having no IS records		*Reference*		
Having IS records:				
Less than one year on IS		1.69 (3.28) ***		
1-2 years or less on IS		1.84 (3.80) ***		
3-8 years on IS		1.46 (2.21) **		
9-11 years on IS		1.65 (2.90) ***		
12 years or longer on IS		2.28 (4.88) ***		
IS incidence while caring for a primary child:				
Having IS records			0.14 (10.93) ***	
Proportion of time on IS (%)			0.98 (4.28) ***	
IS incidence between 1/10/87 and last caring date:				
Having IS records				0.22 (9.25) ***
Proportion of time on IS (%)				0.97 (6.83) ***

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). Other variables controlled for include Indigenous status, country of birth, relative family income, number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability, a dummy variable of boy, SEIFA index, and remoteness.

Table A3. Estimated Death Hazards by Different Measures of IS History (Cox PH model, hazard ratios)

	(1)	(2)	(3)	(4)
Having IS before 1987	1.20 (0.88)			
Total IS Duration since 01/10/87:				
Having no IS records	*Reference*			
Having IS records:				
Less than one year on IS	2.03 (4.30) ***			
1-2 years or less on IS	2.19 (4.77) ***			
3-8 years on IS	1.59 (2.68) ***			
9-11 years on IS	1.59 (2.63) ***			
12 years or longer on IS	1.97 (3.91) ***			
Total IS Duration in TDS2:				
Having no IS records		*Reference*		
Having IS records:				
Less than one year on IS		2.03 (4.32) ***		
1-2 years or less on IS		2.20 (4.81) ***		
3-8 years on IS		1.58 (2.65) ***		
9-11 years on IS		1.61 (2.71) ***		
12 years or longer on IS		2.04 (4.10) ***		
IS incidence while caring for a primary child:				
Having IS records			0.13 (10.35) ***	
Proportion of time on IS (%)			0.98 (5.01) ***	
IS incidence before last caring date:				
Having IS records				0.24 (8.14) ***
Proportion of time on IS (%)				0.97 (8.36) ***

Notes: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. Absolute values of z-statics in parentheses (standard errors adjusted for clustering on parent ID). Other variables controlled for include Indigenous status, country of birth, relative family income, number of children cared before primary child, teenage motherhood, disability, birth-parent, marriage instability, a dummy variable of boy, SEIFA index, and remoteness.

Figure A1. Kaplan-Meier Survival Estimates by IS Receipt of Primary Parents between 1 October 1987 and the Last Caring Dates